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Design of a Bottling Line Mechanism

A Major Qualifying Project Report

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Abstract

E&J Gallo Wineries in Modesto, CA experienced down bottles on their wine cooler bottling line causing large amounts of downtime. Research was done into the history of the bottling line along with analysis of the current process. A redesign of the single filing process and pre-filler rail segments was also completed. CAD models were developed for each area along with implementation of the pre-filler rails. The newly installed rails proved to reduce the vibrations in the pre-filler area and provided for a smoother entry into the filler.

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Chapter 1.0 – Introduction

E&J Gallo Wineries was founded by Ernest and Julio Gallo in 1933. Since opening it has been owned and managed by family with its first facility in Sonoma County. E&J Gallo now has sites in Modesto, Monterey, and Napa Valley, California with other locations. They employ over 4,600 people and deal with over 90 foreign countries making it one of the largest wineries in the world. Gallo currently produces and bottles distilled wine-based spirits, table, sparkling and beverage wines, their grapes coming from the major grape growing areas in California (E&J Gallo Winery, 2004).

This project focused solely on the bottling aspect of the wine production, specifically the wine cooler line. The B&J (Bartles & Jaymes) wine cooler line has been in operation for over twenty years, with twelve flavors in the line. Currently Gallo is bottling the B&J wine coolers at their Modesto site and have been using the same method for almost a decade. Line 11 is the B&J bottling line and is running Krones equipment throughout the area of focus, in particular a Krones Glideliner that is a pressureless single filer. The Glideliner is an angled conveyor belt system that uses a weighted rail to aid the necking process of five bottles wide down to one.

Gallo had been experiencing large volumes of down bottles on Line 11 causing significant amounts of downtime on the line. The major concern was down bottles becoming lodged in the filler auger, requiring the operator to break the bottle out and cause on average 10-15 minutes of downtime. The goal of this project was to improve the current necking process of the B&J wine cooler bottles on Line 11 by preventing the downtime due to fallen bottles. Because of the limited resources available for the project, the project team elected to focus on removing down bottles after they fell, instead of approaching it from a root cause standpoint to keep bottles from falling. In addition the area of the line in focus was the Glideliner to the filler entry. It was felt the efforts put forth during the project would have more of an impact if this approach was taken.

The Glideliner was the newest piece of equipment within the segment of the line being studied so it became the first area for investigation. From early observations it was clear the Glideliner was not performing to its fullest potential, it also had been changed from its original arrangement to a pressured system. Research was done into the history of the Glideliner with analysis of the necking process it creates for the bottles. This research was conducted primarily through interviews of operators and maintenance personnel involved with Line 11. Static and dynamic tests were also conducted to determine the operational environment contained within the Glideliner.

Another location in focus was the area leading up to the filler entry. Bottles are in single file at this point and pass through a final down bottle trap before being picked up by the filler auger and carried into the filler system. This down bottle trap was in need of repair and caused increased vibrations between bottles and excessive noise. The violent handling of bottles in this area was linked to the problem of down bottles becoming lodged in the filler auger and became another key aspect to address.

Down bottle data collection, and close observation, both done personally and with the help of video equipment, was conducted to emphasize aspects needing the most attention. Analysis was conducted to gain understanding of the process to develop design concepts that would be used to correct the problem. Design concepts were formed based on current methods, background research, and analysis. These concepts were modeled in three dimensions using Pro Engineer Wildfire 2.0, a 3D CAD modeling package. A final design was brought through implementation while another design concept was handed off on completion of the project to be carried out at a later date.

The purpose of this Major Qualifying Project was to identify, analyze, and correct the down bottle problem being experienced by E&J Gallo Wineries. The steps taken to complete this task are outlined in the following chapters.

Chapter 2.0 – Background

This background chapter shows the need for improvement in the current necking process of Gallo Wineries' Glideliner bottling line, on fallen or misaligned bottles. Research on current operations of other facilities, patent research, and analysis of the current process are included. By studying the current process and comparing it with processes from other plants a general concept formed of what needs to be altered to achieve improvement. The goal of this literature review is to provide Gallo Wineries with a selection of possible design changes or redesign alternatives including a detailed model and tactics for each concept.

2.1 Line 11 Overview

A general layout for Line 11 was obtained from a Krones presentation sent over from Gallo before arrival on-site. This helped give an understanding of where certain aspects of the line were located, including the Glideliner (sliding area), filler entry (right end), twist washer, and unloading station. Shown in Figure 1 is the overview of Line 11.

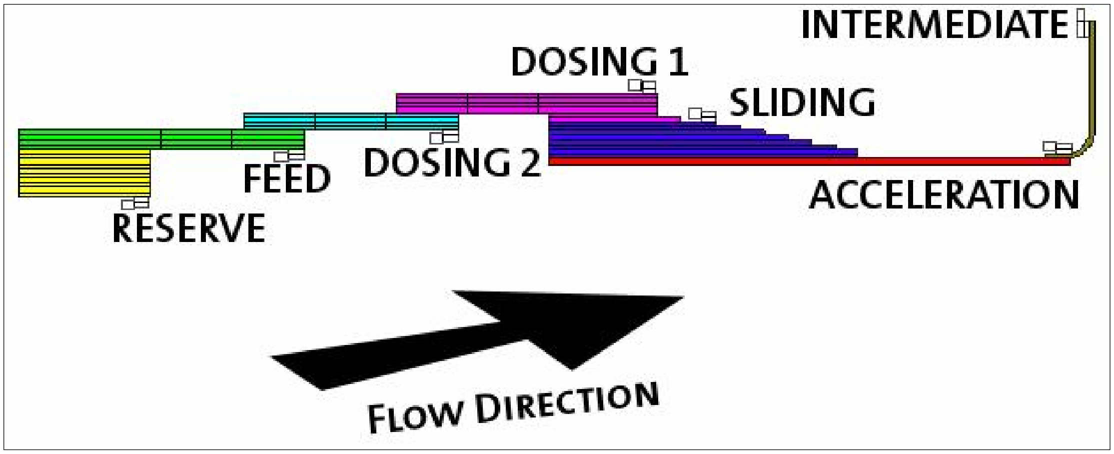


Figure 1 - Line 11 Overview (Krones 2005)

The areas in focus included the dosing areas all the way up to the end of the intermediate area, which is located directly before the filler entry. In between the acceleration and intermediate sections is a wall that is one of the landmarks discussed in future sections in regards to the rails directly after the wall. Shown below in Figure 2 is a CAD model depicting each of the components in the area of focus, including the down bottle traps.

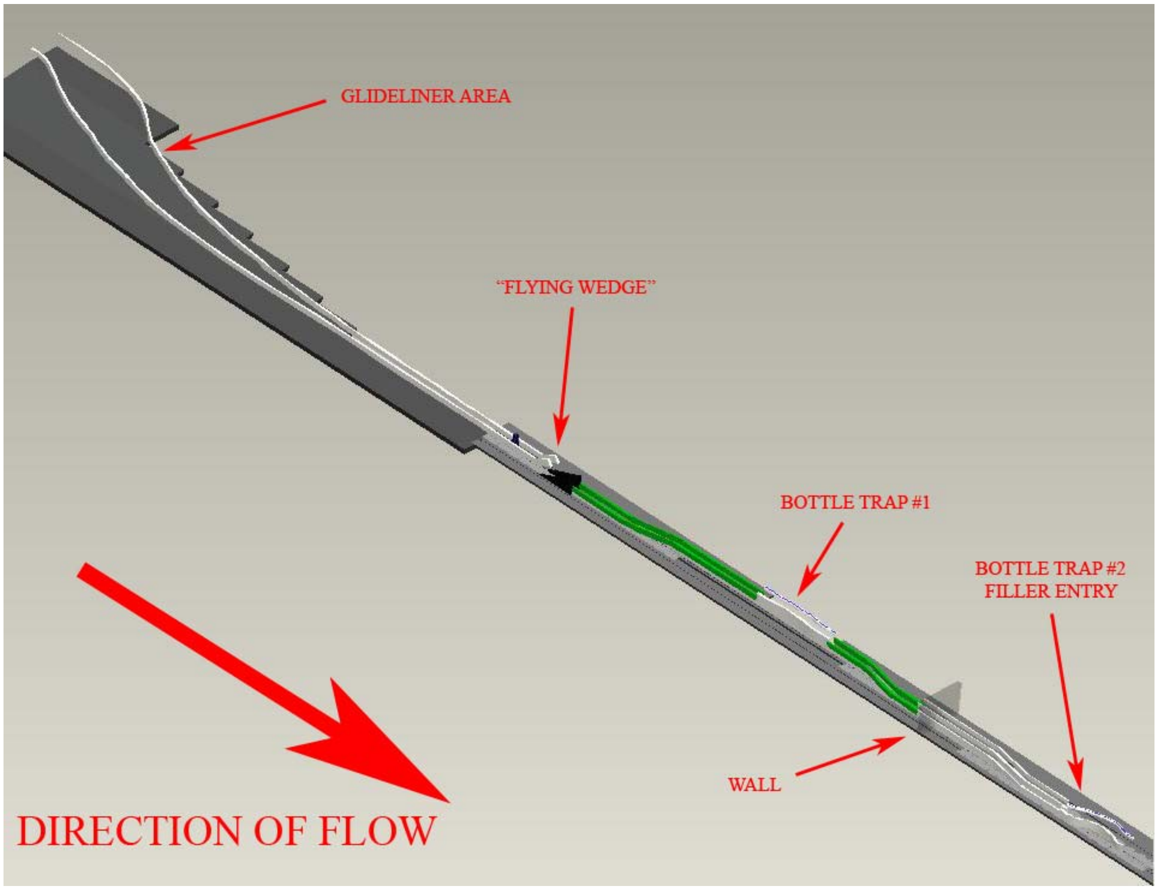


Figure 2 - CAD Model Overview of Aspects in Focus

2.2 Previous Glideliner Process

Gallo has been using a Krones Glideliner, a pressureless single filer, for their necking process on Line 11, the B&J wine cooler line, for almost a decade now. Figure 3 shows the original install of the Glideliner in 1996. The direction of flow is towards the camera. Although it is not obvious in the photo, the Glideliner slopes downward at an angle of about 9 degrees transverse to the direction of flow, allowing a smoother necking process through the area. A weighted rail rides along the sides of the bottles and keeps bottles from moving out of the flow. The conveyor belts increase in speed slightly starting at the far most right side of the picture and moving left. The incoming flow of bottles is at five bottles across and is quickly necked down to one bottle across.

Shown on the picture in Figure 3 in the weighted rail are some small weighted blocks that were used to adjust the pressure applied to the bottles by the rail. The blocks were part of the Krones package and came in incremental sizes to better adapt to the different applications of the Glideliner. This rail went through three phases before arriving at its current setup (Figure 4). It started out running with the Krones recommended weights in the rail, according to everyone spoken with at Gallo it ran effectively during this time. At some point much later after the initial install, new weights were developed to try to give the pressure applied to the rail some more accuracy. When more down bottles started to be created in the Glideliner area the weighted rail was removed altogether in an attempt to correct the problem. Finally one night after an increase in down bottles, a fixed rail was put in place and has remained so since.

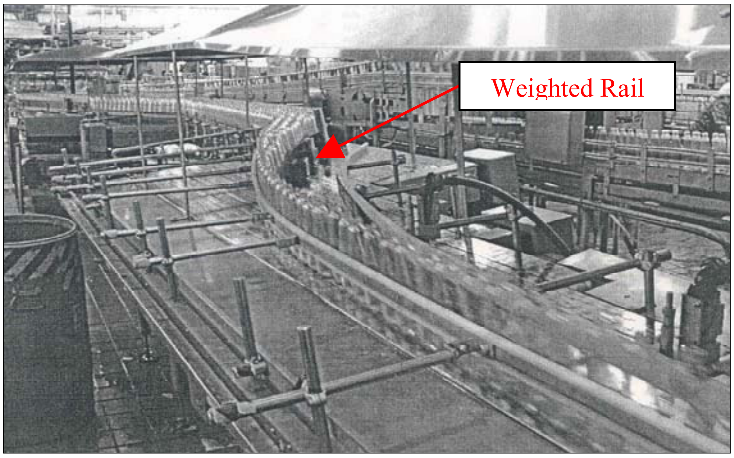


Figure 3 - Previous Glideliner Setup

2.3 Current Glideliner Process

The current Glideliner process has changed significantly over the past few years. Shown in Figure 4 is the current Glideliner setup, notice the removal of the weighted rail and the addition of the fixed rail running along the top portion of the Glideliner (right side). This has caused problems with pressure and removal of down

Figure 4 - Current Glideliner Setup

bottles, as discussed later in the report.

Analysis of the current process was an important step in the background research to discover which aspects caused the most problems relating to down bottles, in particular, which caused increased amounts of downtime due to down bottles. Preliminary information regarding the operation of the bottling line was obtained by Prof. Ault during a plant visit in October 2005. Mike Delikowski, Stephan Micallef, and Mike Warren, all engineers at Gallo, provided additional information about the Glideliner through multiple Interwise sessions during the project preparation phase in term B2005. Their knowledge and efforts proved to be helpful in filling in some of the gaps leftover from the Krones documentation and the pictures obtained by Professor Ault (2005) while at Gallo.

One of the more helpful documents sent from Gallo was an Excel sheet with Glideliner machine and type parameters. This diagram shows the overall layout of the Glideliner and its sensors, Figure 5 below. Table 1 shows the parameters that are in use on Line 11. A list of the sensors and their descriptions can be found in Appendix D with tables defining some of the standard parameters that are set for the Glideliner.

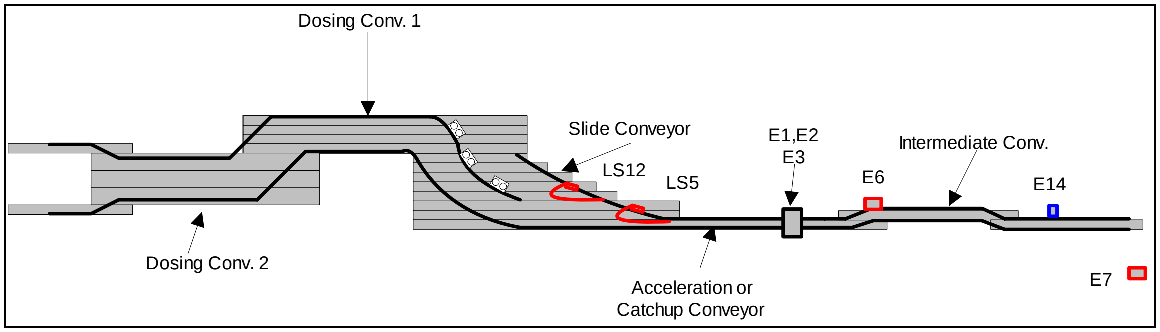


Figure 5 - Line 11 Glideliner (Shallock 1)

Conveyor	Percentage Based on Filler Speed
Intermediate Conveyor	115%
Catch-Up Conveyor	125%
Slide Conveyor	105%
Dosing Conveyor 1	120%
Dosing Conveyor 2	120%
Feed Conveyor	100%
Reserve Conveyor 1	100%
Reserve Conveyor 2	115%

Table 1 - Current Glideliner Machine Parameters

The Krones Glideliner presentation was helpful in determining the overall layout and rough setup procedure for the Glideliner (Krones, 2005). It stemmed a discussion about the "Flying Shoe" and its role in removing down bottles, which later proved the "Flying Shoe" to be an operational bottle trap. From our discussions with Gallo they made it clear that a possibility exists of the Glideliner not being setup properly, which could contribute to some of the down bottles and failure to eject them. This was considered during discussion on the methodology and the various approaches to take.

On arrival at the Gallo Wineries a Krones service document from Mike Warren was obtained with an introduction that explained the Glideliner process in detail:

> The Glideliner takes mass flow of bottles and reduces them to a single file. The Glideliner removes jams, pressure on the worm and noise. Down bottles are eliminated under its guide rails by means of the tilt or at its wedge area.
>
> The Glideliner monitors the parent machines speed and the catch-up conveyor speed. Gaps that form are detected by a series of gap control photoeyes and the conveyors zones are controlled by the calculations in the microprocessor. The Glideliner has 5 main zones and 3 optional zones. The zones control multiple conveyor chains or single conveyor chains.
>
> The intermediate zone delivers the bottles to the parent machines in feed conveyor. The intermediate is used as a buffer between the Glideliner control section and the parent machine. The intermediate takes up some of the shock during start-up and running.
>
> The catch-up zone is where gaps are detected and brought together. This zone is a single conveyor chain. The gap control sensors – LS1, LS2, & LS3 (E1, E2, & E3) are located on this zone. The LCT3 monitors this conveyor speed via a sprocket and proximity switch (E6). The microprocessor calculates the size of the gaps formed at these gap control sensors and speeds up the zones to close the gaps.
>
> The sliding zone is used to separate the mass flow into single file. The mass flow from dosing 1 comes into the system on top where the conveyor chains are slowest. Due to the tilt of the Glideliner the bottles slide down to the faster conveyor chains following the lower guide rail. The conveyor chains from top to bottom are traveling between 10 and 15% faster. This change in speed and tilt causes the bottles to spread. It is critical that the sprockets in this zone are correct.
>
> The dosing 1 zone is used to feed the correct amount of bottles into the sliding zone. The bottles on this zone are placed in a pattern. This pattern is used for getting a consistent amount of E bottles into the system. Thus for every foot of conveyor travel X amount of bottles will be feed into the system.
>
> The dosing 2 zone is used to keep the backpressure of Dosing1 consistent. Too much pressure could cause more bottles being pushed into the system. This will cause the Glideliner to possible jam and be more erratic – increase in noise.

> The feed conveyor is used to keep dosing 2 primes. The line switches are mounted on this conveyor. If the flow of bottles becomes too much then the reserve conveyors can be slowed down. If the flow of bottles decreases then the reserve conveyors can increase or the bottle stop can close. (Schallock 1)

The process used at Gallo involves pushing the bottles along the conveyor, relying on backpressure in several locations, which is different from some of the other methods we will see later in this chapter. Based on early assumptions we hypothesized that the backpressure may have been causing several the problems where bottles do not exit the conveyor if they are down at the traps. Therefore, the focus of our dynamic modeling was to determine methods to estimate the backpressure and examining how the backpressure can be controlled. In many areas of the line backpressure aids the flow of bottles, i.e. at the twist washer, but there are also many locations where high backpressure is not necessary or desirable. The only method determined to measure the backpressure was unable to be completed due to the need to interrupt production.

To identify the critical variables during operation, preliminary calculations of the dynamics of the bottle were completed. This allowed us to study how the bottle reacts under the current conditions and how it might react if we change certain operating parameters along the line. Working Model software was used to simulate the dynamics of the bottle on the conveyor belt. While actual trajectories were not obtained, these simulations strengthened our understanding of the effects of gravity and friction on bottle motions at various angles of the conveyor.

After further discussion with Stephan Micallef, a range of conveyor speeds was constructed that may occur during a normal day on the Glideliner. Figure 6 below shows the conveyor speeds with their respective scaled values drawn on each conveyor belt. This data is important for determining the dynamics of a bottle and understanding better how a bottle travels through the Glideliner.

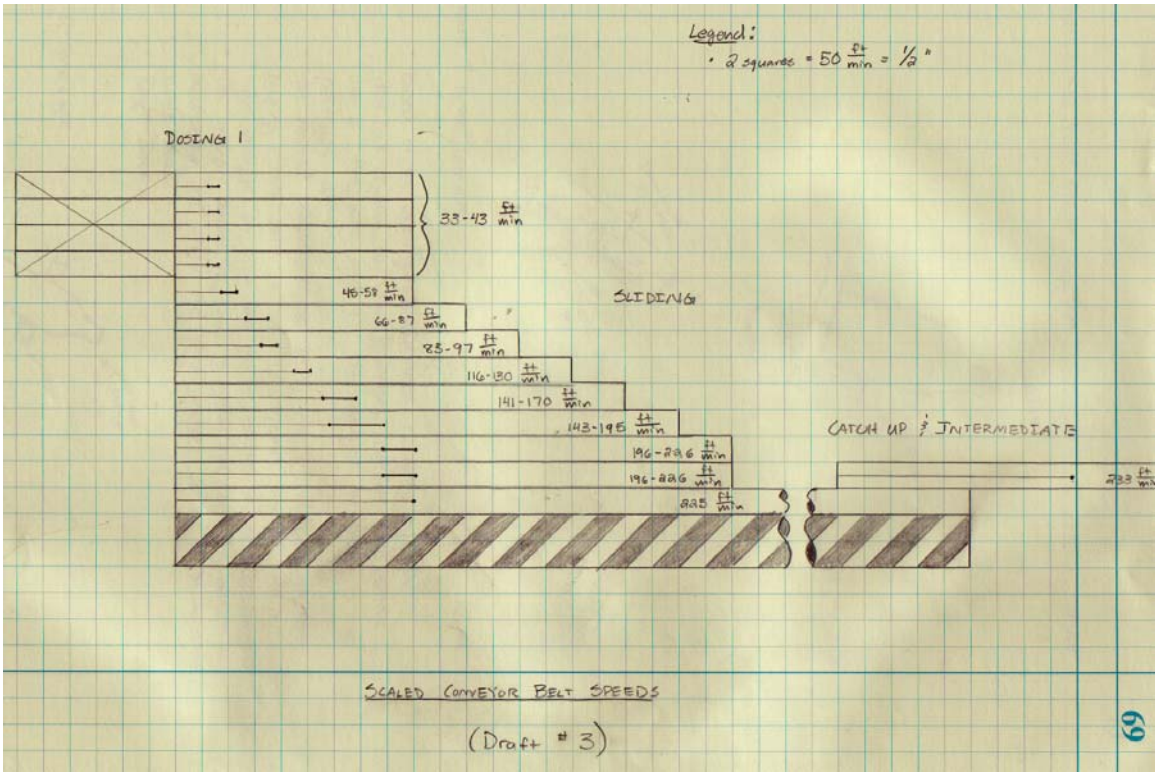


Figure 6 - Glideliner Scaled Conveyor Speeds

Questions arose about the arrangements of the various traps currently set up on the Gallo line during a discussion through Interwise teleconferencing software; shortly thereafter Stephan Micallef was able to send a rough sketch of the dimensions of the rails and the current traps. Figure 7 below shows a rough sketch of the dimensions of the rails at the two traps that are positioned before the filler. Based on the dimensions shown in Figure 7 section views at each conveyor location were drafted to scale to see how a bottle passes through the segments. The pictures may be found in Figure 8 and Figure 9, respectively. Both bottle traps eject bottles normal to the path of motion, relying on the curve of the bottle trap rail and gravity for ejection. The traps use a very thin rail stock for the rail on the outer portion of the trap where the bottles get pushed out, this ensures the bottle has clearance to eject below the rail. With all the aspects reviewed in the previous chapter a lot of questions still existed about the proper setup and orientation of the Glideliner. This is when contact was made with Krones and a request for a courtesy visit.

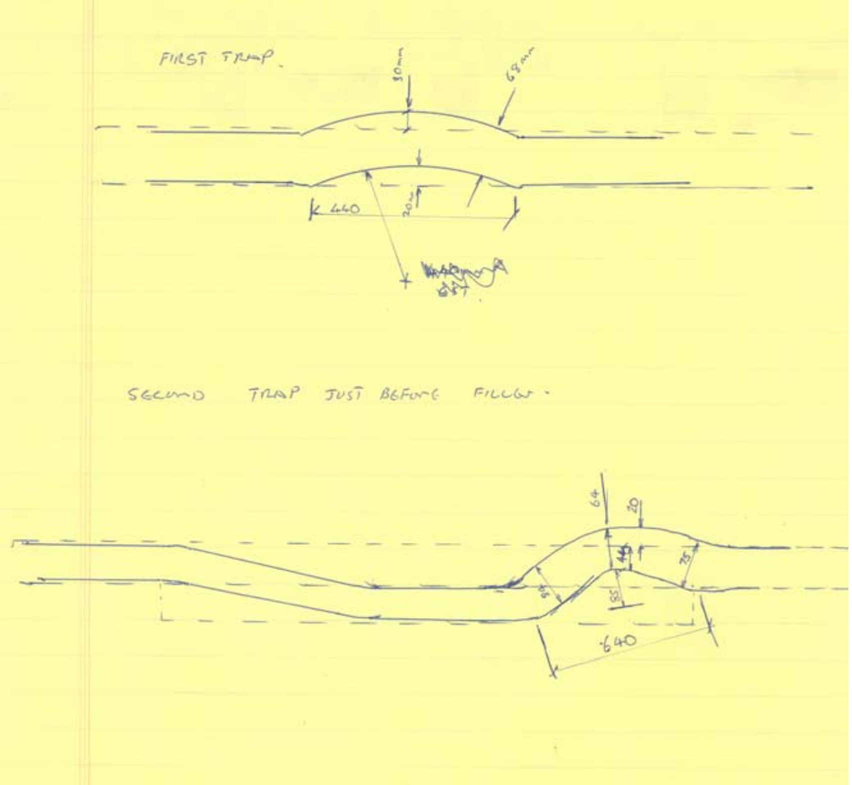


Figure 7 - Bottle Trap Dimensions (in mm)

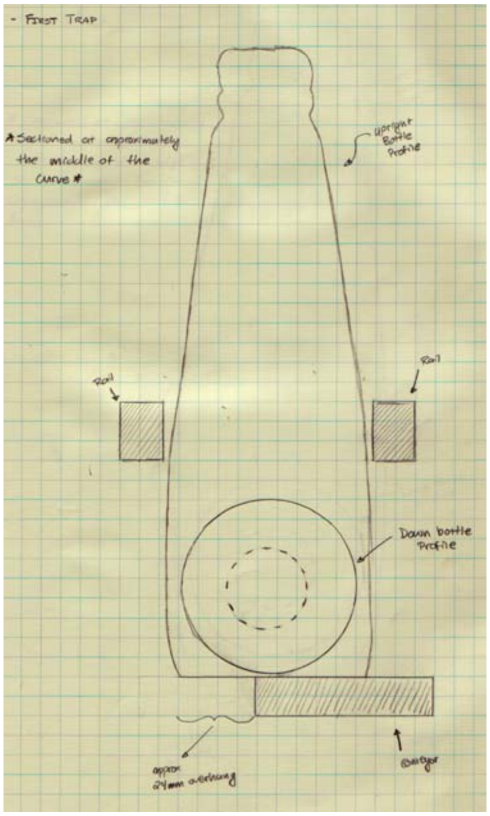


Figure 8 - Bottle Trap Section View (Trap 1)

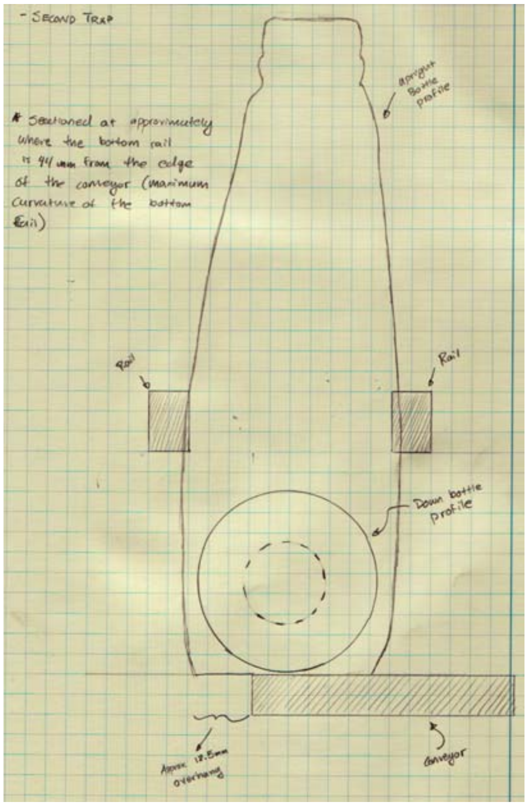


Figure 9 - Bottle Trap Section View (Trap 2)

2.4 Krones Visit

Contact was made with Krones shortly after arriving on-site at Gallo to obtain further information on how the Glideliner was intended to run. From the initial contact it was learned the Glideliner was defined as a pressureless single filer. No other information was given at the time and scattered contact was kept with Krones in an attempt to gain more information. Near the end of the project Krones made contact with Gallo about a courtesy visit to discuss the Glideliner. On February 25, 2006 Ben Moody of Krones made his visit to Gallo to discuss with the project team and Gallo liaisons the current Glideliner setup and proposed recommendations on how to optimize the process for a pressureless single filer.

Mr. Moody pointed out aspects of the line that were not otherwise apparent to many of the Gallo personnel as many who had originally worked on the line had left Gallo. Certain aspects such as the wear strips located underneath the conveyor chains were unknown to the project group and could have possibly been part of the issues that lead to the changing of the Glideliner to a pressured system. Mr. Moody also went over the procedure for reverting back to a pressureless system and his recommendation on how to make the installation as smooth as possible.

His recommendation involved having a Krones technician work on the line for a minimum of two days in order to get proper setup completed while the line was down and also tune the line during operation. Mr. Moody recommended that Patrick Yeager of Krones be brought in based on his experience with Glideliners and conveyor systems. The technician would spend the first day removing the rail system currently in place and setting up the Krones weighted rail. Any maintenance issues would be addressed at this time to ensure a smooth tuning procedure on the second day. With everything setup, all sensors checked and the LCT-3 controller verified to be working properly the second day would be spent with the line running. A large amount of the production schedule for that day would be devoted to fine tuning the process and adjusting any sensors to ensure proper flow of bottles through the Glideliner. With this completed the Krones technician would instruct all maintenance personnel involved with Line 11 the proper maintenance schedule for the line. Following through with this recommendation would result in keeping close contact with Krones to ensure all problems are resolved before the need arises to remove the method and change back over to the pressurized system.

2.5 Bottling Plant Tours

To gain a better understanding of processes for necking at other facilities, trips were made to local bottling plants in New England. The main focus was on the portion of the conveyor belts leading up to the beverage filler, however other aspects were examined and questioned to develop a better understanding of the overall bottling process.

2.3.1 Wachusett Bottling Plant

Wachusett Brewery, located in Westminster, MA, is a small-scale, beer only facility. They were founded in December of 1994 and have been brewing and bottling since. They started at only 100 barrels/year and are up to 11,000 barrels/year in 2004. The primary goal in visiting Wachusett was to view a smaller scale production line (Wachusett Brewing Company, 2006).

Thanks to a WPI alumnus, Mr. Kevin Buckler, a close look at Wachusett's bottling process was possible. Witnessing a small-scale operation where human operators are a requirement gives one a great appreciation for the technology involved in automation. It also helps to underline the basics involved in conveying glass bottles. Wachusett only bottles in one room and the equipment they use is completely modular so they can break down the bottling line when they are not using it and store it out of the way. Each step of the process requires an operator to observe and ensure proper operation of each station.

The bottles start in large palettes, which are loaded into an unloading station where operators use a large bar to drag off the top layer of bottles onto the conveyor belts. The bottles are then taken off one row at a time into a single file line, which passes through a backpressure twist washer, much like the one in use at Gallo. From here the bottles make a 90 degree turn out of the twist washer onto a conveyor and then pass through the filler. There is a mechanical switch that counts the number of bottles that pass through to ensure the filler does not get backed up. After the bottles pass through the filler they are then passed onto a capper, which places them on a conveyor single file and on to the labelers. Wachusett currently uses two labelers to increase the efficiency of the line; the labelers are one of the oldest pieces of machinery on the line. After being labeled they move on to the packaging station where operators hand pack and pass off the boxes to be sealed. Wachusett currently bottles at speeds of 120 bottles per minute.

2.3.2 Polar Beverages Bottling Plant

The Polar Beverages Bottling Plant, located in Worcester, MA, is a larger scale, multibeverage bottling facility. They were founded in 1882 and have been family owned since, currently in their fourth generation. They are the official bottlers of many beverages including 7up, A&W, Arizona, Gatorade, Sunkist and Monster Energy to name a few. The primary goal in visiting the Polar Beverages bottling plant was to develop an understanding for a bottling process that does not involve glass bottles (Polar Beverages Inc., 2004).

While the process is not directly related to that of the Gallo Wineries where they are bottling glass, the Polar Beverage plant is a high capacity plant and has been in operation for many years, giving them a large amount of experience. Polar used glass bottles before they changed to plastic bottles and aluminum cans. While not using glass can increase safety in the plant it also introduces other potential problems that might occur during the bottling process. Using bottles that are not as rigid as glass makes handling and delivery slightly more complicated. Conveyors must be more tightly packed and not allow gaps to be created otherwise fallen bottles will occur more frequently. Deformation is another aspect that must be considered because of the malleability of the aluminum cans and plastic bottles.

The Polar bottling plant is closer in size to Gallo, in square footage, which helps to give an appreciation of the vastness of the bottling facilities. It becomes clear that arrangement and timing of the conveyors and machinery in the facility becomes important for a smooth and fluid operation. Some of the distances the products must travel, most having to change onto different conveyors many times, provides for a difficult logic setup in all the sensors, PLCs, and encoders. Polar also uses solenoid-actuated mechanisms to eject down bottles, along with an x-ray device to determine if cans are full enough. Other mechanisms include in-between rail ejection for cans, an air-conveyor for plastic bottles, and an angled conveyor system to eject misaligned plastic bottles.

Two trips were taken into the plant to understand fully their process. The second trip proved to be informative because of the gained understanding over time of the problem. We were able to inquire about more specifics to their process, which in turn helped create new design concepts, which will be put to use in the Gallo process. Mr. Crowley of the Polar beverages facility proved to be informative of the process and provided a great help to the project development.

2.3.3 Anheuser-Busch Bottling Plant

Anheuser-Busch is a large company, having many facilities across the country; the particular facility visited was the bottling facility in Merrimack, NH. Anheuser-Busch has been around longer than the Polar facilities, having been founded in 1864. The Anheuser-Busch bottling plant bottles both glass and aluminum, not containing any plastic bottling lines. This trip had a more specific goal than the others, focusing on their necking process since it is similar to that of the Gallo Wineries. The specific process that was observed was the necking process of glass beer bottles as they were being necked down to one lane before the filler.

Thanks to WPI alum Joe Gaffen, assistant brew master, a closer look was taken at the necking process that is not normally shown on a typical facility tour. Time was spent observing the process used to neck bottles from around 8-12 bottles wide down to a single line of bottles. The necking process occurs directly before their filler, which is running around 1200 bottles/min average; therefore it is important that no fallen bottles find their way into the filler.

From the diagrams found in Appendix B, the conveyor is pulling the bottles instead of pushing them, unlike Gallo Wineries, to neck down to single file line. The varying speeds of the conveyor not only aid in the necking process but also close gaps further along, closer to where bottles enter the filler. They have a similar down bottle catch as Gallo, except the Anheuser-Busch method uses two conveyor belts at varying speeds and cuts a steeper angle onto the 2nd conveyor belt that provides for an easier ejection of a down bottle. This method differs from the Gallo method since Anheuser-Busch uses a front ejection method to allow the conveyor belt to push bottles straight out of the path of motion. Gallo's method involved relying on the curve of the rail and gravity to eject the bottle normal to the path of motion. Overall the Anheuser-Busch method was well developed and according to Mr. Gaffen, has few problems during operation, especially with down bottles.

2.6 Patent Research

While in this business there are many trade secrets and methods are not openly discussed, there exist a few patents on the general bottling process. Researching current patents has allowed determination of the current methods used in a beverage bottling process. It has also provided insight into the specifics of the process all the way down to what procedures are used in lubricating the conveyor belts that move the bottles. The seemingly relevant patents are documented in Appendix C, including pictures and abstracts for each. Many of the patents were helpful in drafting up concepts for new methods and for modifying the current process.

2.7 Current OEM Products

To gain a better understanding of the available products on the market today an investigation into other companies was completed. While most of the companies that specialize in building conveyor systems for beverage companies usually work on a customizable only basis there are a few companies that distribute OEM products that can be started up right out of the box. Two companies that have well developed products similar to the Krones Glideliner are Hartness International and Foodmach.

Figure 10 - Neck Air Conveyor (Hartness 2005)

Hartness' website was more helpful in presenting their current product line to the public. They produce various styled conveyors, ranging from top grip conveyors, elevator/lowerators, to bottom grip conveyors similar to those currently set up at Gallo Wineries. From the specifications given by some of the brochures, Hartness is developing their products with large capacity facilities in mind, with conveyor speeds of up to 200 FPM, compared to Gallo at approximately 233 FPM. Unfortunately, the Hartness website does not discuss the necking process and how it is handled on their conveyor systems. All other aspects, including technical specifications and visual aids, are readily available on their website for viewing, which has aided in understanding the process being portrayed. Hartness also claims to need no lubrication and have zero pressure in some of the assembly lines which is an interesting aspect considering all other assembly lines viewed during the plant tour process used some form of propylene glycol lubricant (Hartness, 2005).

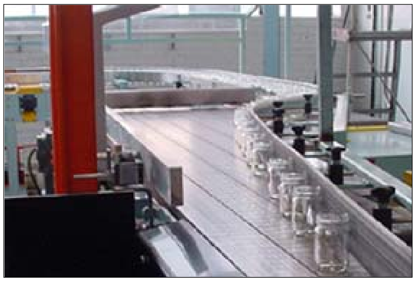


Figure 11 - Small Jar Necking (Foodmach, 2005)

Foodmach's website was much less informative than Hartness International's, due to their approach of offering customized machinery. From their brief description of what they offer they seem to have similar products as Hartness, including accumulators, accelerator and slow down units, elevators/lowerators, and pressureless single filling

(Foodmach, 2005).

This background research developed a good foundation for the project. With the help of the Gallo liaisons, we studied the current and previous processes used at Gallo. Visits were made to both large and small bottling facilities in the Northeast. A detailed patent search was conducted to gain an understanding of the intellectual property that exists on bottling methods. Alternative companies to Krones were researched to discover other choices for OEM conveyor systems. The information presented here was used in developing design concepts that would improve the performance of the B&J bottling line.

Chapter 3.0 – Methodology

This chapter outlines the steps that were taken to reduce the number of down bottles and amount of line downtime experienced on Line 11. This included a data collection phase in which the line was viewed daily for multiple hours at a time, notes were taken and on two separate occasions a formal down bottle data collection survey was conducted. Analysis both before and after arriving on-site was conducted to develop an understanding of the situations created on the line during operation. A set of design concepts were created and two design reviews were held to gather opinions on the direction of the project and analysis of the created concepts. Lastly the designs that proved most favorable were proposed for implementation.

3.1 Analysis & Data Collection

Analysis and data collection was completed both on-site and off-site to ensure full understanding of the bottling process used by Gallo. The off-site analysis was conducted using a test bed erected from a set of conveyor belt links and empty B&J wine cooler bottles sent to WPI from Gallo. The tests included static friction, dynamic friction, and center of gravity analysis on the bottle while interacting with the conveyor belt test bed.

The rest of the testing and analysis was completed in the first few weeks after arriving at Gallo and the data collection began immediately. This testing and analysis included modeling of a single bottle trajectory through the Glideliner, packing factor analysis in the Glideliner area, and video analysis of the current traps to ensure their proper operation. The single bottle trajectory was completed to ensure the proper setup of the bottom rail; if a bottle were to pass through the Glideliner and never touch the bottom rail instabilities would result. The packing factor analysis was conducted on the Glideliner to decide the proper rail spacing. The video analysis was conducted on the two down bottle traps found between the Glideliner and the filler. A shift's worth of video was taken on each trap to note how misaligned bottles are ejected. The analysis was completed in tandem with the data collection to ensure proper use of time during the first weeks of the on-site portion.

Data collections started the first working day at Gallo through meet and greet sessions with the operators and maintenance personnel involved with Line 11. From there constant contact was kept to ensure involvement in all happenings on the line during the time frame for the project. Gallo operators conducted one down bottle data survey before the author arrived on-site; the information was handed over on the first day of work. A second set of down bottle data was collected a few weeks later to focus more on location instead of quantity. Observation of the line continued throughout the project to ensure no aspect was left unattended.

3.2 Design Concepts and Reviews

Design concept creation started almost immediately and was fueled by the patent research and plant visits that were conducted off-site. These design concepts were refined and added to during the background research and the first few weeks while on-site. A design notebook was kept to journal the background research portion of the project and clearly define and date each design concept created. Once the background research had been completed and all probable design concepts had been created the first design review was held on January 17th, 2006. This meeting was held with both the Gallo liaisons and the WPI adviser to work towards refining the design concepts and ensure project focus was intact. A second design review was held on January 27th, 2006 to wrap up topics discussed in the first design review and decide on a final approach for the rest of the project.

3.3 Design Proposal and Implementation

On completion of the design reviews the final design had been decided and all effort from February 1st, 2006 on was focused on getting the design completed and implemented. CAD models were developed to portray properly the designs with CAD drawings for use during fabricating of the new conveyor rails. Once the design had been completed maintenance team leaders were given copies of the drawings and feasibility of the installation was determined. Piggybacking a scheduled maintenance project that was being completed on the line, the new rails were installed with the help of a contracting group. Other design concepts were completed and handed off to the Gallo employees on leaving the project center for future implementation efforts.

Chapter 4.0 – Analysis & Data Collection

This chapter provides an overview of the analysis and data collection that was performed both while on and off-site. The friction analysis was completed off-site on a makeshift test bed of conveyor belt links sent to WPI by Gallo to gain an understanding of the working environment before arriving on-site. Both static and dynamic friction tests and a center of gravity analysis were completed. The data collection allowed for narrowing down of the project scope and focus on areas that were in the most need of improvement. All data collection in this chapter was based on watching either personally or with video equipment to observe as much of the line as possible from the twist washer exit until the filler entry.

4.1 Friction Analysis

The static and dynamic friction tests were conducted using a test bed created from conveyor belt stock that was sent to WPI from Gallo. The tests were completed to gain a better understanding of the environment the bottles are subjected to while passing through the Glideliner. The static friction test was conducted to discover the effect of the angle of the Glideliner on the bottle while not in motion. The dynamic friction test was used to evaluate the force needed to achieve sliding along the conveyor chain through this area. The data provided insight into the static and dynamic variables present in the area without the usage of lubrication. The static friction test yielded an average angle of nine degrees, the same value currently used for the angle of the Glideliner. The calculated static coefficient of friction was .158. The dynamic friction test yielded a coefficient of friction of .271. Both experiment details can be found in Appendix E.

4.2 Center of Gravity Analysis

Center of gravity analysis was completed to confirm the data given in the bottle drawings sent over from Gallo wineries. The first test, a bottle tip test, was not consistent with what Gallo was using for their center of gravity. Thus a second test was conducted in the CAD package Solid Works 2005 to verify the value obtained and still showed a lower value than that from the Gallo bottle drawing. The bottle tip test yielded a tipping point of 13.7 degrees, where the tipping point based on Gallo's bottle drawings is 18.5 degrees. The Solid Works analysis was slightly closer to the Gallo value at 17 degrees but still shows discrepancies between all three values. Further analysis would need to be completed in order to determine the optimum angle of the Glideliner to ensure bottles do not tip over. The center of gravity analysis indicates that a pressureless single filer needs an accurate setup procedure to determine the ideal slope of the Glideliner. It also showed the Glideliner could possibly not be setup properly, answering some of the questions to why large volumes of down bottles were experienced while using the old method. Experiment details can be found in Appendix F.

4.3 Single Bottle Trajectory Analysis Through Glideliner

Using the speeds of the conveyor belts and a scaled drawing of the conveyor belts in the Glideliner area the free trajectory of a single bottle across the Glideliner surface was calculated. For this analysis, the y-direction was taken to be perpendicular to the path of motion and the x-direction to be parallel with the direction of motion. It was assumed that the surface was frictionless to reduce the complexity of the calculations. It was also assumed that the bottle instantaneously changed velocity with changing conveyor belt links in the x-direction and traveled at the same speed as the conveyor. Using Equations 1 and 2 below, a single bottle trajectory was developed.

$$y - y_0 = V_{y\_0} * t + \frac{1}{2} * g * Cos(10) * t^2$$

(Eqn. 1)

$$V_y{}^2 = V_{y\_0}{}^2 + 2 * g * Cos(10) * (y - y_0)$$

(Eqn. 2)

Y is the final position in the y-direction, y_0 is the initial position in the y-direction, V_{y_0} is the initial velocity in the y-direction, t is time, g is the force due to gravity, the Cos(10) is to consider the Glideliner is at an angle, and V_y is the final velocity in the y-direction.

Shown in Figure 12 is a sample calculation for one conveyor segment; the trajectory across each conveyor was calculated using the same method. Based on the data found from these calculations a trajectory was found and plotted to scale shown in Figure 13. The green line in Figure 13 shows the bottom rail in the Glideliner, the red line shows the trajectory at lower conveyor speeds and the blue line shows the trajectory at higher conveyor speeds. It was discovered through this analysis that the configuration of the bottom rail was suitable since the single bottle contacted the rail within the first two inches of travel. The detailed calculations can be found in Appendix G.

To find t on the First Belt:

$$3.248\cdot \text{in} = V_{y\_o}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{\text{in}}{\text{s}^2}\right)\cdot(\text{Cos}10)\cdot t^2$$

$$t = 0.131\,\text{s}$$

Velocity at the end of 1st Belt:

$$V_y^{\,2} = V_{y\_0}^{\,2}\cdot 2\cdot\left(386.22\cdot\frac{\text{in}}{\text{s}^2}\right)\cdot(\text{Cos}10)\cdot(3.248\cdot \text{in})$$

$$V_{y2} := 49.71\,\frac{\text{in}}{\text{s}}$$ (Initial Velocity of 2nd Belt)

Distance in X-Direction: Velocity in X-Direction x Time

$$6.6\,\frac{\text{in}}{\text{s}}\cdot 0.131\,\text{s} = 0.846\cdot \text{in}$$

Figure 12 - Sample Calculations of Belt #1

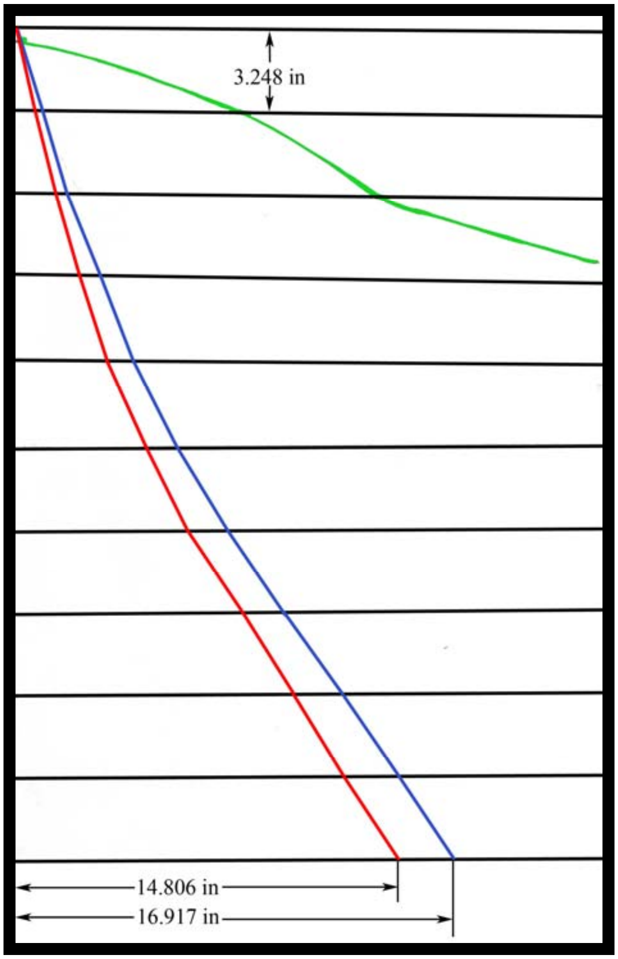


Figure 13 - Scaled Trajectories

4.4 Glideliner Packing Factor Analysis

The Dosing areas directly before the Glideliner section recently went through routine maintenance involving replacement of the rails and a new rail spacing arrangement applied to it. One of the engineers at Gallo used an equation adapted from the Pythagorean Theorem to discover the ideal rail spacing based on using the B&J wine cooler bottles. The standard packing for the dosing area at five bottles wide can be found in Figure 14 and the equation for the spacing can be found in Equation 3 below.

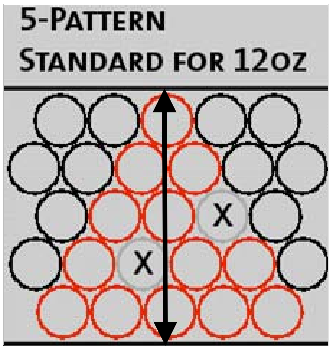


Figure 14 - 5-Pattern Standard Packing for 12 oz.

$$RAIL\_SPACING = ((BOTTLE\_WIDTH * QTY) + 1'') * Cos(30\deg)$$

(Eqn. 3)

This equation, in combination with the average width of a B&J bottle (approximately 2.515 inches) yields rail spacing values based on bottle quantity listed in Table 2.

Bottle Quantity (# of Bottles)	Rail Spacing (inches)
6	13.9343
5	11.7563
4	9.5782
3	7.4001
2	5.2221
1	≈ 2.6500

Table 2 - Rail Spacing Based on Bottle Quantity

4.5 Initial Observations

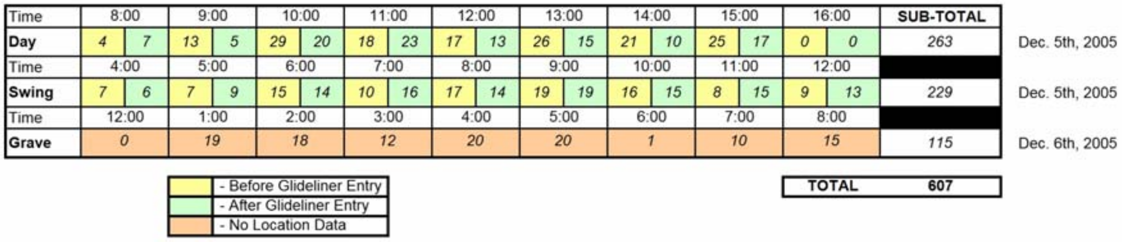
As was discussed in chapter 3.1, the first few weeks at Gallo were spent watching the line. During this time contact was made with operators, engineers, and maintenance personnel who were involved directly with working on Line 11 to get a better understanding of how the line was currently performing. The contacts made in the first few weeks helped when it came time to begin erecting the new rails for the filler entry and the Glideliner area, as discussed in chapter 6.0.

The first observation made was the drastic change from the Krones method to the current “pressurized” system in place in the Glideliner area. This became the starting point for digging up historical data on the changes made to the line and reasons for those changes. While the data proved hard to find, many opinions were given from Gallo employees who remember Line 11 working with the Krones “pressureless” system. All the employees who clearly remember Line 11 running under the Krones method claimed the line ran perfectly.

Based on the initial observations of the line the area that was causing the most problems was not clear. The Glideliner was clearly not ejecting down bottles in the manner that it was intended but bottles did not seem to be falling in the Glideliner unless caused by down bottles that had entered the Glideliner from the Dosing areas. The configuration of the rails in the Glideliner did not allow for down bottles to eject below the rails as intended and caused increased pressure in some regions. To better discover the primary location where bottles were falling some down bottle data was taken on two separate occasions.

4.6 Down Bottle Data

The first set of down bottle data was taken December 5th and 6th, 2005 before arriving on-site (Figure 15). The survey was split into two sections for observation, a section before the Glideliner entry and one after the Glideliner entry. The graveyard shift data did not include any location information. The data from the December survey showed bottles were falling mostly before the entrance to the Glideliner. It was agreed that two location points was not enough to determine the primary area for fallen bottles so another survey was done on January 26th, 2006.



Time	8:00		9:00		10:00		11:00		12:00		13:00		14:00		15:00		16:00		SUB-TOTAL	
Day	4	7	13	5	29	20	18	23	17	13	26	15	21	10	25	17	0	0	263	Dec. 5th, 2005
Time	4:00		5:00		6:00		7:00		8:00		9:00		10:00		11:00		12:00			
Swing	7	6	7	9	15	14	10	16	17	14	19	19	16	15	8	15	9	13	229	Dec. 5th, 2005
Time	12:00		1:00		2:00		3:00		4:00		5:00		6:00		7:00		8:00			
Grave	0		19		18		12		20		20		1		10		15		115	Dec. 6th, 2005

🟨 - Before Glideliner Entry
🟩 - After Glideliner Entry
🟧 - No Location Data

TOTAL 607

Figure 15 - Down Bottle Data from December 5-6, 2005

For the second down bottle survey, three location points were taken to clearly show the area with the most down bottles (Figure 16). The locations included one area from the unloading section of the line to the entrance of the twist washer, another which included the portion from the exit of the twist washer up until the entry of the Glideliner, and the other from the entry of the Glideliner up to the filler. The survey was a success, showing the area from the Twist Washer to the Glideliner having the most down bottles. The total test time was 338 minutes with a total of 101 minutes of downtime. While 52 minutes of downtime was planned, 49 minutes was not. Not all the 49 minutes of downtime was caused by downed bottles but a good amount of it was, including one instance in particular where two bottles got stuck directly near the single file location and stopped the flow of bottles completely. One primary observation taken out of this survey was that a majority of bottles that fall cause other bottles to fall. It is a rare event when a bottle falls and does not cause more to fall later down the line. The Glideliner is a perfect example of this. The majority of down bottles that enter the Glideliner cause other bottles to fall over as a result; most of the 28 down bottles listed in Figure 16 are a result of other down bottles coming from the Dosing areas and causing more to fall in the Glideliner.

Time	9:00	10:00	11:00	12:00	13:00	14:00	**SUB-TOTAL**
Unloader to Twist Washer	10	40	21	5	4	8	*88*
Twist Washer to Glideliner	9	70	5	5	7	6	*102*
Glideliner to Filler	8	8	1	9	1	1	*28*
						TOTAL	**218**

Figure 16 - Down Bottle Data from January 26, 2006

While the area leading up to the Twist Washer had many down bottles, they were taken care of properly before arriving at a single file location. The slow nature of the conveyor sections leading up to the Twist Washer and the length allow for more opportunities to eject down bottles. As previously stated the approach for this project was to remove down bottles that had fallen, not attack the root cause of the problem, however if root cause was found it would be looked into to help with future projects. The root cause was determined with this survey to be the exit of the twist washers and the conveyor belts and rails contained in that area. A video was taken of the twist washer exit and handed on to the project liaison to create a full package of data for whoever continues work on the project. There was also investigation into the bottle traps currently installed on the line to ensure they were in proper working order.

4.7 Bottle Trap Videos

With the use of high-speed cameras, video analysis was conducted on each of the two bottle traps currently installed on the line. Both traps were proved to work sufficiently, particularly the trap found directly before the wall. There was speculation about whether the traps were doing what they were supposed to and this video analysis cleared any speculations. It was later determined the trap found directly before the filler handled the bottles in too rough a manner and was removed.

4.8 Twist Washer Exit Video

On completion of the project another video analysis was done on the exit of the twist washer to help in documenting the root cause of the down bottle problem on Line 11. The video was setup directly above the bottles on one of the supporting structures for the rails in this area to get a top view of both exits for the twist washer. The video documentation ran for one shift and the tape was handed on to the liaison for the project to ensure placement into the proper hands if the project was going to be continued later.

Chapter 5.0 – Design Concepts and Reviews

This chapter provides an outline of the design concepts developed during the first half of the project and the design reviews that followed. The design concepts were developed based on background research completed while off-site; the plant visits were the primary influence on the design concepts. The design reviews were scheduled meetings with the Gallo liaisons, project team members, and the WPI advisor to decide the direction of the project and to evaluate the concepts created. These reviews helped keep the focus of the project and address any unanswered questions about the progress of the project.

5.1 Design Concepts

A series of design concepts were developed based on the background research completed off-site. While these methods may not have been carried out they were important to the design process to brainstorm and create discussion of possible methods to solve the problem. Many proved later to be inappropriate for the situation on Line 11; however some are still valid designs that could easily be carried through the rest of the design phase to become a probable solution. The concepts can be viewed in detail in Appendix H.

5.1.1 "Neck Pincher" Method

This concept was developed after a discussion with the WPI advisor during a PQP meeting on November 8th, 2005. There was discussion of a patent found on air conveyors and about the air conveyors witnessed at the Polar Beverages bottling plant. The idea involved a redesign of the Glideliner area and replaces the conveyors with a mechanism that would hold the bottle by the neck for conveying. The concept

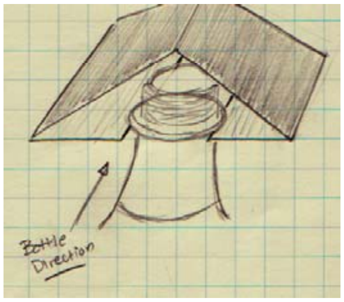


Figure 17 - "Neck Pincher" Method

would provide for a foolproof down bottle trap by not accepting downed bottles onto the conveyor because of their orientation. Shown above in Figure 17 is the proposed concept.

5.1.2 Active Down Bottle Rejection Mechanism

With all the passive devices that are used to eject down bottles the thought of an active mechanism was created to provide a different approach. The active mechanism would use the photo eyes and sensors currently installed on the line to find out when a down bottle is present. With the proper timing based on conveyor speeds the mechanism would be triggered to actively push the down bottle out the path of motion. The mechanism could be anything from a linkage to a cam type of application to ensure the bottle is ejected cleanly without causing more problems with the flow. The only concern with this concept is the speed in which the mechanism would have to run. The mechanism would need to be configured to creep slowly towards the bottle and then quickly but gradually contact the bottle to ensure the bottle is not broken during the process. Shown below in Figure 18 is the proposed concept.

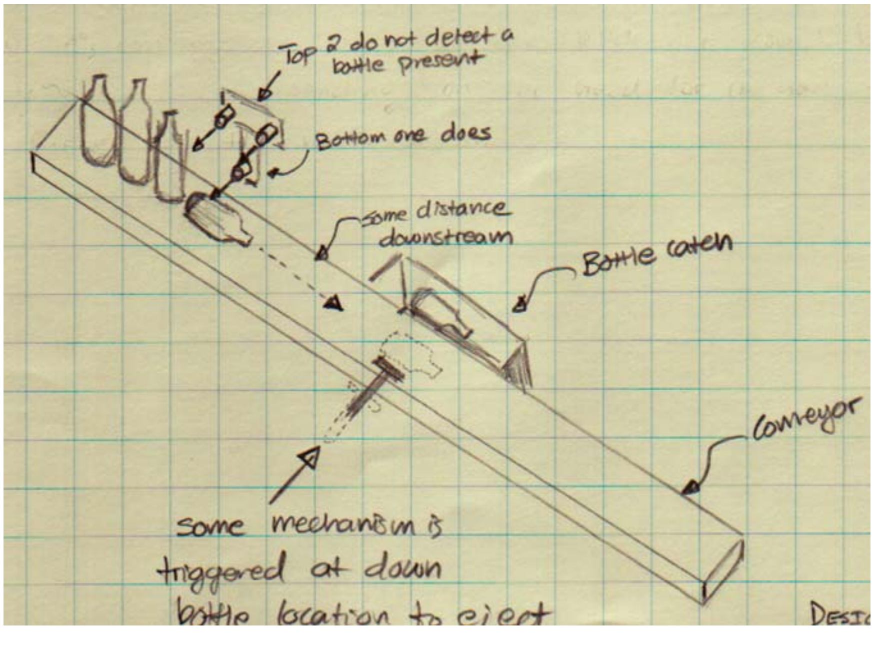


Figure 18 - Active Down Bottle Rejection Mechanism

5.1.3 Steep Curve Fix Method

The steep curve fix method was developed after witnessing the necking process of glass beer bottles at the Anheuser Busch bottling plant in Merrimack, NH. On completion of the necking process bottles are passes from conveyor belt to conveyor belt to ensure gaps are closed and pass through down bottle traps to remove misaligned bottles. During this time a more abrupt change over could be performed with clearance under the rail to allow a down bottle to pass through. Because of the orientation of a down bottle passing through the rails leading up to where this steep curve would be it would be possible for the down bottle to eject straight off the path of motion. The only concern with this concept is how the vibrations would be controlled as the bottles are passed through this segment. Increased vibrations were witnessed in the down bottle trap directly before the filler where bottles were transferred to another conveyor chain abruptly so the concept would need to be studied before implementation could be completed. Shown below in Figure 19 is the proposed concept.

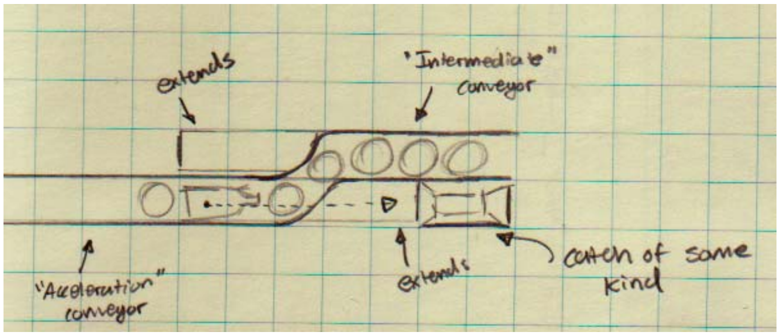


Figure 19 - Steep Curve Fix Method

5.1.4 Angle Ejector Method

The angle ejector method was developed after a discussion with Chris Crowley of Polar Beverages about how the New York division handles ejecting down bottles. He had mentioned they tilt their conveyors at an angle much like the Glideliner to allow bottles to roll off the lip and out of the path of motion. Granted the New York facility no longer bottles glass and are using plastic but the concept can still apply to the B&J glass bottle. The concept would involve tilting the conveyors during the single file portion before the filler at an angle and providing enough clearance under the rail with no rail at the higher portion of the slope. This would allow bottles to eject underneath the rail and roll off the top portion of the slant if the orientation of the bottle provided for it. If instabilities were developed in bottles not having the second rail installed it could be set up and rely solely on the bottles rolling under the bottom rail and out of the path of motion. The only concern with this concept is if the backpressure was too great in the area the bottle may become pinched and not roll out of the path of motion. This could be fixed by implementing this concept with the active down bottle mechanism to help push the down bottles out to ensure ejection. Shown below in Figure 20 is the proposed concept.

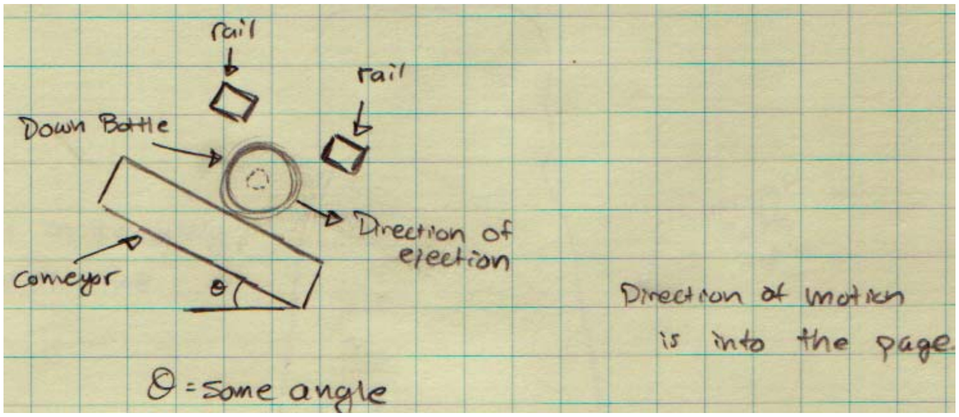


Figure 20 - Angle Ejector Method

5.2 Design Reviews

The design reviews were scheduled for the first few weeks of the on-site work to ensure focus was kept throughout the beginning of the project and the proper track was taken to solve the problem. The design reviews were scheduled a little more then a week apart to ensure time was given to adjust project focus and prepare for the second review. Agendas of the design reviews can be found in Appendix I.

5.2.1 Design Review #1

The first design review was held on January 17th, 2006, about a week after arriving on-site at Gallo. This review was held to ensure the transition from off-site to on-site was as smooth as possible and discuss the design concepts that were developed during the background research. The contacts that were made and contacts that should be made were discussed, mainly the maintenance team leaders and how it was important to meet with them. Names such as Carl Bennet, Henry Swisegood, Ron Lopez, and Loel Peters were discussed and their related experience with Line 11. Some new concepts were discussed and developed during the review; one in particular was Mike Delikowski's idea on how to use an active mechanism to reject bottles. It involved using a weighted mechanism such as a spring instead of a complicated electrical system and larger mechanism to perform the ejection. The scope of the project was also discussed and possible routes were evaluated. By the end of the review it became clear the project was going to switch focus to involve addressing maintenance issues through small changes to current concepts. It was decided at the end of the review that observation of the line would continue and as much data collection would be completed and refining design concepts for the next review.

5.2.2 Design Review #2

The second design review was held on January 27th, 2006. During the time from the first review to the second most data had been collected including data from the down bottle survey held on January 26th. It was also decided from this down bottle survey that bottles do not particularly fall at the Glideliner, they only fall in the Glideliner because of down bottles coming into the Glideliner from the Dosing areas. This design review was the starting point for the refocus of the project towards addressing maintenance related issues as opposed to gutting the Glideliner and moving towards a new method. It was determined this would be a better approach both from a cost standpoint for Gallo and an implementation standpoint from the WPI team. With the time frame on the project and the resources available implementation would only take place if a smaller scale design was developed and applied to a specific area in the line. From this point on efforts were focused on preparing an inexpensive and easily installed device to reduce the vibrations before the filler and keep down bottles from arriving in the filler auger.

Chapter 6.0 – Design of New Rails

This chapter outlines the design and production of the newly installed rails directly before the filler entry and documenting the design of the Glideliner area rails. With the time constraints of the project the Glideliner rails were unable to be installed by the end of the time spent in Modesto, however a design plan was left to be installed shortly after completion of the project. The rails before the filler were installed on February 25th, 2006, a few weeks before the end of the project and have been reported to be working well.

6.1 Design Rationale

To ensure installing new rails will provide an improvement to the bottle flow a rationale for each installation needed to be developed. Both designs were developed from watching other processes at Gallo similar to the ones in place on Line 11 and adapted to fit the application.

6.1.1 Pre-Filler Rails

Figure 21 - Down Bottle Trap before Filler

The primary objective in redesigning the pre-filler rails was to remove the rough handling of the bottles in this area. The area exhibited large vibrations of the bottles and a tremendous amount of noise because of an abrupt conveyor belt change directly at the down bottle trap. Shown in Figure 21 is the old method with the bottle trap in place. Notice the thin rail on the left hand side of the path of bottles. This is where the vibration was created and the primary cause for increased noise. When designing new rails for this area, the trap was removed and the path of the bottles was smoothed out by making a more gradual rail bend. The rail bend shown in Figure 22 is directly before the wall, just upstream of the bottle trap area shown in Figure 21. This area does not exhibit bottle vibrations.


Figure 22 - Rail Bend before Wall and Filler

To help reduce the vibrations, a larger rail stock was used to allow for more rail contact on the bottles. The height of the rail off the conveyor chain was also decreased to contact more of the flat portion of the bottle instead of contacting the tapered upper section of the neck. A slot was cut for the down bottle sensor and a hole for the photo-eye found directly before the wall to ensure both sensors were still working. To minimize the amount of rail connections, a new rail was bent to stretch from the wall straight into the filler entry.

6.1.2 Glideliner Rails

With all the changes the Glideliner area has gone through in the past years a new design had to be chosen carefully to ensure previous flaws were not carried over into the new concept. It was decided that for the new design a pressurized system would remain intact to limit the changes needed to be made. To provide a more gradual necking process and optimize the pressure distribution a straight taper concept was developed. This taper was based on the rail spacing arrangement found in the Dosing area leading up to the Glideliner. The packing factor analysis from section 4.4 was applied to the new rail configuration.

One of the original flaws with the Glideliner was during the install of the mechanism; this was because of the lack of space in the footprint of the line. Krones wanted more space for the Glideliner and


Figure 23 - Glideliner Widening Area

Gallo was unable to give it to them so Krones had to work with the room they had. This caused a shorter necking process and led to more problems after setting up the pressurized system. The proposed new design uses the entire area for the necking process and removes widening five bottles across to nine (Figure 23), which was contributing to the abnormal pressure distributions. The current Glideliner rails had also started to sag vertically, removing the opportunity to eject down bottles in the area by allowing them to pass under the rail, one of the original benefits of using the Glideliner. With the newly designed rails the distance between the conveyor chain and the bottom of the rail has been optimized to allow the proper spacing for down bottles to roll out of the flow of bottles. Shown in Figure 24 is a graph depicting the normal distances between the rails vs. the distance in the x-direction along the conveyors for the current Glideliner setup.

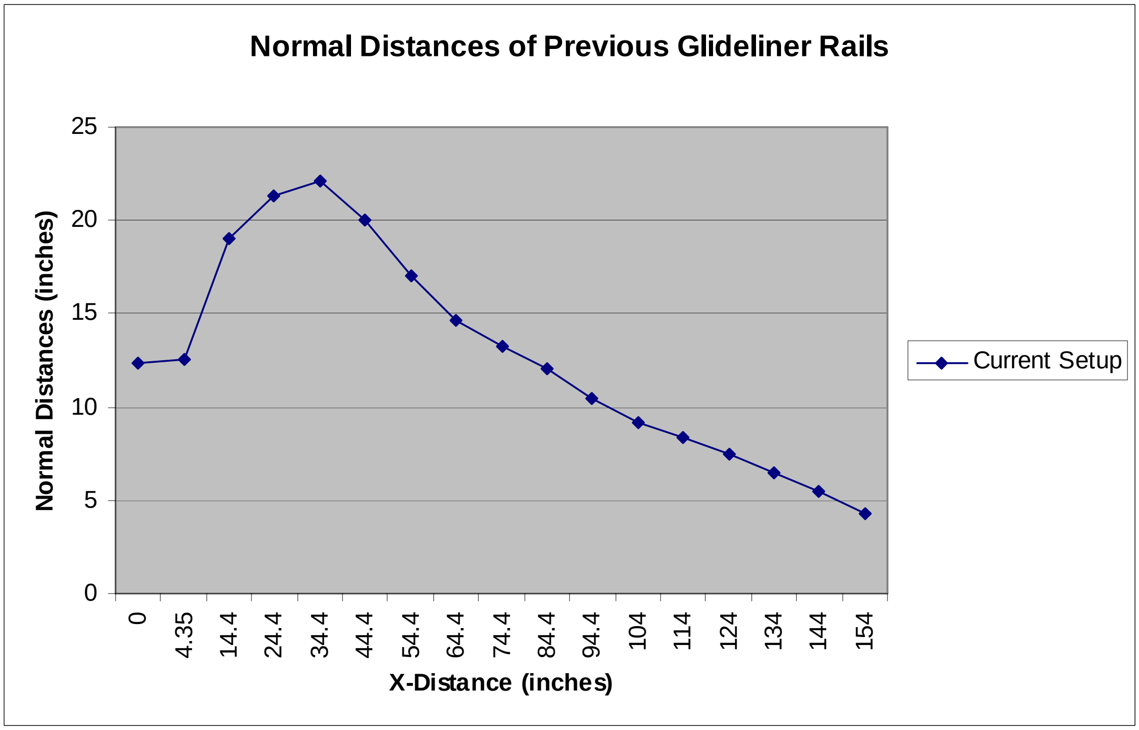


Figure 24 - Normal Distances of Previous Glideliner Rails

6.2 CAD Models and Drawings

As stated previously all concepts were developed in 3D using the CAD package ProEngineer Wildfire 2. Shown below in Figure 25 is the CAD model developed for

Line 11 from the Glideliner area up until the filler entry. In the following sections each of the CAD models are displayed, scaled drawings can be found in Appendix J.

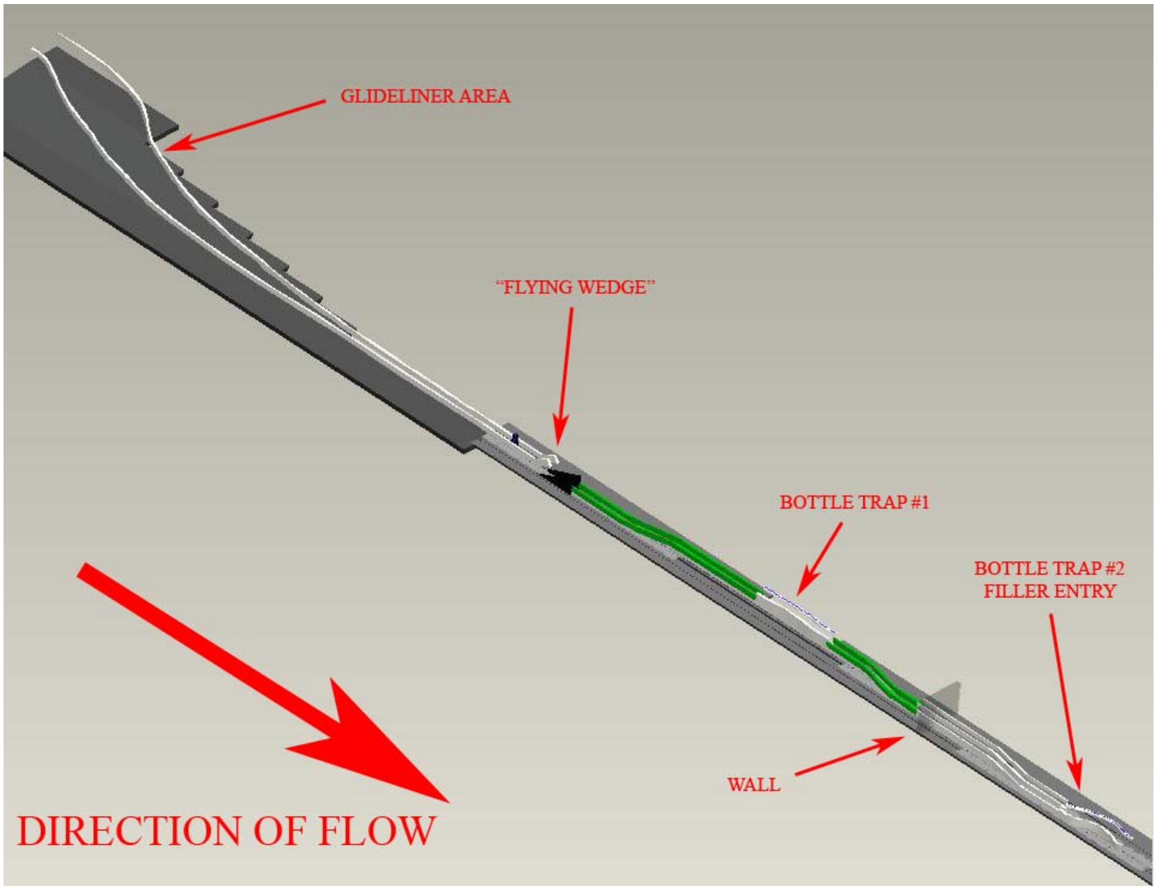


Figure 25 - CAD Model of Glideliner to Filler Entry

6.2.1 Pre-Filler Rails

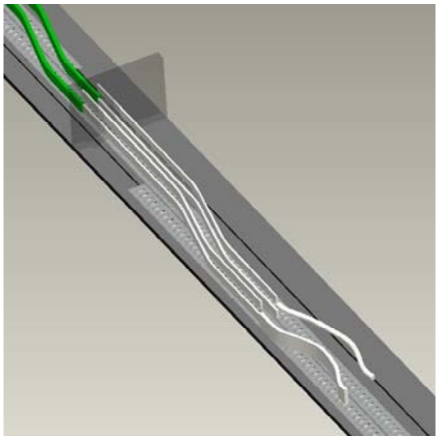


Figure 26 - Existing Rails with Bottle Trap

The pre-filler rails were the first to be modeled after completing a model of the entire line from the entry into the Glideliner up to the filler. Shown in Figure 26 is the before CAD model of the pre-filler area with the bottle trap in place. Modeling was carried up through the bottle trap and stopped directly before the entry into the filler. Once the proper configuration of the new rails was determined a few iterations of the design were done in CAD to ensure the bend was as smooth as possible. The red rail shown in Figure 27 is the final design that was implemented on the line near completing the project.

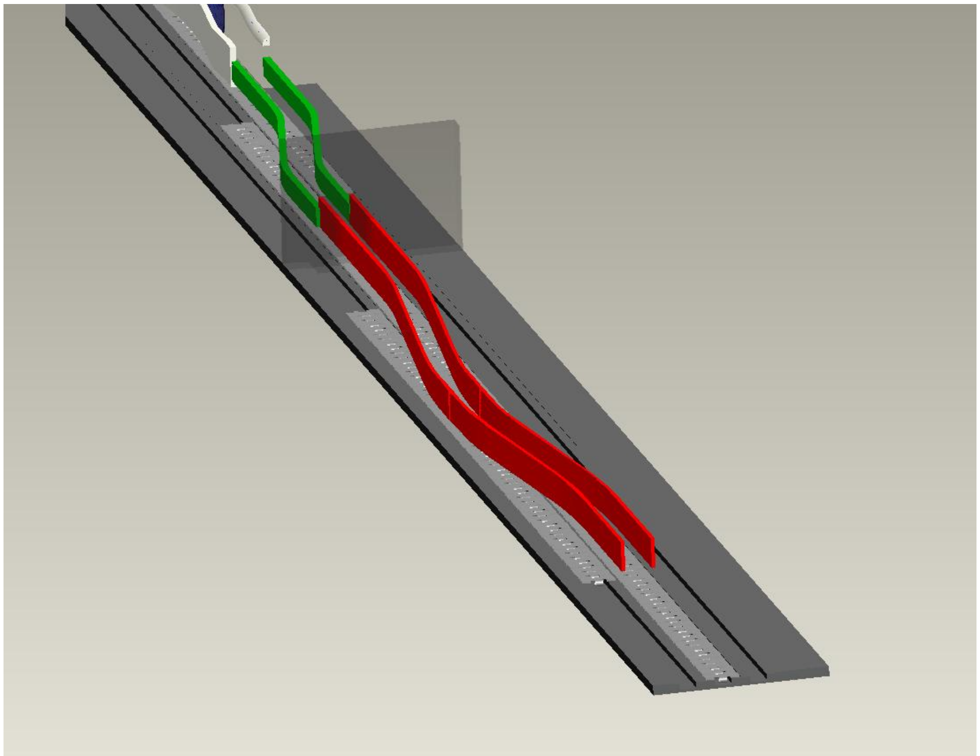


Figure 27 - Proposed Pre-Filler Rails

6.2.2 Glideliner Rails

The Glideliner section proved to be a little more complex than the pre-filler rail model. With the rails passing through the flat portion of the entry into the Glideliner and then into the angled portion some thought needed to be taken on how to approach modeling this section. The existing rails were modeled by measuring perpendicular distances from a flat surface at the bottom of the Glideliner every 20 centimeters. These

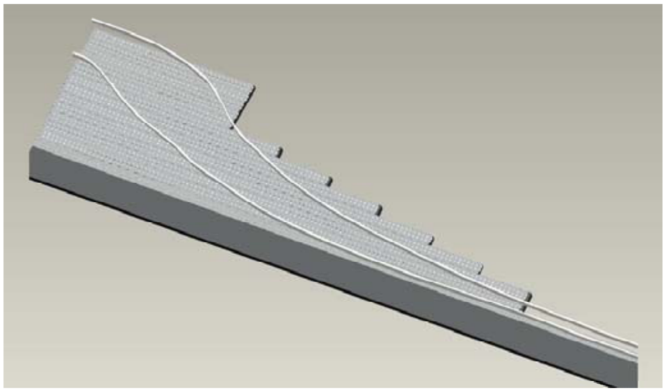


Figure 28 - Current Glideliner Rail Orientation

points were plotted and a spline curve was then fit to the points to get the proper curve of the rails. The rail curves shown in Figure 28 do not appear to be smooth because of the spacing of location points taken but the general form of the Glideliner rails was obtained. On completion of the current Glideliner rails, models of the proposed Glideliner rails were developed by removing the spline curves and replacing them with straight lines, tapering down to the single file portion. Entry rounds were also added to the rails to ensure a smooth transition from the Dosing area into the Glideliner and from the Glideliner into the single file area. Shown in Figure 29 are the proposed Glideliner rails. Figure 30 shows a graph of the normal distances between the rails in the proposal and the old Glideliner rail setup vs. the distance in the x-direction starting at the entry of the Glideliner until the single file portion. Notice the drastic change in distances between the proposed method and the rail orientation currently in use.

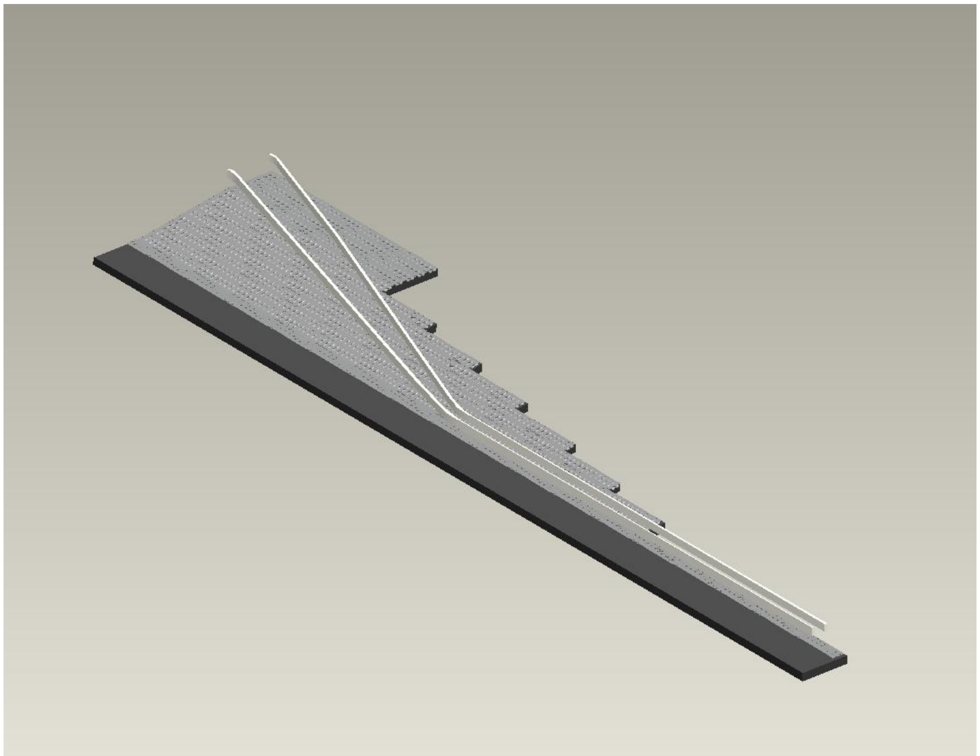


Figure 29 - Proposed Glideliner Rails

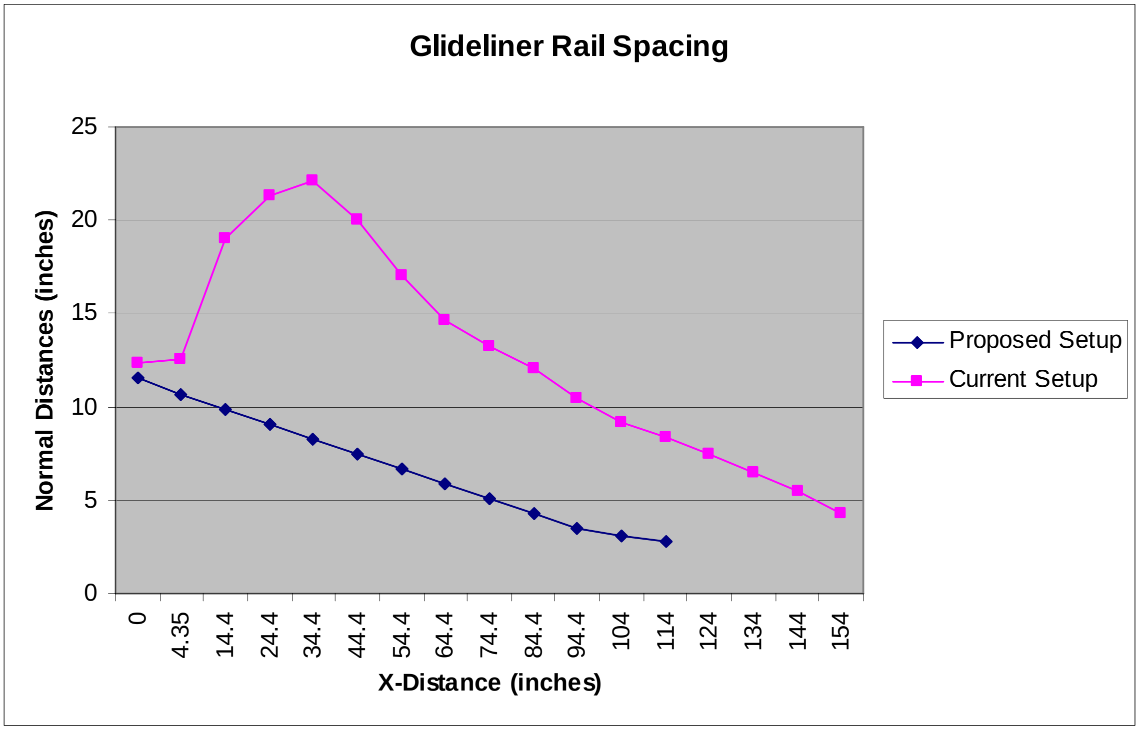


Figure 30 - Normal Distances of Glideliner Rail Proposal vs. Old Rail Setup

6.3 Implementation

The project was fortunate enough to have completed the design for the pre-filler rails before a weeklong routine maintenance session was being conducted on the line. During this time areas before the twist washer were being addressed and the pre-filler rails were added to the weeklong work. This involved working closely with the contractors performing the maintenance and ensuring the installation was successful. Some attention needed to be paid in the area during the install because of the two sensors that are found in and around the rails that control filler speed and trigger the bottle stop in the event of a down bottle. With the rails built they were installed using the existing mounting hardware and a hole and slot were cut out for the photo eye and mechanical down bottle sensor, respectively. The installed rails can be seen in Figure 31.

Figure 31 - Installation of New Pre-Filler Rails

6.4 Results

After installing the pre-filler rails, some time was spent observing how the new rails handle the bottles. Operators reported reduced vibrations and noise in the area and after completion of the project reports continued on the reduction. There have been reports of down bottles still arriving in the filler auger however. To address this problem it has been suggested that the mechanical sensor that detects down bottles be moved to a location before the wall since it is not triggering the bottle stop early enough on the event of a down bottle making it into the new rails. Another suggestion is to slot out an area at the bottom of the rail near where the old bottle trap used to be in an attempt to eject downed bottles in the case the bottle stop is not triggered soon enough.

Drawings of the proposed new Glideliner rails were sent to Gallo and the configuration of the rails was discussed with their engineers to ensure the installation is as smooth and successful as possible.

Chapter 7.0 – Conclusions and Recommendations

The objectives of this project were to reduce downtime caused by down bottles arriving in or before the filler and to reduce vibrations and noise directly before the filler entry. This was carried out through completing thorough background research to gain an understanding of the bottling process along with testing and analysis of the current situations experienced on the line. This included a down bottle survey, friction, and center of gravity analysis. These efforts lead to designing and installing a new pre-filler rail and a proposal for a new rail system for the Glideliner area.

7.1 Conclusions

Through extensive background research and analysis of the current process a baseline understanding of the process was developed to help determine a proper approach for the down bottle problem. When arriving on-site data collection was immediately started to ensure the problem was narrowed down within the first few weeks of being on-site. This lead to an understanding of the primary location for concern, the area contained from the Glideliner to the filler entry.

With the project focus defined, design concepts and methods were derived based on the data collection and analysis. Vibrations and increased noise in the pre-filler area was the first area to be addressed with a new rail system. This new rail system was implemented to remove the down bottle trap directly before the filler that was causing all the vibrations and noise and possibly contributing to the down bottle problem in the filler auger. During a weeklong routine maintenance session the pre-filler rails were installed with the help of Gallo contractors and the maintenance team leaders. These rails proved immediately to reduce vibration and noise. However, down bottles continued to arrive misaligned in the filler auger.

The second area of concern was the Glideliner area, in particular its rail orientation and design. A new rail design was developed based on an equation used for perpendicular rail spacing that was used in the dosing areas leading up to the Glideliner. A straight-line taper method was applied to this design to develop a design for two new rails that would try to reduce the number of down bottles passing completely through the

Glideliner. With increased vertical spacing between the conveyor chain and the proposed rails, bottle ejection will again be possible in this area. Also with the redesign comes better pressure distributions based on spacing the new rails to help reduce the number of bottles pushing out the top of the flow because of abnormally high-pressure distributions. The design of these rails was handed on to Gallo on completion of the project and implementation of the rails was scheduled to take place shortly after the completion of the WPI project. Drawing reviews were held with the project team and Gallo engineers to wrap up the design before implementation.

With the methods discussed here and the recommendations in the following chapter the project team is confident the down time because of down bottles issue will be resolved in a timely manner. Application of these concepts and methods will also result in a lower scrap rate for the line, limiting the rework needed. All the objectives put forth to the project team were completed during the eight-week time frame given for the project and positive feedback was received from operators of Line 11.

7.2 Recommendations

On completion of the project two formal recommendations were proposed to Gallo during the final presentation. One approach involved keeping the Glideliner pressurized system intact while the other was to revert back to a pressureless system and use the recommendations put forth by Krones. Two separate methods were proposed, both different from each other, to allow Gallo to evaluate the cost-benefit of each. With root cause being determined within the final weeks on-site a recommendation is also being made to address the occurrence of down bottles at the exit of the twist washer.

7.2.1 Pressurized System

The least expensive of the two proposals is to keep the Glideliner as a pressurized system. The newly designed rails would be built in-house and installed using Gallo contractors or maintenance personnel. The most expensive portion of this method would be the labor cost for the installation. Current rail stock could be used with current mounting hardware. The opportunity arises to replace the mounting hardware with a sturdier setup but is not needed to provide functionality for the new rails. One aspect that needs to be paid closed attention to is the rail height off the conveyor belt. It is important that proper spacing is achieved to allow the Glideliner to act as an ejection mechanism. Failure to do so will result in a small improvement over the current system and not resolve any problems downstream of the Glideliner.

7.2.2 Pressureless System

The more complicated and expensive method is to revert the Glideliner back to a pressureless system based on Krones' recommendation. This would require a Krones technician to be on-site for a minimum of two days tuning and testing the line. It would also require maintenance issues such as loose support bars to be tightened, lubrication optimization, replacement of wear strips under conveyor chain, and close examination of all conveyor chain links to ensure no bumps or abrasions. Verification of all controls and sensors in the area would also be conducted to ensure the LCT-3 controller on the line is performing as intended. With all maintenance issues addressed the weighted rail would be reinstalled, either with the old rail (if found) or a new weighted rail would need to be bought. Tuning would need to be made with the line running to ensure proper setup and orientation of the limit switches found near the end of the necking process. This method would require training of maintenance personnel to ensure understanding was developed between Krones and Gallo on how to address maintenance issues in the area. This would help prevent any further issues such as those experienced in the past with a large number of down bottles in the Glideliner. It is felt that using this method would prove to be the most beneficial based on the opinions of Gallo employees about how the line ran as a pressureless system.

7.2.3 Root Cause

With root cause discovered during the last two weeks of on-site project work it is being strongly recommended to Gallo that this area be addressed. The exit of the twist washer was determined to be the root cause of the down bottle problem because of colliding adjacent bottles during conveyor belt changes. Methods were discussed with the Gallo liaisons on how to address the issue. One method would be to add a snake (weighted rail), much like the one used in the old Glideliner method, to keep bottles better constrained during exit of the twist washer. The other method would be to decide the ideal speeds of each conveyor during the entrance into the Dosing areas and adjust the sprockets accordingly. With the current speeds it seems to provide for jerky motions in the bottles as they change from belt to belt at varying speeds. There also was another observation on the current rail setup near the exit of the twist washer. The rails currently constraining the bottles during exit have two separate hole sets drilled into the support structure to allow repositioning of the rails. The other hole set could be trialed to discover if the problem is decreased.

7.2.4 Pre-Filler Adjustments

With the continuing problem of misaligned bottles arriving in the auger there has been contact with Gallo in an attempt to resolve the issue. It has been recommended that the down bottle sensor at the beginning of the new rail install be relocated. Another possible solution would be to slot out an area near the where the old trap was to allow misaligned bottles to eject. Moving the sensors would provide the most benefit due to the current stopping time needed by the filler while running at speeds over 1000 bottles per minute. The sensor would need to be relocated before the wall on the line but after the down bottle trap to ensure proper detection.

Based on the recommendations put forth by the project team Gallo has already started to implement the concepts in hope of resolving the down bottle issue on Line 11. Shown in Figure 32 is the installed snake near the twist washer exit. They are in the process of determining the benefit of this installation. Word has been received the rails still need some adjustments to decrease the down bottles as a significant number of down bottles are

Figure 32 - Twist Washer Exit Snake

still arriving in the Glideliner area. It has also been determined that Gallo will be installing the proposed Glideliner rails within the next two weeks. Reports of the pre-filler rails reducing vibrations and noise have also been received. Gallo will also evaluate the possibility of moving the down bottle sensor in this area further upstream. This would allow more time for the filler to stop in the event of a down bottle arriving in the pre-filler rails.

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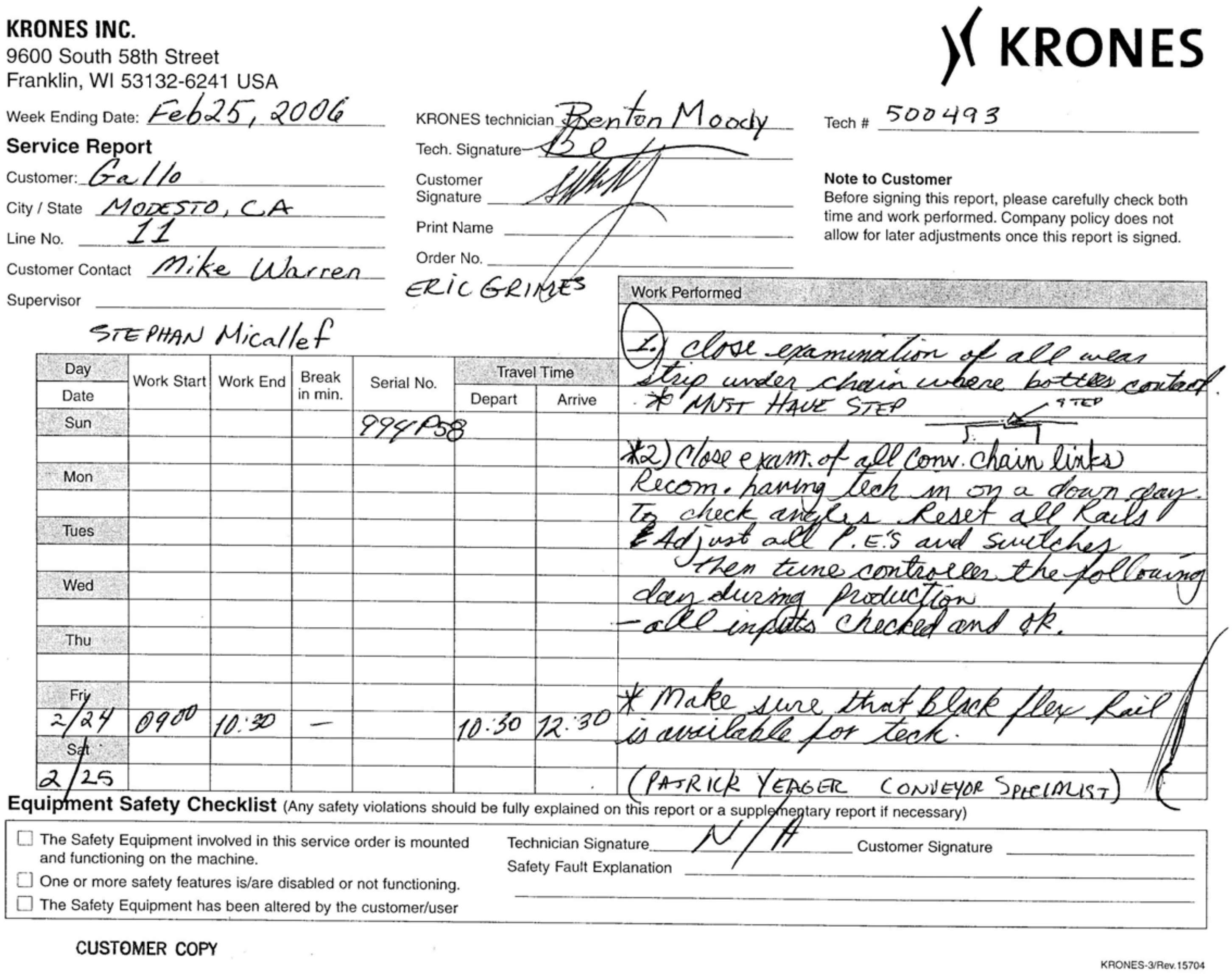
Appendices

Appendix A

Krones Visit Documentation



KRONES INC.
9600 South 58th Street
Franklin, WI 53132-6241 USA

KRONES

Week Ending Date: Feb25, 2006

Service Report

Customer: Gallo
City / State MODESTO, CA
Line No. 11
Customer Contact Mike Warren
Supervisor STEPHAN Micallef

KRONES technician Benton Moody
Tech. Signature
Customer Signature
Print Name
Order No.
ERIC GRIMES

Tech # 500493

Note to Customer
Before signing this report, please carefully check both time and work performed. Company policy does not allow for later adjustments once this report is signed.

Day Date	Work Start	Work End	Break in min.	Serial No.	Travel Time Depart	Travel Time Arrive
Sun				994P58		
Mon						
Tues						
Wed						
Thu						
Fri 2/24	0900	10:30	—		10:30	12:30
Sat 2/25						

Work Performed

1.) close examination of all wear strip under chain where bottles contact.
* MUST HAVE STEP
STEP

*2) Close exam. of all Conv. chain links
Recom. having tech in on a down day. To check angles Reset all Rails & Adjust all P.E'S and switches then tune controller the following day during production
- all inputs checked and ok.

* Make sure that black flex Rail is available for tech.

(PATRICK YEAGER CONVEYOR SPECIALIST)

Equipment Safety Checklist (Any safety violations should be fully explained on this report or a supplementary report if necessary)

☐ The Safety Equipment involved in this service order is mounted and functioning on the machine.
☐ One or more safety features is/are disabled or not functioning.
☐ The Safety Equipment has been altered by the customer/user

Technician Signature N/A
Customer Signature
Safety Fault Explanation

CUSTOMER COPY

KRONES-3/Rev.15704

Figure 33 - Krones Visit Documentation

Appendix B

Trip Reports

- **Wachusett Bottling Plant**

Gallo Winery Project Center
ME – MQP C-Term 2006

Trip Report

Eric Grimes

Trip Date: Wednesday, November 16th

Company: Wachusett Brewery

Location: Westminster, MA

Purpose of Visit: To gain a better understanding of the processes required to bottle beverages on a small scale production line.

Summary:

Professor Ault and I met with Mr. Kevin Buckler (Founder / Plant Engineer) of the Wachusett Brewery in Westminster, MA. Our main focus was to observe how glass bottling is accomplished on a smaller scale.

Since the size of Wachusett is drastically smaller then Anheuser-Bush and Polar, the method used to bottle was quite different. The bottling room is quite small and uses modular conveyor belts so they can break down the line while they are not bottling to provide more room in the brewery. Attached with this trip report is a layout drawing sketched from observing the process. There you can see that the operation moves around in a circle, the bottles end up boxed just about where they are started as empties. A large rack of bottles on palettes are placed at the beginning of a large conveyor that takes bottles at palette wide width. The bottles are dragged off the top layer by a large square rack, much like a pool table rack, onto a moving bulk conveyor. Necking down to a single file occurs when the bottles move onto a conveyor moving perpendicular to the bulk conveyor and have a small funneling region where the bottles have about a foot to two feet of length to finish the necking process. Once on this conveyor the bottles are pushed using backpressure through a twist washer. Upon arriving at the other side they again move onto a conveyor moving perpendicular to the current direction and pass on towards the filler. Professor Ault noticed a small mechanical sensor shortly after the switch onto the perpendicular conveyor; we were told it is a switch to stop the upstream conveyor if the bottles back up to the location on the in feed to the filler. After this bottles are sent into the filler and then down another perpendicular line and into the labelers, where they can enter one of two labelers in operation. Once passing through this station they are sent on to be boxed and conveyed to an unloading location where the boxes are then delivered to another location for shipment.

One noticeable item was the conveyor links used in their bottling line were plastic, and very similar to those sent to me by Gallo Wineries of their conveyors upstream to the Glideliner. Wachusett claims there aren't too many down bottles, if they do observe down bottles it tends to be when the bottles exit the twist washer and are pushed down towards the filler but are usually caught by the operator that is in charge of manning the filler station. At time bottles can become pinched during the necking process before the twist washer and can cause problems but we were told these problems were not all too frequent, partially due to their relatively low bottling speeds of around 120 bottles per minute.

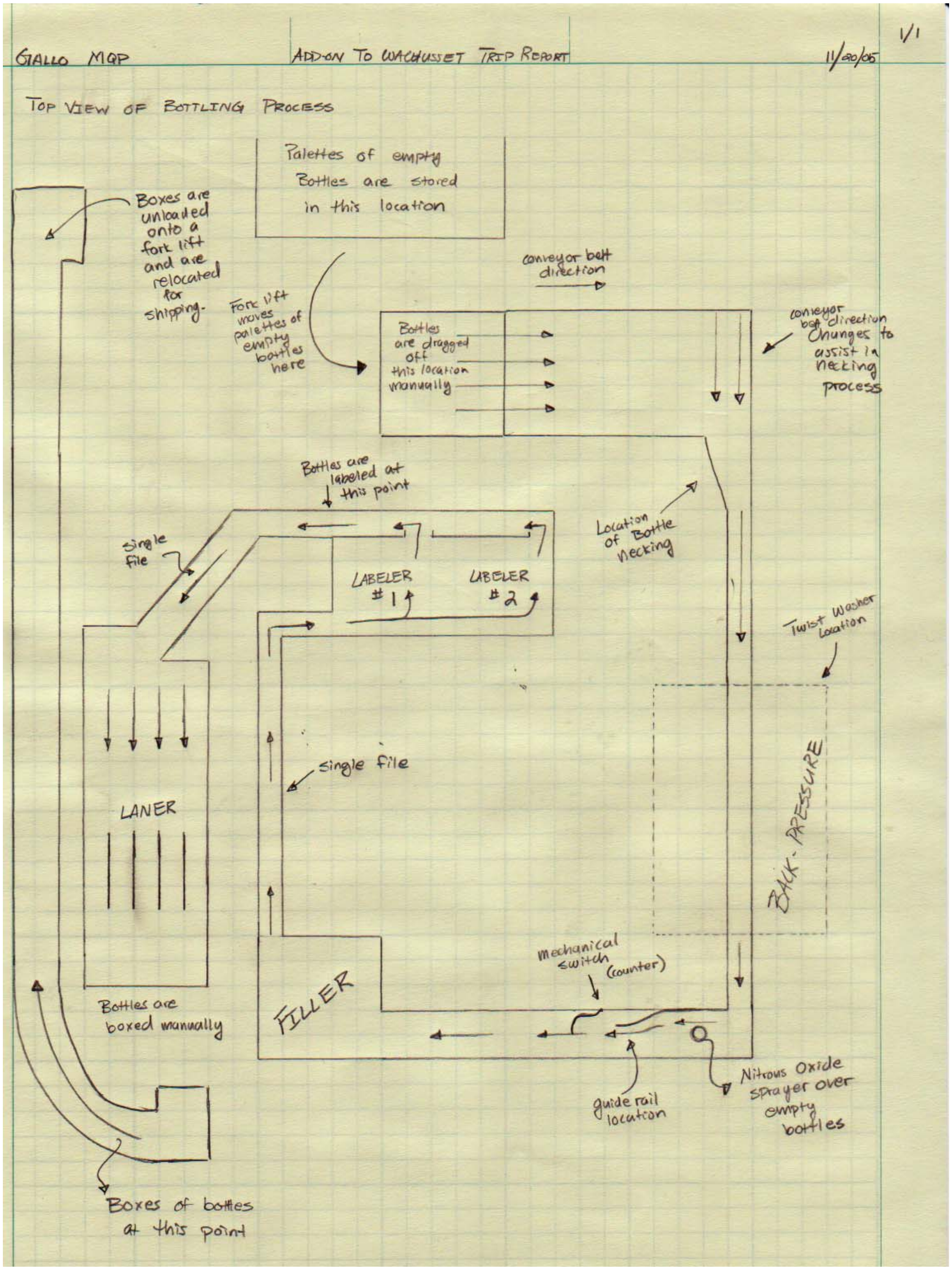


Figure 34 - Wachusett Bottling Facility Overall Layout

- **Polar Beverages Bottling Plant**

Gallo Winery Project Center
ME – MQP C-Term 2006

Trip Report

Eric Grimes

Trip Date: Thursday September 15th

Company: Polar Beverage Company

Location: Worcester, MA

Purpose of Visit: To gain a better understanding of the processes required to bottle beverages on a mass production scale.

Summary:

We met with Chris Crowley, Executive Vice President, who gave us a personal tour of the entire Polar Bottling facility. Saw from beginning to end the process of bottling plastic bottles, aluminum cans and water cooler jugs. Found that all actual bottling processes are completely automated, while the preparation and end-product are dependent on human interaction. The storage of palletized cans and bottles is accomplished with a forklift operator, and the loading of empty cans, bottles, and boxes requires also requires an operator.

Some key features we saw on the bottling line was the necking of plastic bottles from 6:1 and cans from pallet's width to 1. The use of compressed air aided the necking of bottles while the use of soap lubricated the cans, both cutting down on friction and saving energy. The maximum degree of reduction on the bottling lines was 7 degrees at any necking location. The use of rollers on the necking gates also cut down on friction while keeping the bottles stable.

Polar used high speed cameras to analyze the necking and capping processes in order to troubleshoot the problems they had in their line. The high capture rate of pictures allowed them to see things that the human eye could not possible pick up. For example the rate of capping cans is 1200 per minute; the camera was able take 12 images of each can.

Polar Beverages follows their own Good Manufacturing Practice Policy which complies with USFDA standards, we were given a copy of their policy.

Gallo Winery Project Center
ME – MQP C-Term 2006

Trip Report

Eric Grimes

Trip Date: Wednesday December 7th

Company: Polar Beverage Company

Location: Worcester, MA

Purpose of Visit: To gain a better understanding of the processes required to bottle beverages on a mass production scale.

Summary:

Professor Ault and I met with Chris Crowley, Executive Vice President, who gave us a personal tour of the Polar Bottling plant in Worcester, MA. The main focus of the trip was to obtain more detail of what was seen in a previous trip along with inquiring more about the process based on the knowledge obtained about the Gallo process over the past few weeks. Pictures and videos were taken of relevant processes.

There was on particular process that stood out during the discussion with Mr. Crowley about a method used at the New York bottling plant. Mr. Crowley explained it as a method of removing down bottles by leaving one of the side rails off and running the single file lane at an angle. This angle will somehow allow the down bottles to roll off the conveyor into some sort of trap while keeping the upright bottles in the correct orientation. Even after the trip in a discussion with Professor Ault we were unable to fully realize how the method would work but a concept drawing of what we think it is can be found in Figure 1 below. This method stemmed an idea which can be found documented in my design notebook (Page 71) on using a tilting conveyor in order to eject down bottles but in an opposite manner as discussed above.

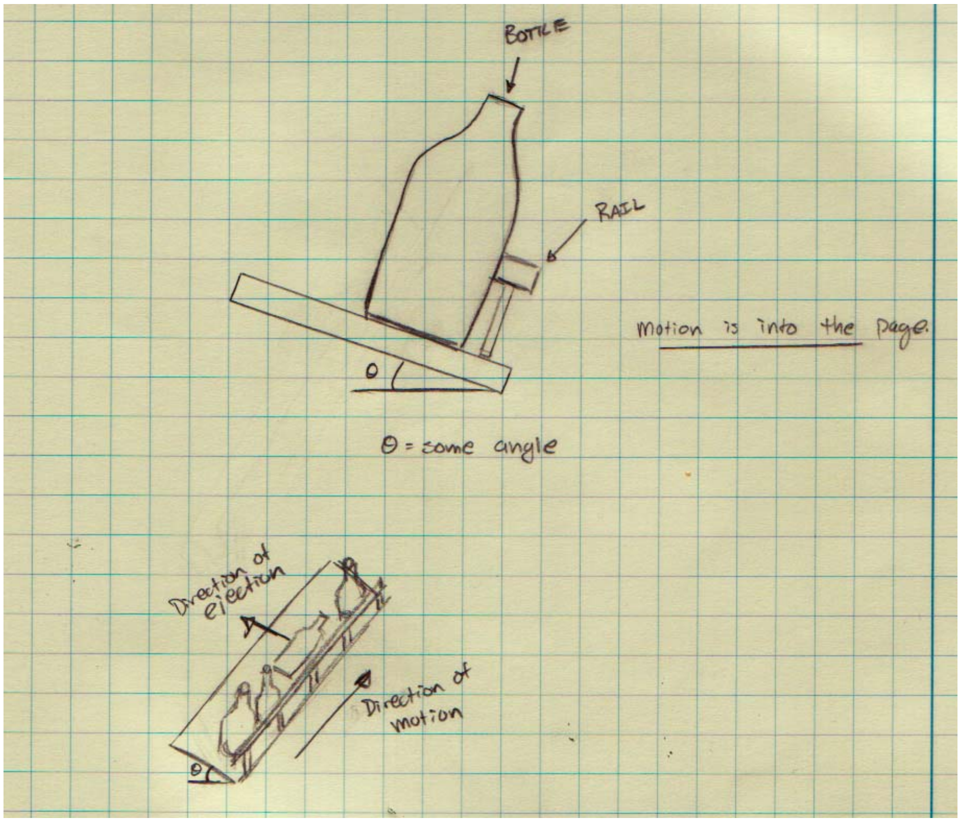


Figure 35 - Rail-Off Method

Another aspect that was looked at closely was the can ejection mechanism. While the difference between cans and glass bottles are quite significant the process was still analyzed in order to understand how other ejection mechanisms work. The can system used a pinching method which caused the can to eject out in-between the conveyor rails on the side of the can line. It would roll up and out, a picture can be found below of the area of ejection along with a video which can be found on the MyWPI website.

Figure 36 - Can Ejection Mechanism

When looking at one their necking processes for their 1 liter plastic bottles I noticed something similar to the Gallo process. Their conveyor belt speeds are similar where the bottom most conveyor belt where the bottles are at single file is slightly slower then the conveyor belt above it. You can see a picture of it in Figure 3 below. Originally I was unsure of the accuracy of the diagram Gallo had sent me sine I was under the impression that the bottom most conveyor belt would be moving the fastest out of all of them. This helped to understand better what Gallo is doing for their individual speeds.

Figure 37 - Necking Process of 1 Liter Plastic Bottles

We were able to get a close look at how an air conveyor works, in which the bottles are held by the neck while being conveyed by bursts of air. There is a concept drawn up using a method similar to this on Page 1 of my design notebook. This was definitely an interesting process to witness and it became fairly clear that if air was used to convey the objects then glass would most likely be too heavy. Also the bottles clang together quite a bit during the conveying process which could pose a problem using glass.

One of the major points that Mr. Crowley expressed was that keeping bottles as close together will help you prevent bottles from falling over. Everywhere in their process they try and keep the bottles packed as tightly as possible in order to prevent any tipping of the bottle. None of their conveyor belts are at an angle during the necking process which is different from the line under observation at the Gallo Wineries. Out of the places visited for the background research portion of this project all three places do not use an angle in their conveyors during their necking process. This creates a concern that perhaps the 9 degree angle of the Gallo conveyor is attributing to a lot of the down bottle problems.

- **Anheuser-Busch Bottling Plant**

Gallo Winery Project Center
ME – MQP C-Term 2006

Trip Report

Eric Grimes

Trip Date: Friday, October 14th

Company: Anheuser Busch Bottling Plant

Location: Merrimack, NH

Purpose of Visit: To gain a better understanding of the processes required to bottle beverages on a mass production scale.

Summary:

Professor Ault and I met with Mr. Joe Gaffen (Assistant Brew master) of the Anheuser Busch Bottling Plant in Merrimack, NH. Our main focus was to observe the necking process of their glass bottle line before the filling station.

Some observations included the usage of soap on the conveyor belt to keep the bottles moving smoothly along the line. Similar methods were used at the Polar plant in their can and plastic bottling lines. I also noticed the varying speeds in the strips of the conveyor belt which I'm assuming were used to keep the bottles necking properly down to a single file. The conveyor belt was 15 strips wide allowing for circumstances where the bottles may pile up and take longer to get into the single file line. The conveyor narrows every few feet, reducing around 2 or 3 strips at a time until it reaches a point where all the bottles are in a single file line at around 2 strips wide. At the beginning of the necking process a small spray of water is applied near the neck of the bottles to keep the bottles moist. There was a noticeable rotation in the bottles as they were necked down to a single file. Mr. Gaffen didn't seem to believe it had any effect on the necking process. After the necking process the bottles are filled at around 1200 bottles per minute.

Overall I felt Anheuser Busch's necking process was very well put together and seems to run flawlessly. I did notice some broken glass pieces farther along the process after the bottles had already been necked to a single file. They were located underneath the process near the mechanisms and in the catch for bottles on the side of the conveyor belt.

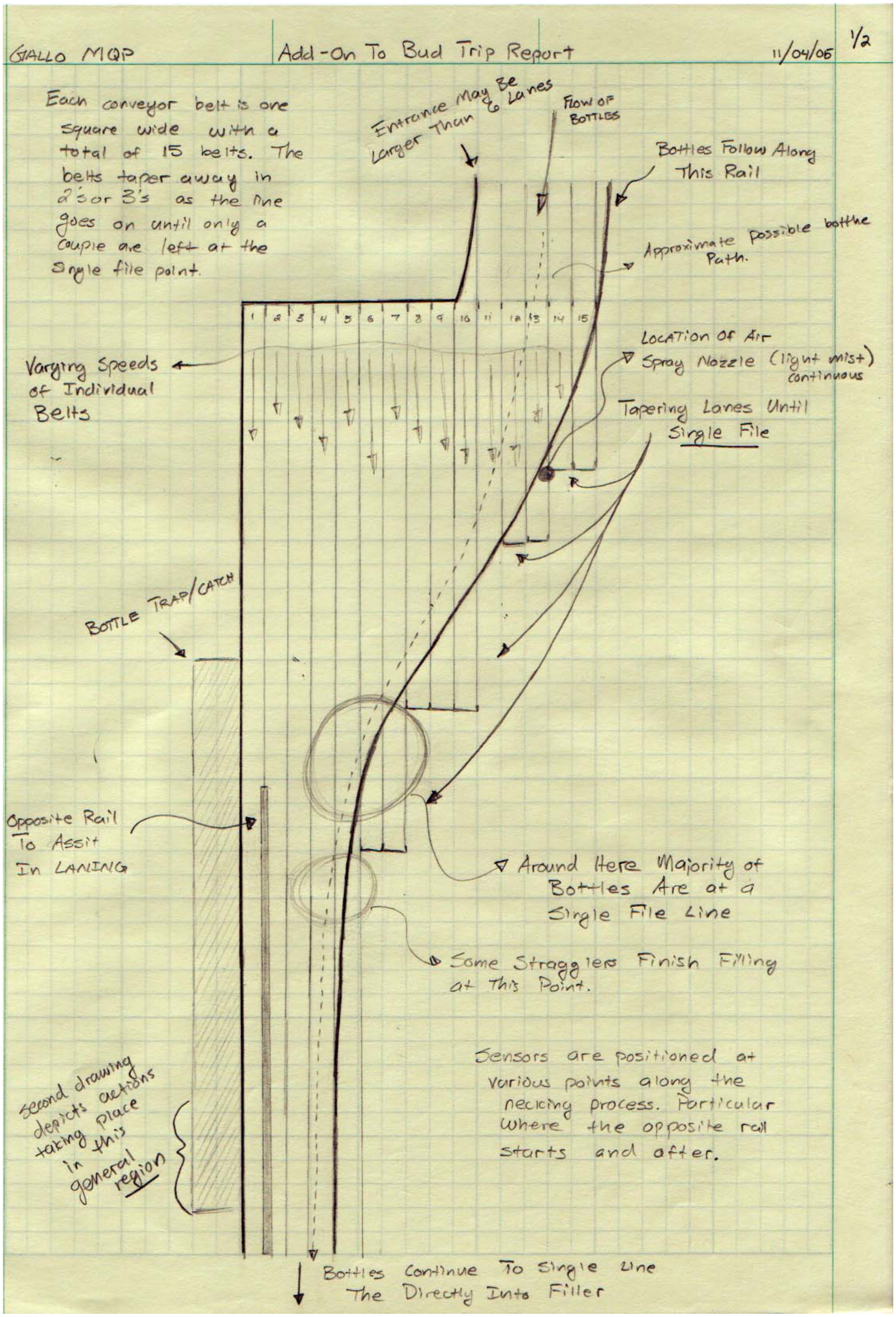
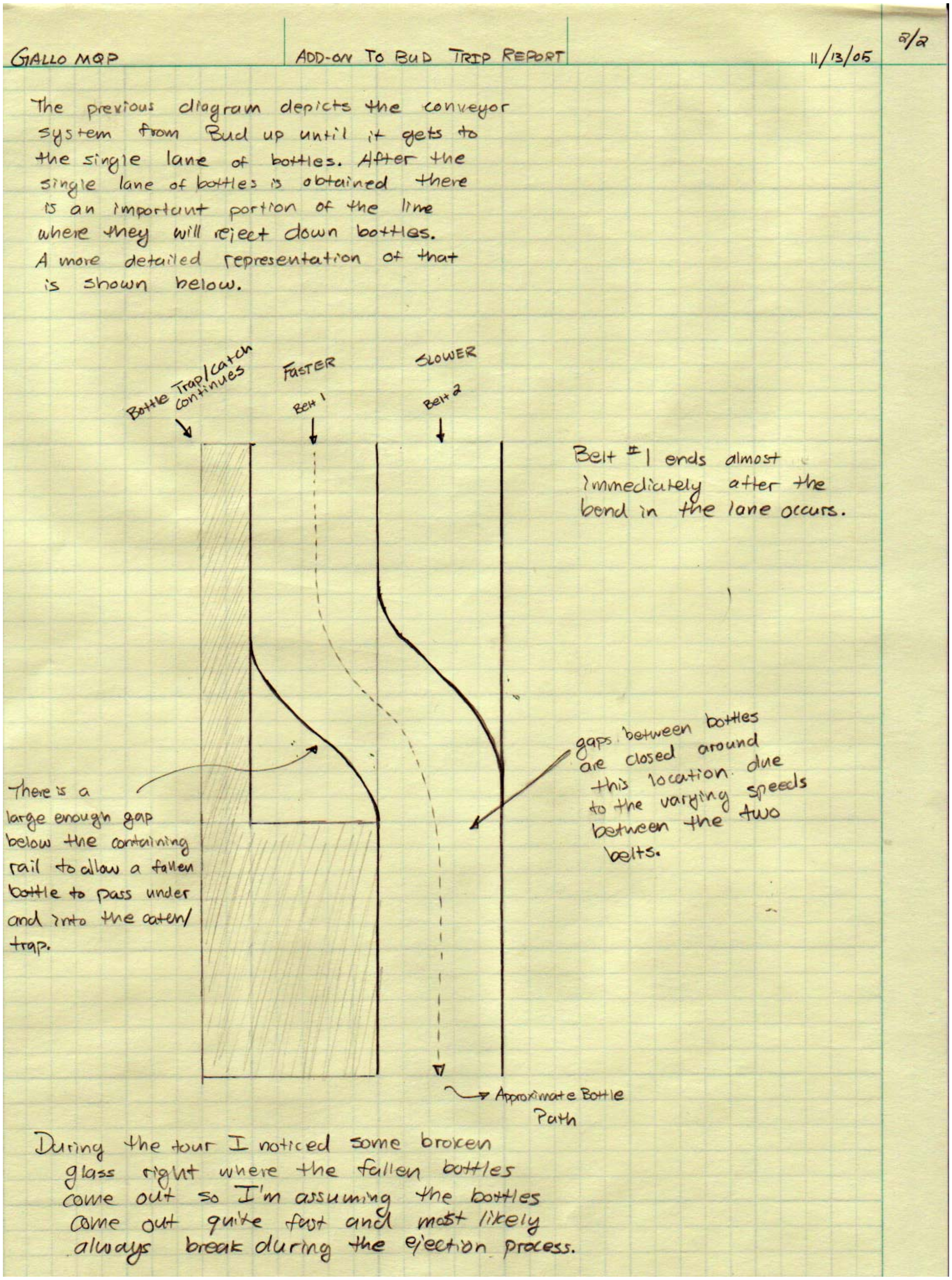


Figure 38 - Anheuser Busch Bottling Line Overview



GALLO MQP | ADD-ON TO BUD TRIP REPORT | 11/13/05 | 2/2

The previous diagram depicts the conveyor system from Bud up until it gets to the single lane of bottles. After the single lane of bottles is obtained there is an important portion of the line where they will reject down bottles. A more detailed representation of that is shown below.

Belt #1 ends almost immediately after the bend in the lane occurs.

There is a large enough gap below the containing rail to allow a fallen bottle to pass under and into the catch/trap.

gaps between bottles are closed around this location due to the varying speeds between the two belts.

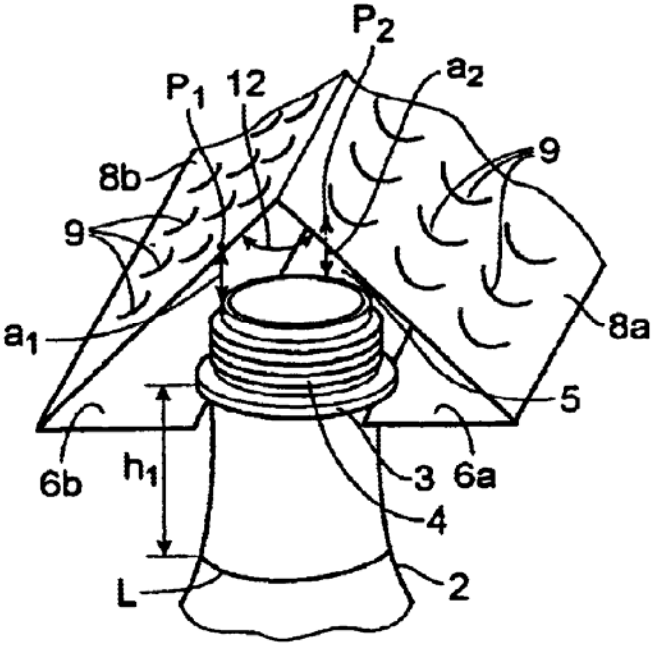
During the tour I noticed some broken glass right where the fallen bottles come out so I'm assuming the bottles come out quite fast and most likely always break during the ejection process.

Figure 39 - Anheuser Busch Bottle Trap Detail View

Appendix C

Patents

- **Air Conveyor for Conveying Articles**
    - **Patent No.: US 6,961,638 B2**
    - **Date of Patent: Nov. 1, 2005**



Abstract:

This invention relates to an air conveyor for conveying articles with a collar and a head arranged above that, in particular plastic bottles along a conveyor channel having two carrying strips arranged along the conveyor channel on which the articles are conveyed by suspending them from the collars, and having a head space having inclined side walls formed above the carrying strips. Air nozzles, which act upon the heads of the articles, are provided in the inclined side walls. This counteracts a tendency of the articles to become tilted or jammed together.

Link:

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/srchnum.htm&r=1&f=G&l=50&s1=6,890,128.WKU.&OS=PN/6,890,128&RS=PN/6,890,128

- **Lubricant for Conveyor System**
    - **Patent No.: US 6,855,676 B2**
    - **Date of Patent: Feb. 15, 2005**

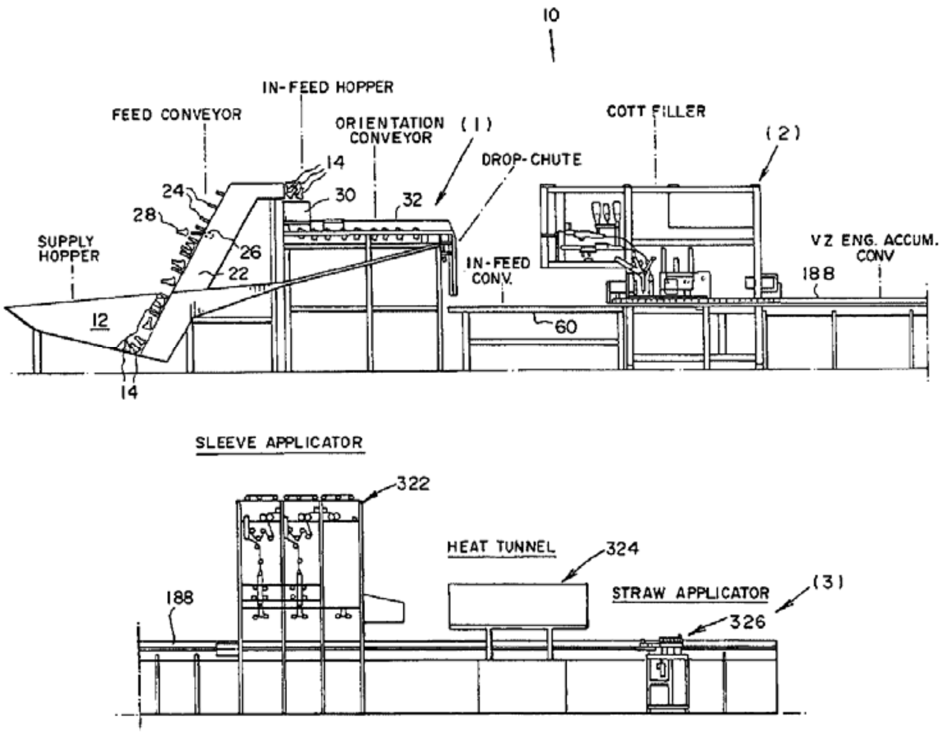
Abstract:

A method of lubricating conveyor tracks or belts is herein described wherein the lubricant composition contains a polyalkylene glycol polymer and a fatty acid; also described are methods of manufacture of such lubricant compositions in both concentrate and diluted form. The compositions may also comprise additional functional ingredients.

Link:

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/srchnum.htm&r=1&f=G&l=50&s1=6,855,676.WKU.&OS=PN/6,855,676&RS=PN/6,855,676

- **System and Apparatus for an Automated Container Filling Production Line**
    - **Patent No.: US 6,910,313 B2**
    - **Date of Patent: Jun. 28, 2005**



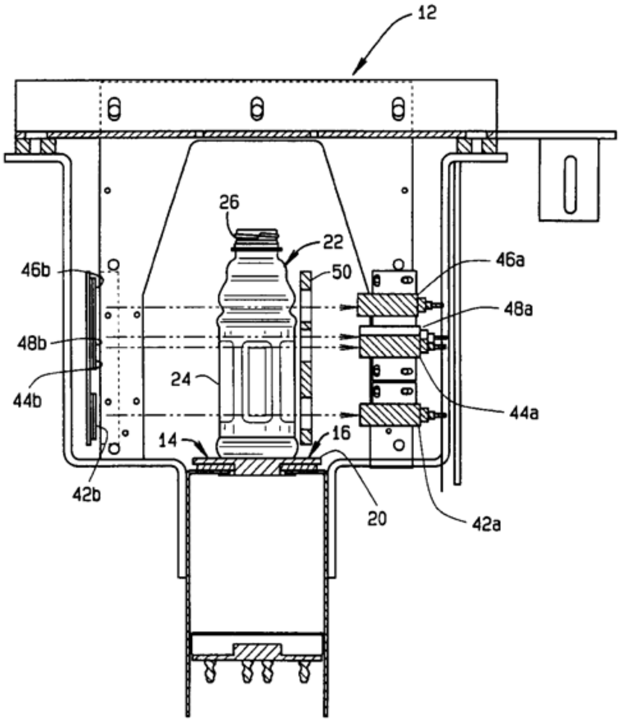
Abstract:

An automated container production line or automatically removing, orienting, filling, sealing and providing a label and applying a straw to the outside of the labeled container is provided which utilizes a novel orienting conveyor for receiving misaligned containers from a supply bin and orienting the containers for a plurality or novel short production lines having a positioning screw conveyor which intermittently starts and stops the advancement of the containers as groups of containers in which various groups of containers are simultaneously filled, sealed, inspected and then subsequently transported to a sleeving device for adding labels, a heat shrink tunnel for fastening the sleeve to the container and then to a novel straw applicator for subsequently attaching a straw to the outside of the container. The novel automated container filling, sealing and inspecting production line includes a computer program for controlling the production line in conjunction with various sensor devices for determining whether the containers are properly aligned, properly filled, properly sealed and completed in accordance with the highest quality control standards to not only assure product quality but also assure that containers not meeting specifications are removed from the production line and not processed further.

Link:

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/srchnum.htm&r=1&f=G&l=50&s1=6,910,313.WKU.&OS=PN/6,910,313&RS=PN/6,910,313

- **Reject Bottle Detection and Ejection Mechanisms**
    - **Patent No.: US 6,961,638 B2**
    - **Date of Patent: Nov 1., 2005**



Abstract:

A reject bottle detection and ejection apparatus has a plurality of sensors positioned along the length of a belt conveyor that senses whether a bottle conveyed by the conveyor is positioned in an upright orientation, in an inverted orientation, in a sideways orientation, in a slanted orientation, or whether the bottle is damaged, and an air jet nozzle positioned downstream of the plurality of sensors that selectively emits a jet of air at a bottle conveyed past the air jet that has been sensed to be not in the upright orientation or to be damaged, thus removing the bottle from the conveyor.

Link:

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/srchnum.htm&r=1&f=G&l=50&s1=6,961,638.WKU.&OS=PN/6,961,638&RS=PN/6,961,638

Appendix D

Glideliner Process

LCT3 Glideliner – Sensor Descriptions

E1	LS1	Gap Control
E2	LS2	Gap Control
E3	LS3	Bottle Present
E4	Line Ready	Bottle Stop Ready to Open at Feed Conveyors
E5	Jam Switch	Acceleration Conveyor
E6	Conveyor Clock	Catch up Conveyor Clock Pulses
E7	Filler machine pitch	Used to determine Speed of Filler
E8	Bottle Stop Open	Is the Bottle Stop Open
E9		
E10		
E11		
E12	Jam Switch	Sliding Conveyor
E13	Through put Regulation	N/A
E14	Infeed Gap Sensor	Closes Bottle Stop if Gap is Present
E15	Run Empty	Empties out the Line
E16	Machine On	Starts The Conveyors at Initial Start
E17	Bit 0 Bottle Select 1	N/A
E18	Bit 1 Bottle Select 2	N/A
E19	Bit 2 Bottle Select 3	N/A
E20	Bit 3 Bottle Select 4	N/A
A1	Bottle Standing Indication	Bottles are going the same speed as the Conveyor
A2	Bottle Sliding Indication	Acceleration conveyor is faster than the Bottles
A3	Glideliner is Ready	Open the Bottle Stop
A4		
A5	Enable of Control of Conveyors	Drive Enable
A6	Gap Too Big	Gap Too Big, Closes Bottle Stop
A7	Jam Stop	Jam Detected, Closes Bottle Stop
A8	Jam Switch Sliding Inverted	Jam Detected, Stops The Dosing Conveyors
AN1	0-10VDC	Intermediate Conv.
AN2	0-10VDC	Catch-up Conv.
AN3	0-10VDC	Slide Conveyor
AN4	0-10VDC	Dosing Conv. 1
AN5	0-10VDC	Dosing Conv. 2
AN6	0-10VDC	Feed Conveyor
AN7	0-10VDC	Reserve Conv. 1
AN8	0-10VDC	Reserve Conv. 2

Line 11 Glideliner

Machine Parameters

Machine Parameters	Value	Machine Parameters	Value
B/C Ratio	103	Min. V. Machine	10000
Gap Size Limit	12		
Synch. Counter	100	Conveyor Mode	
Fill Speed Conveyor		Interm. Conv. Mode	1
		1st Res. Conv. Mode	3
Slow Fill	30	2nd Res. Conv. Mode	3
Fast Fill	50		
Speed Display	BPM	Min. V. Conveyor	
Bottle Stop Setup		Intermediate Conv.	0
		Feed Conveyor	0
Bottle Stop Setup	Yes	Reserve Conv. 1	0
V. Btl Stop Open	20000	Reserve Conv. 2	0
Post Run Time	0	Type Select	Internal
V. Btl Stop Adapt	N/A	Language	English
		Mode of Operation	Glideliner

Type Parameters

Type Parameters	Value	Type Parameters	Value
Adaptive Values		Glideliner	
Intermediate Conv.	115	Preset Gap	1
Catch-up Conv.	125	Gap Resp. Select	1
Slide Conveyor	105	Slid. Resp. Select	2
Dosing Conv. 1	105	Stop Conv. Pulse	5
Dosing Conv. 2	105	Starting Speed	17
Feed Conveyor	100	Flow Control	N/A
Reserve Conv. 1	100	Back-up Switch	Yes
Reserve Conv. 2	115	Deceleration Value	20
		Ramp Values	
		Ramp UP	0.9
		Ramp DOWN	1.2

Appendix E

Friction Analysis

- Static Friction Test

Figure 40 - Friction Analysis Method

Figure 41 - Friction Analysis Method [Angled]

Materials Used:

- 1” x 5 ¼” x 26” piece of wood
- 12 links from the Glideliner conveyor (Part Number: REX SS815)
- 1 Empire Polycast Magnetic Protractor (Inclinometer) (From Rehab Lab)
- 4 #16-1 ½” nails
- 1 hammer
- 1 wine cooler bottle used on the conveyor under inspection
- 1 1/8” punch
- 1 roll of scotch tape

Method:

1. Cut a piece of 1” x 5 ¼” wood to roughly 26”
2. Take the (12) links of the REX SS815 (assembled) and place roughly centered on the piece of wood from Step 1.
3. Using the (4) #16-1 ½” nails, nail one in each of the four corners of the assembled conveyor chain, positioning the nails as far in towards the center as possible and in the crevice between the last and second to last links of the conveyor chain.
4. Mount the Empire Polycast Magnetic Protractor near the left-hand side of the conveyor chain securely using the scotch tape.

5. Place the wine cooler bottles somewhere near the Empire Polycast Magnetic Protractor (remember its rough position and attempt to place the bottle near that location for each trial).
6. Slowly lift the piece of wood until the bottle begins to slide.
7. Record the angle observed directly when the bottle begins to slide.
8. Repeat steps 5-7 for n number of trials in the experiment.

Experiment Notes:

- Wood block was lifted by hand so human error needs to be taken into account.
- Experiment was conducted at room temperature.

Results:

Trial #	**Angle Observed (DEG)**	**Trial #**	**Angle Observed (DEG)**	**Trial #**	**Angle Observed (DEG)**	**Trial #**	**Angle Observed (DEG)**
1	8.5	26	8.5	51	9.5	76	9.5
2	9	27	9	52	9	77	9
3	8.5	28	8.5	53	9	78	9
4	9	29	9	54	9.5	79	9
5	8.5	30	9	55	9.5	80	9
6	8.5	31	9	56	11	81	9
7	8.5	32	9	57	9	82	9
8	8	33	9	58	9.5	83	8.5
9	8	34	9	59	9	84	8.5
10	8.5	35	9	60	8.5	85	8.5
11	8.5	36	9	61	9	86	8.5
12	9	37	8.5	62	9	87	9
13	9	38	9	63	9	88	9
14	9	39	9	64	8.5	89	9
15	9	40	8.5	65	8	90	8.5
16	8.5	41	8.5	66	8.5	91	8.5
17	8.5	42	9	67	8.5	92	8
18	9	43	9	68	9	93	9
19	8.5	44	8.5	69	8.5	94	9
20	9	45	8.5	70	9.5	95	9
21	8.5	46	9	71	9	96	8.5
22	8.5	47	11	72	11	97	11.5
23	9	48	8.5	73	13	98	9.5
24	9	49	9	74	11	99	9
25	9	50	10	75	9	100	9

Table 3 - Friction Analysis Data (No Lubrication) – Empty Bottle

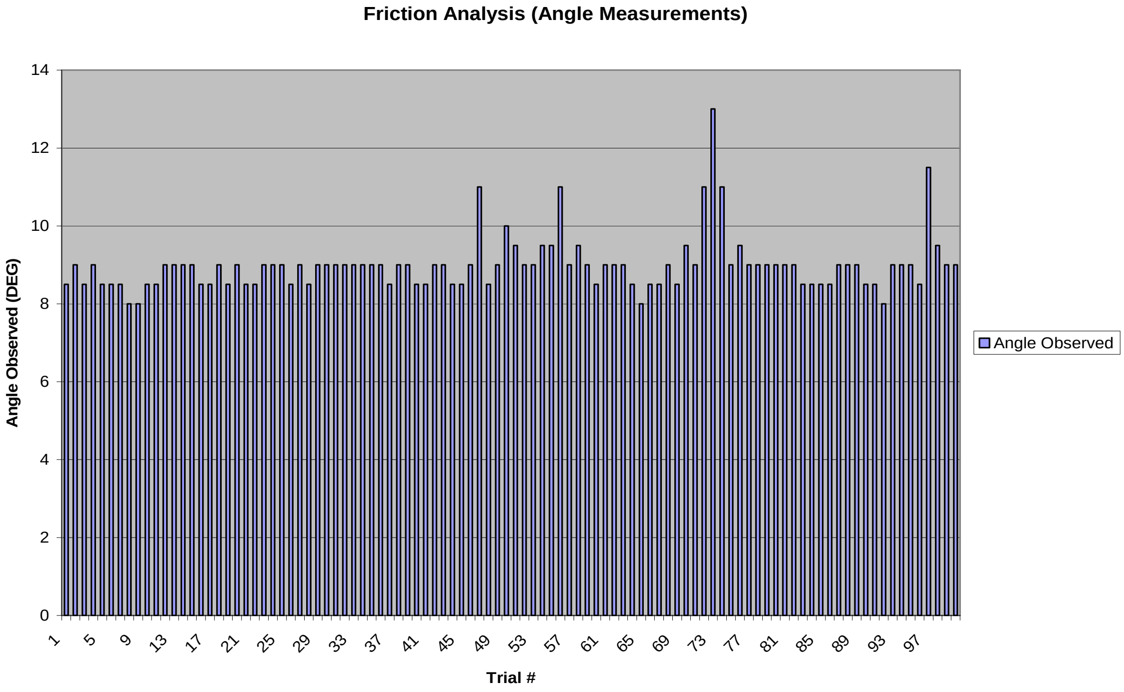


Figure 42 - Friction Analysis (No Lubrication) – Full Bottle

Trial #	**Angle Observed**
1	9
2	9.5
3	10
4	9.5
5	10
6	10.5
7	10
8	10
9	10.5
10	10
11	10
12	9
13	9.5
14	9.5
15	9
16	10
17	9
18	8.5
19	9
20	10
21	9.5
22	9.5
23	9.5
24	10
25	9

Table 4 - Friction Analysis Data (No Lubrication) – Full Bottle

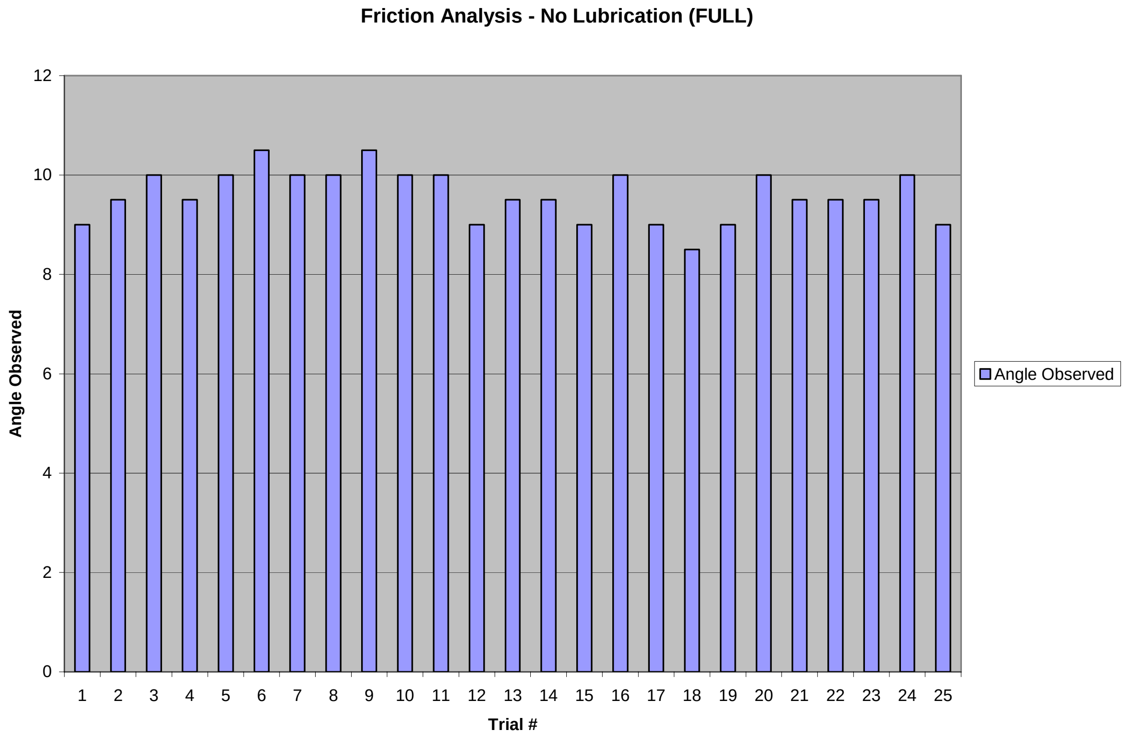


Figure 43 - Friction Analysis (No Lubrication) - Full Bottle

Conclusion:

- The test overall proved the validity of Gallo's similar friction test that led to them using a 9° angle on their Glideliner conveyor. It also led to the ability to calculate the coefficient of friction needed to perform a dynamic analysis on the bottle to understand the process better.

- Dynamic Friction Test

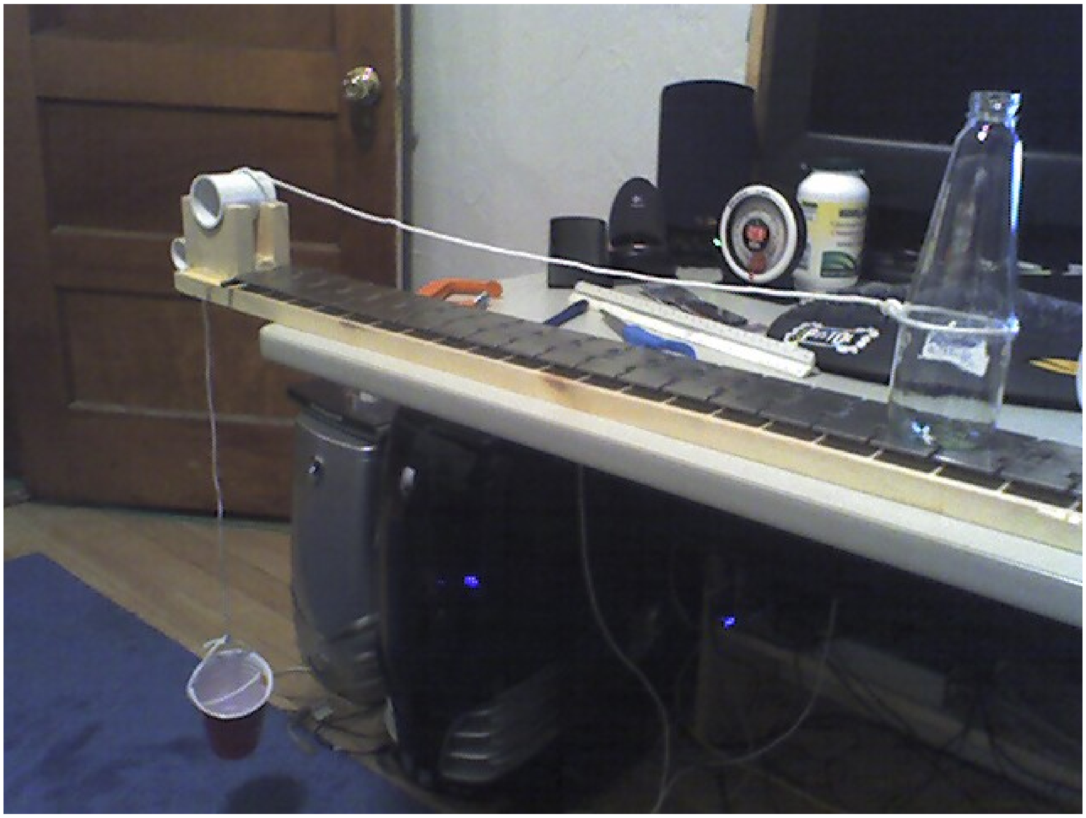


Figure 44 – Dynamic Friction Analysis Method

Figure 45 – Make Shift PVC Pipe Pulley

Figure 46 - Weight Hanger

Figure 47 - Wine Cooler Bottle Used (Tied)

Materials Used:

- 1 plastic party cup
- 1 ¾" x 4" x 6' piece of Pine
- 1 6' piece of Nylon Premium Quality Rope
- 1 ½" straight PVC pipe fitting
- 1 1" straight PVC pipe fitting
- 4 #16 x 1-1/2" wire nails
- 4 #17 x 1" wire nails
- 1 wine cooler bottle under observation
- Wood glue
- Scotch tape
- 36 links from the Glideliner Conveyor (Part No: REX SS815)
- Incremental weights (in this case loose change)

Method:

1. Using steps 6 and 7 in the document in the Appendix (http://physics.clarku.edu/courses/110labs/Lab4.pdf)
2. Construction:
   a. Cut off a foot of the wooden plank to build a holder for the PVC pipe

    b. Using the 1’ piece of wood make a holder for the PVC pipe as shown in Figure 2
    c. Nail the assembled conveyor belt links to the wider (4”) portion of the wood planks
    d. Mount the make shift PVC pulley at one end of the conveyor
    e. Tie the rope around the bottle near the center of gravity (in this case ≈ 2.5”) and tie the other end to the cup which will act as a holder for the incremental weights
3. Follow the steps in Step 1 and record the results for n trials in the experiment

Experiment Notes:

- Experiment was conducted at room temperature.

Results:

EMPTY BOTTLE

Trial #	Weight Components	Weight (grams)
1	4xQuarters 4xPennies 3xDimes	38.884
2	14xPennies	32.900
3	5xDimes 5xNickels	36.340
4	5xNickels 5xPennies	34.400
5	5xDimes 9xPennies	32.490

Mean:	35.003
Median:	34.400
Mode:	N/A
Standard Deviation:	2.643
Max:	38.884
Min:	32.490

FULL BOTTLE

Trial #	Weight Components	Weight (grams)
1	7xQuarters 4xDimes 5xNickels 17xPennies	113.712
2	9xQuarters 28xPennies	116.830
3	11xNickels 27xPennies	118.450
4	12xDimes 10xNickels 19xPennies	121.866
5	5xQuarters 5xNickels 5xDimes 22xPennies	116.390

Mean:	117.450
Median:	116.830
Mode:	N/A
Standard Deviation:	2.999
Max:	121.866
Min:	113.712

Table 5 - Dynamic Friction Analysis Data (No Lubrication)

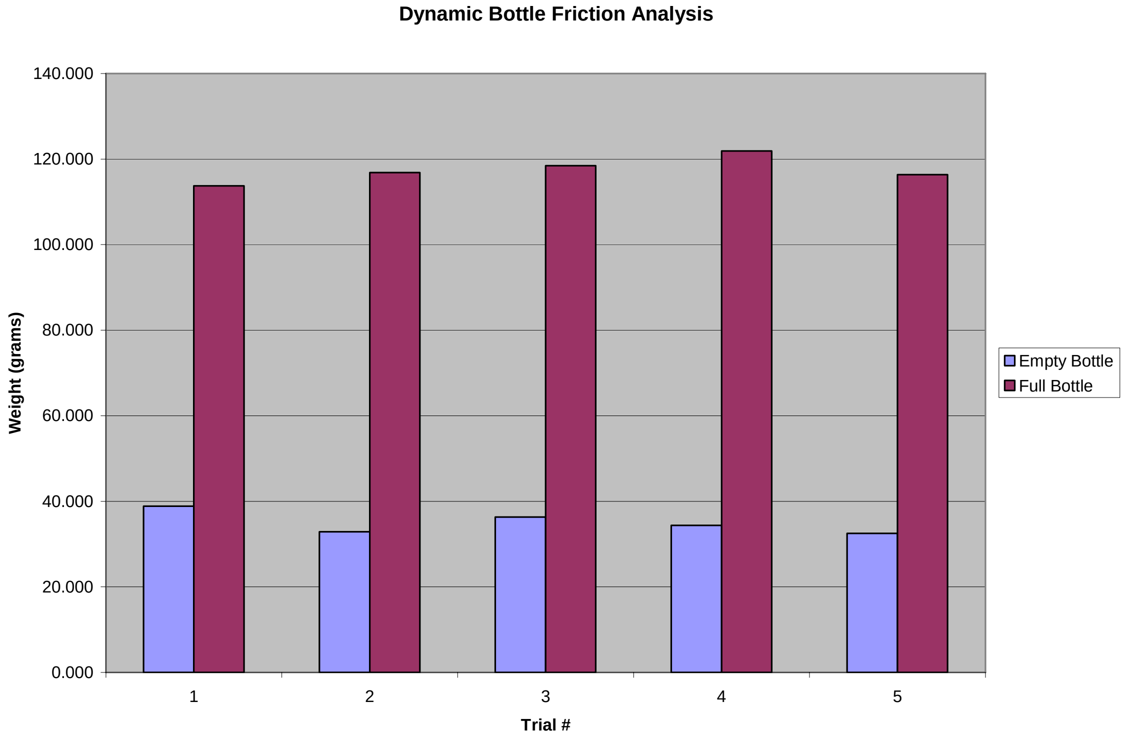


Figure 48 – Dynamic Friction Analysis (No Lubrication)

Conclusion:

- While the experiment may have been slightly crude the overall representation of the dynamic friction was properly displayed through this test. The numbers received appear to be good rough approximations of the dynamic friction and will be used in calculation further into the project.

Appendix F

Center of Gravity Analysis

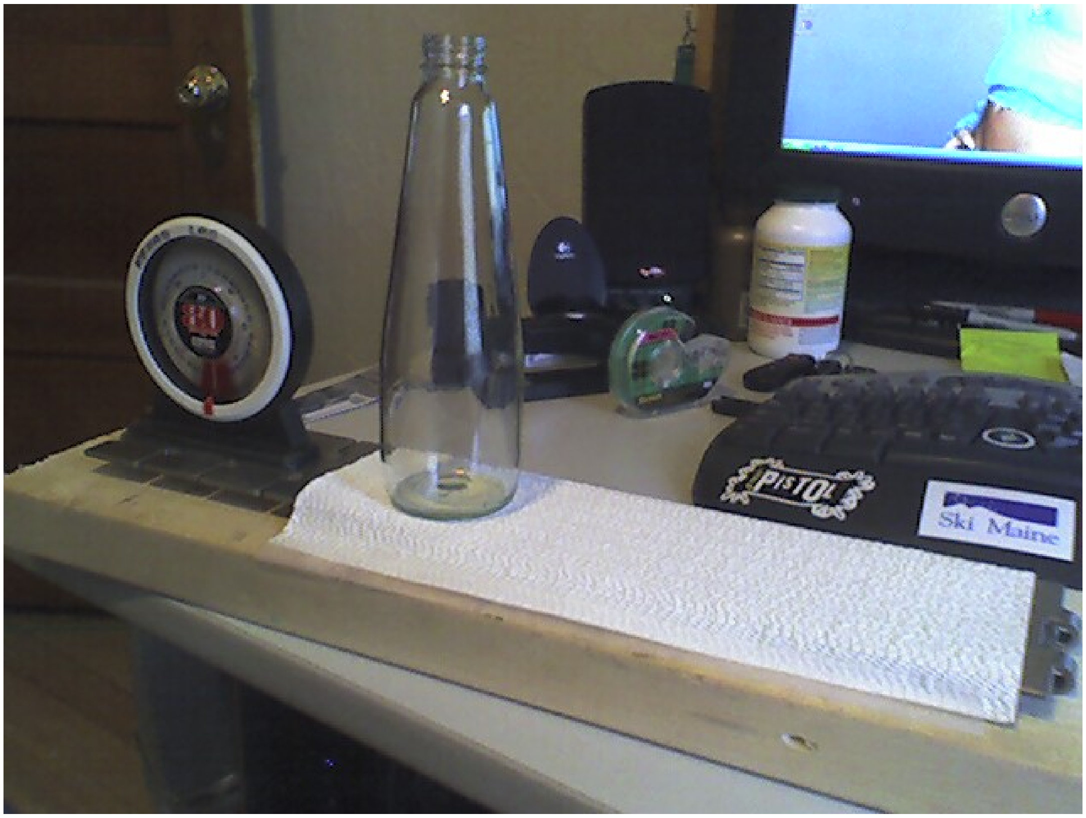


Figure 49 – Bottle Tip Test Method

Figure 50 – Bottle Tip Test Method [Angled]

Materials Used:

- 1" x 5 ¼" x 26" piece of wood
- 12 links from the Glideliner conveyor (Part Number: REX SS815)
- 1 Empire Polycast Magnetic Protractor (Inclinometer) (From Rehab Lab)
- 4 #16-1 ½" nails
- 1 hammer
- 1 wine cooler bottle used on the conveyor under inspection
- 1 1/8" punch
- 1 roll of scotch tape
- 1 5 ¼" x 12" piece of Grip Vinyl Liner

Method:

1. Cut a piece of 1" x 5 ¼" wood to roughly 26"
2. Take the (12) links of the REX SS815 (assembled) and place roughly centered on the piece of wood from Step 1.
3. Using the (4) #16-1 ½" nails, nail one in each of the four corners of the assembled conveyor chain, positioning the nails as far in towards the center as possible and in the crevice between the last and second to last links of the conveyor chain.

4. Mount the Empire Polycast Magnetic Protractor to the left-most side of the piece of wood using scotch tape and taping the protractor to the wider side of the wood in a manner that allows it to be read easily.
5. Place the piece of Grip Vinyl Liner with grip side facing up on the same plane as the protractor. Pull the Grip Vinyl Liner tight and tape down in the appropriate locations.
6. Place the wine cooler bottle anywhere on the Grip Vinyl Liner and slowly lift the left hand side of the wooden plank until the bottle tips over (ensure no sliding occurs).
7. Record the angle.
8. Repeat steps 4 & 5 for n trials in the experiment.

Experiment Notes:

- Wood block was lifted by hand so human error needs to be taken into account.
- Experiment was conducted at room temperature.

Results:

Trial #	Angle Observed	Trial #	Angle Observed
1	15.5	1	14
2	16	2	14
3	16	3	14.5
4	15.5	4	14
5	16	5	15
6	16.5	6	14
7	16	7	14.5
8	16	8	13.5
9	16	9	13.5
10	16	10	13.5
11	15.5	11	13.5
12	16.5	12	13
13	16	13	13.5
14	16	14	12.5
15	16.5	15	13
16	16	16	12.5
17	16	17	13.5
18	16	18	13
19	16	19	14
20	16	20	13.5
21	16	21	14
22	16.5	22	14
23	16	23	14
24	16	24	14
25	15.5	25	14

Table 6 - Bottle Tip Test Data (Full Bottle on Left, Empty Bottle on Right)

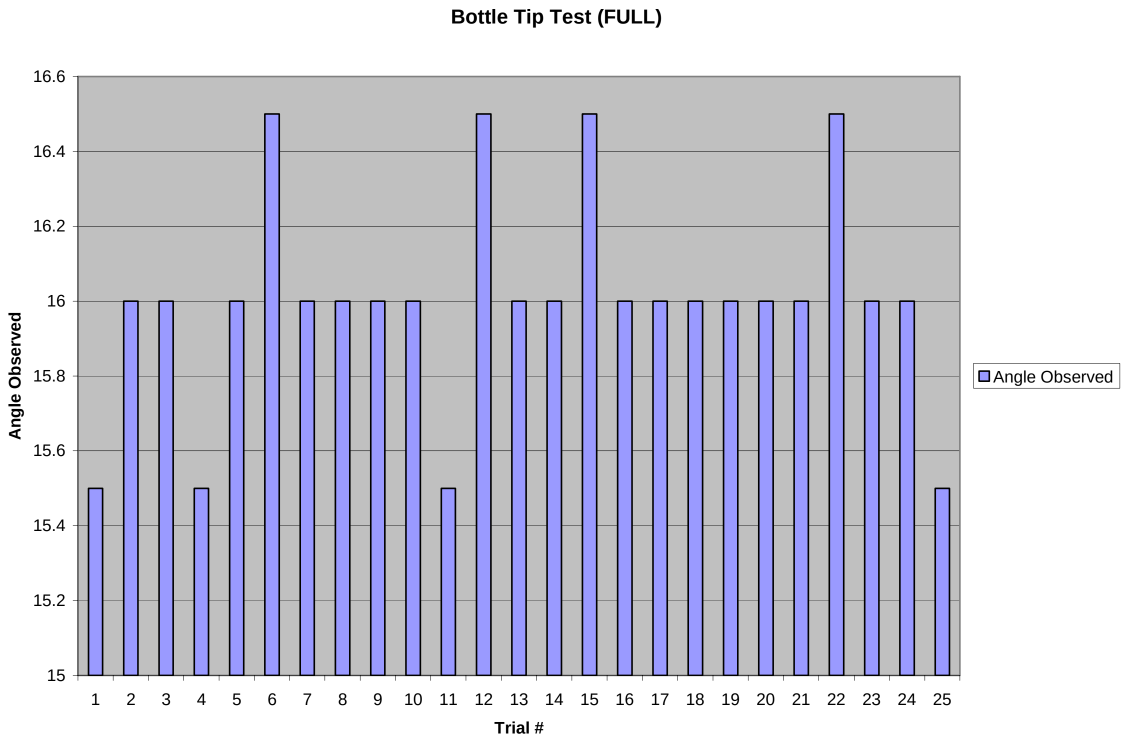


Figure 51 – Bottle Tip Test (Full Bottle)

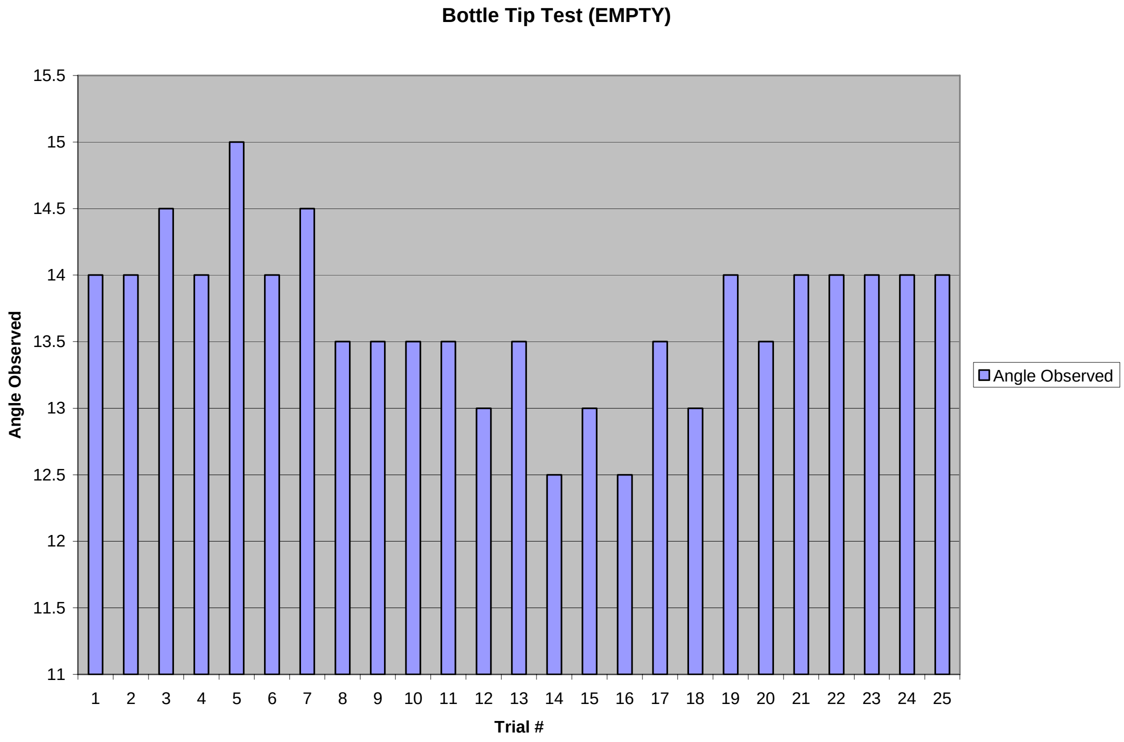


Figure 52 - Bottle Tip Test (Empty Bottle)

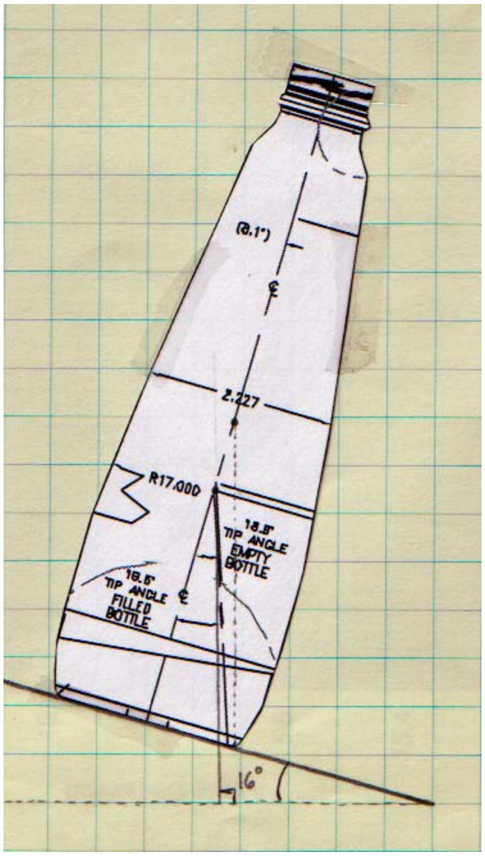


Figure 53 - Bottle Tip Test Angle (Full Bottle)

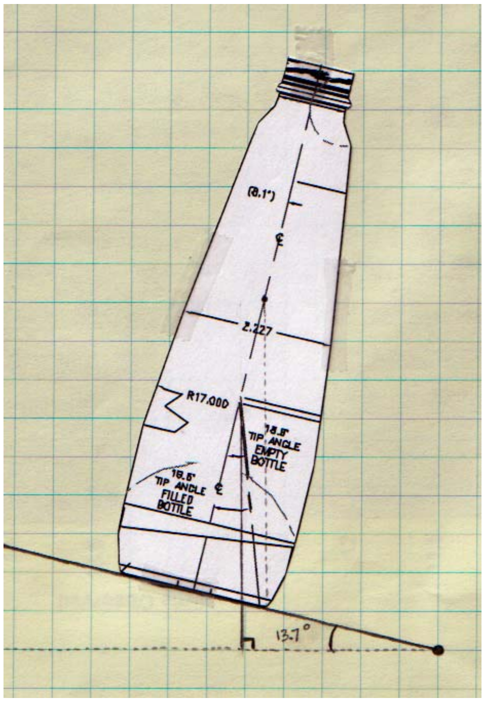


Figure 54 - Bottle Tip Test Angle (Empty Bottle)

Additional Solid Works 2005 Analysis:

- Due to the large differences in values found for the angle of tipping for the bottle yet another test was conducted as a tie breaker. The bottle was modeled in Solid Works 2005 and the center of gravity was calculated. From there the scaled bottle drawing was cut out and placed into a diagram in order to determine the angle at which the bottle will tip over. The results can be found below:

Solid Works 2005 Readout:

```
Mass properties of Gallo Bottle (Part Configuration - Default)

Output coordinate System: Coordinate System1

Density = 0.09 pounds per cubic inch

Mass = 0.31 pounds

Volume = 3.38 cubic inches

Surface area = 108.35 square inches

Center of mass: (inches)
        X = 0.00
        Y = 3.25
        Z = 0.00

Principal axes of inertia and principal moments of inertia: (pounds * square inches)
Taken at the center of mass.
         Ix = (0.00, 1.00, 0.00)        Px = 0.35
         Iy = (0.00, 0.00, 1.00)        Py = 1.71
         Iz = (1.00, 0.00, 0.00)        Pz = 1.71

Moments of inertia: ( pounds * square inches )
Taken at the center of mass and aligned with the output coordinate system.
        Lxx = 1.71     Lxy = 0.00     Lxz = 0.00
        Lyx = 0.00     Lyy = 0.35     Lyz = 0.00
        Lzx = 0.00     Lzy = 0.00     Lzz = 1.71

Moments of inertia: ( pounds * square inches )
Taken at the output coordinate system.
        Ixx = 4.94     Ixy = 0.00     Ixz = 0.00
        Iyx = 0.00     Iyy = 0.35     Iyz = 0.00
        Izx = 0.00     Izy = 0.00     Izz = 4.94
```

Resulting Diagram from Solid Works Readout:

Figure 55 - Resulting Angle from Solid Works Analysis

Conclusion:

- There was a very large discrepancy between what is shown on the AutoCAD drawing from the Gallo Wineries and the angles found during this experiment on the angle for when the bottle will tip over. The empty bottle test was off by 5.1 degrees and the full bottle test was off by 3.5 degrees. In order to help confirm the results a tie breaker test was conducted using Solid Works 2005 to calculate the center of gravity in virtual space to determine the angle of tipping. The Solid Works test was much closer to the actual value given by Gallo Wineries, only being off by 1.5 degrees which is far more reasonable then 5.1. While the first tests may have been slightly crude and a little less accurate then desired the test should have not yielded such a low value. If the test were to be completed again a different method, such as mechanical, would be used to raise the block of wood being used along with a more accurate inclinometer that doesn’t rely on human eye readings within’ .5 degrees.

Appendix G

Single Bottle Trajectory Analysis

We need the velocity in the y-direction for calculations on all belts after the first one. Using the following two equations will give us all information needed in the y-direction.

$$y - y_0 = V_{y\_o} \cdot t + \frac{1}{2} \cdot g \cdot \mathrm{Cos10} \cdot t^2 \qquad V_y{}^2 = V_{y\_o}{}^2 + 2 \cdot g \cdot \mathrm{Cos10} \cdot (y - y_0)$$

<u>First Belt:</u>

To Find t on First Belt: $3.248 \cdot \mathrm{in} = \frac{1}{2} \cdot \left(386.22 \cdot \frac{\mathrm{in}}{\mathrm{s}^2}\right) \cdot (\mathrm{Cos10}) \cdot t^2$

$t = 0.131 \ \mathrm{s}$

Velocity at end of 1st Belt: $V_y{}^2 = 2 \cdot \left(386.22 \cdot \frac{\mathrm{in}}{\mathrm{s}^2}\right) \cdot (\mathrm{Cos10}) \cdot 3.248\mathrm{in}$

$V_{y\_2} = 49.71 \ \frac{\mathrm{in}}{\mathrm{s}}$ Initial Velocity of 2nd Belt

Distance in X-Direction: vel in x-dir x time

$6.6 \ \frac{\mathrm{in}}{\mathrm{s}} \cdot 0.131 \, \mathrm{s} = 0.846 \, \mathrm{in}$

<u>Second Belt:</u>

To Find t on Second Belt: $3.248 \cdot \mathrm{in} = 49.71 \frac{\mathrm{in}}{\mathrm{s}} \cdot t + \frac{1}{2} \cdot \left(386.22 \cdot \frac{\mathrm{in}}{\mathrm{s}^2}\right) \cdot (\mathrm{Cos10}) \cdot t^2$

$t = 0.0541 \ \mathrm{s}$

Velocity at end of 2nd Belt: $V_y{}^2 = \left(49.71 \frac{\mathrm{in}}{\mathrm{s}}\right)^2 + 2 \cdot \left(386.22 \cdot \frac{\mathrm{in}}{\mathrm{s}^2}\right) \cdot (\mathrm{Cos10}) \cdot 3.248\mathrm{in}$

$V_{y\_3} = 70.30 \ \frac{\mathrm{in}}{\mathrm{s}}$ Initial Velocity of 3rd Belt

Distance in X-Direction: vel in x-dir x time

$9 \ \frac{\mathrm{in}}{\mathrm{s}} \cdot 0.0541 \ \mathrm{s} = 0.487 \ \mathrm{in}$

Third Belt:

To Find t on Third Belt:

$$3.248\cdot in = 70.30\frac{in}{s}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10)\cdot t^2$$

$$t = 0.0415 \quad s$$

Velocity at end of 3rd Belt:

$$V_y{}^2 = \left(70.30\,\frac{in}{s}\right)^2 + 2\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10\,)\cdot 3.248in$$

$$V_{y\_4} = 86.10\,\frac{in}{s}$$ Initial Velocity of 4th Belt

Distance in X-Direction:

vel in x-dir x time

$$13.2\,\frac{in}{s}\cdot 0.0415\,s = 0.5478\ in$$

Fourth Belt:

To Find t on Fourth Belt:

$$3.248\cdot in = 86.10\frac{in}{s}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10)\cdot t^2$$

$$t = 0.035 \quad s$$

Velocity at end of 4th Belt:

$$V_y{}^2 = \left(86.10\,\frac{in}{s}\right)^2 + 2\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10\,)\cdot 3.248in$$

$$V_{y\_5} = 99.42\,\frac{in}{s}$$ Initial Velocity of 5th Belt

Distance in X-Direction:

vel in x-dir x time

$$16.6\,\frac{in}{s}\cdot 0.035\,s = 0.581\ in$$

Fifth Belt:

To Find t on Fifth Belt:

$$3.248\cdot \mathrm{in} = 99.42\,\frac{\mathrm{in}}{\mathrm{s}}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{\mathrm{in}}{\mathrm{s}^2}\right)\cdot(\mathrm{Cos}10)\cdot t^2$$

$$t = 0.031\ \mathrm{s}$$

Velocity at end of 5th Belt:

$$V_y{}^2 = \left(99.42\,\frac{\mathrm{in}}{\mathrm{s}}\right)^2 + 2\cdot\left(386.22\cdot\frac{\mathrm{in}}{\mathrm{s}^2}\right)\cdot(\mathrm{Cos}10)\cdot 3.248\mathrm{in}$$

$$V_{y\_6} = 111.15\ \frac{\mathrm{in}}{\mathrm{s}}$$ Initial Velocity of 6th Belt

Distance in X-Direction:

vel in x-dir x time

$$23.2\,\frac{\mathrm{in}}{\mathrm{s}}\cdot 0.031\mathrm{s} = 0.719\mathrm{in}$$

Sixth Belt:

To Find t on Sixth Belt:

$$3.248\cdot \mathrm{in} = 111.15\,\frac{\mathrm{in}}{\mathrm{s}}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{\mathrm{in}}{\mathrm{s}^2}\right)\cdot(\mathrm{Cos}10)\cdot t^2$$

$$t = 0.0279\ \mathrm{s}$$

Velocity at end of 6th Belt:

$$V_y{}^2 = \left(111.15\,\frac{\mathrm{in}}{\mathrm{s}}\right)^2 + 2\cdot\left(386.22\cdot\frac{\mathrm{in}}{\mathrm{s}^2}\right)\cdot(\mathrm{Cos}10)\cdot 3.248\mathrm{in}$$

$$V_{y\_7} = 121.76\ \frac{\mathrm{in}}{\mathrm{s}}$$ Initial Velocity of 7th Belt

Distance in X-Direction:

vel in x-dir x time

$$28.2\,\frac{\mathrm{in}}{\mathrm{s}}\cdot 0.0279\,\mathrm{s} = 0.787\,\mathrm{in}$$

Seventh Belt:

To Find t on Seventh Belt: $3.248 \cdot \text{in} = 121.76 \frac{\text{in}}{\text{s}} \cdot t + \frac{1}{2} \cdot \left(386.22 \cdot \frac{\text{in}}{\text{s}^2} \right) \cdot (\text{Cos}10) \cdot t^2$

$t = 0.0256 \ \text{s}$

Velocity at end of 7th Belt: $V_y{}^2 = \left(121.76 \frac{\text{in}}{\text{s}} \right)^2 + 2 \cdot \left(386.22 \cdot \frac{\text{in}}{\text{s}^2} \right) \cdot (\text{Cos}10) \cdot 3.248\text{in}$

$V_{y\_8} = 131.62 \ \frac{\text{in}}{\text{s}}$ Initial Velocity of 8th Belt

Distance in X-Direction: vel in x-dir x time

$28.6 \ \frac{\text{in}}{\text{s}} \cdot 0.0256 \ \text{s} = 0.732 \ \text{in}$

Eigth Belt:

To Find t on Eigth Belt: $3.248 \cdot \text{in} = 131.62 \frac{\text{in}}{\text{s}} \cdot t + \frac{1}{2} \cdot \left(386.22 \cdot \frac{\text{in}}{\text{s}^2} \right) \cdot (\text{Cos}10) \cdot t^2$

$t = 0.0239 \ \text{s}$

Velocity at end of 8th Belt: $V_y{}^2 = \left(131.62 \frac{\text{in}}{\text{s}} \right)^2 + 2 \cdot \left(386.22 \cdot \frac{\text{in}}{\text{s}^2} \right) \cdot (\text{Cos}10) \cdot 3.248\text{in}$

$V_{y\_9} = 140.79 \ \frac{\text{in}}{\text{s}}$ Initial Velocity of 9th Belt

Distance in X-Direction: vel in x-dir x time

$39.2 \ \frac{\text{in}}{\text{s}} \cdot 0.0239\,\text{s} = 0.937\,\text{in}$

Ninth Belt:

To Find t on Ninth Belt:

$$3.248\cdot in = 140.79\frac{in}{s}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10)\cdot t^2$$

$$t = 0.0224 \ \ s$$

Velocity at end of 9th Belt:

$$V_y{}^2 = \left(140.79\frac{in}{s}\right)^2 + 2\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10)\cdot 3.248in$$

$$V_{y\_10} = 149.40 \ \frac{in}{s}$$ Initial Velocity of 10th Belt

Distance in X-Direction: vel in x-dir x time

$$39.2\,\frac{in}{s}\cdot 0.0224\,s = 0.878\,in$$

Tenth Belt:

To Find t on Tenth Belt:

$$3.248\cdot in = 149.40\frac{in}{s}\cdot t + \frac{1}{2}\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10)\cdot t^2$$

$$t = 0.0212 \ \ s$$

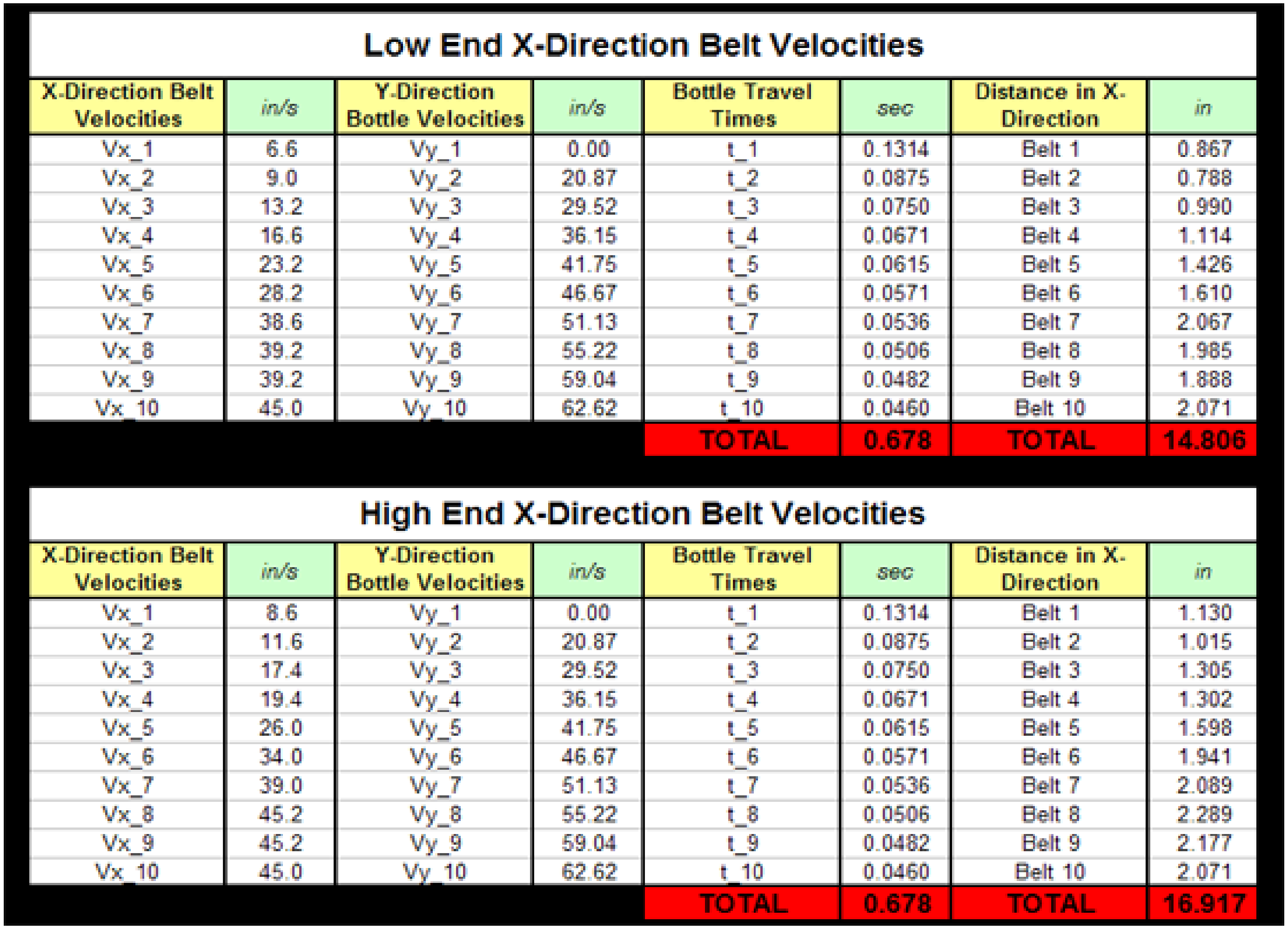
Velocity at end of 10th Belt:

$$V_y{}^2 = \left(149.40\frac{in}{s}\right)^2 + 2\cdot\left(386.22\cdot\frac{in}{s^2}\right)\cdot(Cos10)\cdot 3.248in$$

$$V_{y\_11} = 157.54 \ \frac{in}{s}$$ Initial Velocity of 11th Belt

Distance in X-Direction: vel in x-dir x time

$$45\,\frac{in}{s}\cdot 0.0212\,s = 0.954\,in$$



Low End X-Direction Belt Velocities

X-Direction Belt Velocities	in/s	Y-Direction Bottle Velocities	in/s	Bottle Travel Times	sec	Distance in X-Direction	in
Vx_1	6.6	Vy_1	0.00	t_1	0.1314	Belt 1	0.867
Vx_2	9.0	Vy_2	20.87	t_2	0.0875	Belt 2	0.788
Vx_3	13.2	Vy_3	29.52	t_3	0.0750	Belt 3	0.990
Vx_4	16.6	Vy_4	36.15	t_4	0.0671	Belt 4	1.114
Vx_5	23.2	Vy_5	41.75	t_5	0.0615	Belt 5	1.426
Vx_6	28.2	Vy_6	46.67	t_6	0.0571	Belt 6	1.610
Vx_7	38.6	Vy_7	51.13	t_7	0.0536	Belt 7	2.067
Vx_8	39.2	Vy_8	55.22	t_8	0.0506	Belt 8	1.985
Vx_9	39.2	Vy_9	59.04	t_9	0.0482	Belt 9	1.888
Vx_10	45.0	Vy_10	62.62	t_10	0.0460	Belt 10	2.071
				TOTAL	0.678	TOTAL	14.806

High End X-Direction Belt Velocities

X-Direction Belt Velocities	in/s	Y-Direction Bottle Velocities	in/s	Bottle Travel Times	sec	Distance in X-Direction	in
Vx_1	8.6	Vy_1	0.00	t_1	0.1314	Belt 1	1.130
Vx_2	11.6	Vy_2	20.87	t_2	0.0875	Belt 2	1.015
Vx_3	17.4	Vy_3	29.52	t_3	0.0750	Belt 3	1.305
Vx_4	19.4	Vy_4	36.15	t_4	0.0671	Belt 4	1.302
Vx_5	26.0	Vy_5	41.75	t_5	0.0615	Belt 5	1.598
Vx_6	34.0	Vy_6	46.67	t_6	0.0571	Belt 6	1.941
Vx_7	39.0	Vy_7	51.13	t_7	0.0536	Belt 7	2.089
Vx_8	45.2	Vy_8	55.22	t_8	0.0506	Belt 8	2.289
Vx_9	45.2	Vy_9	59.04	t_9	0.0482	Belt 9	2.177
Vx_10	45.0	Vy_10	62.62	t_10	0.0460	Belt 10	2.071
				TOTAL	0.678	TOTAL	16.917

Figure 56 - Single Bottle Trajectory Analysis Results

Appendix H

Design Concepts

- "Neck Pincher" Method

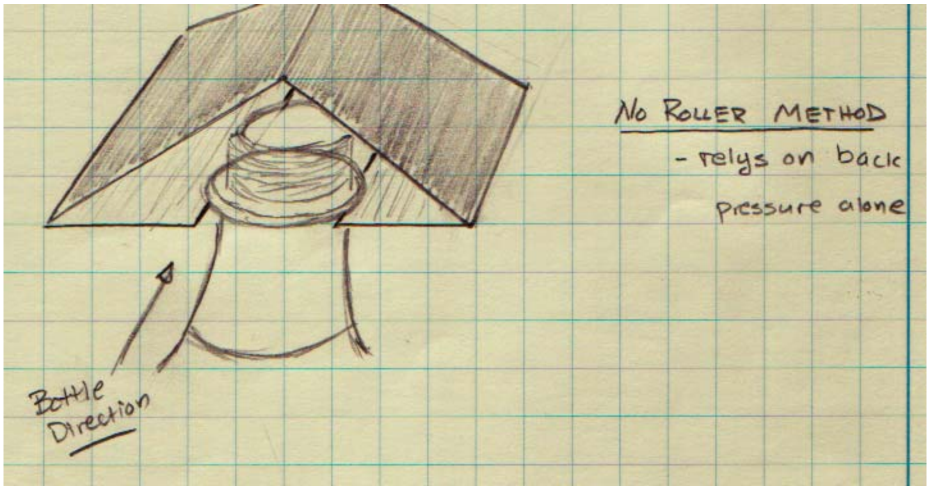


Figure 57 - Neck Pincher with No Rollers

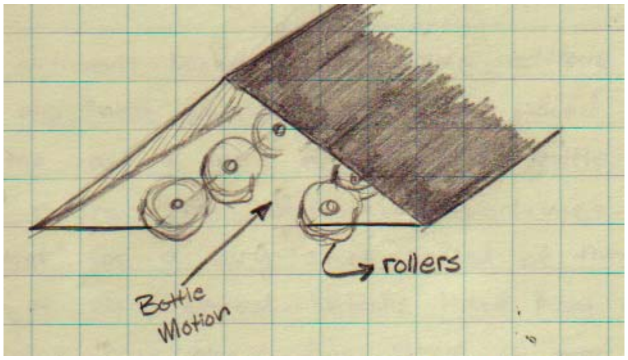


Figure 58 - Neck Pincher with Rollers

  - Based on a discussion during a PQP meeting on November 8th, 2005 with Professor Ault.
  - This concept would result in a total REDESIGN of the Glideliner up until the filler.
  - This concept would impose a new method of holding the bottles and would no longer use conveyors but back-pressure much like a twist washer.
  - Could model exactly like a twist washer and not use any rollers or something similar, or could use some form of roller in order to assist in getting the bottles down the line.
    - Rollers may assist the process but will also create more moving parts which may result in increased maintenance.
  - This will solve the issue regarding bottles not falling into the down bottle traps when they are not oriented properly.

- This method could possibly create a more complicated necking process and the scrap rate it creates would need to be analyzed.
- The major attraction to this method is that once the bottles are in single file there would be no chance of a bottle going down. Also the down bottles going <u>into</u> this new holder would not get picked up and would never create a problem for the line.
- This method would involve holding the bottles at the top of the neck near the ridge of where the cap screws on, providing a more secure grip on the bottle.
- Spin off alternative method mentioned in the 4th bullet on the first page of this design of using roller to reduce the need for increased backpressure in order to convey the bottles.
- As stated previously could cause problems with maintenance due to the many moving parts. The added roller however will reduce the wear around the neck of the bottle and allow for increased speeds of the bottle.
- Possible issue is the entry of the bottles into the roller/non-roller conveyor. Small tolerance will make the accuracy of the entry conveyor a very large concern.
- The interface with the filler will have to be taken into consideration as well in order ensure smooth transition into the filler. Possibilities of having the new rails continue through the filler and out the other side? What does the other side of the filler look like?
- Possible Layout:

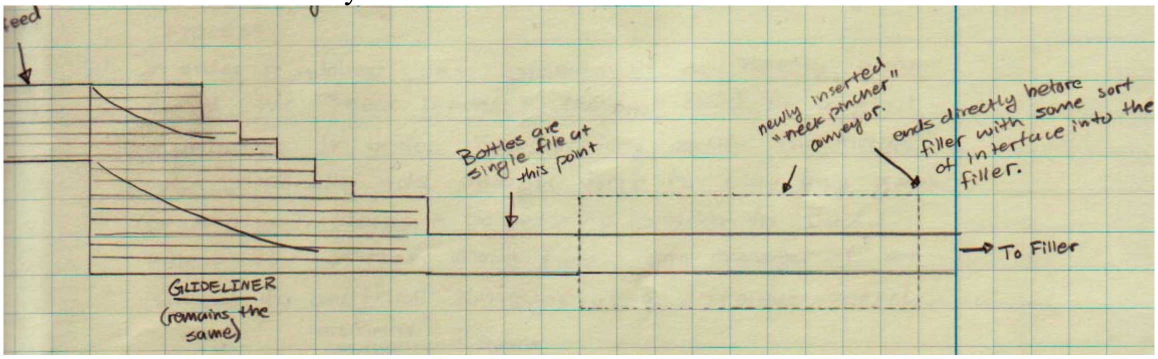


Figure 59 - Possible Neck Pincher Layout

- As you can se from the above figure the bottles are already single file when they enter the new conveyor.
- The "Filler Feed Station" portion would no longer be needed since that is where most fallen bottles are removed from the line.
- Since fallen bottles will exit the line at the beginning of the "Neck Pincher" the length of the new line dose not matter, it could be as short or as long as needed.
- Another possible layout would require very little alterations to the existing line.

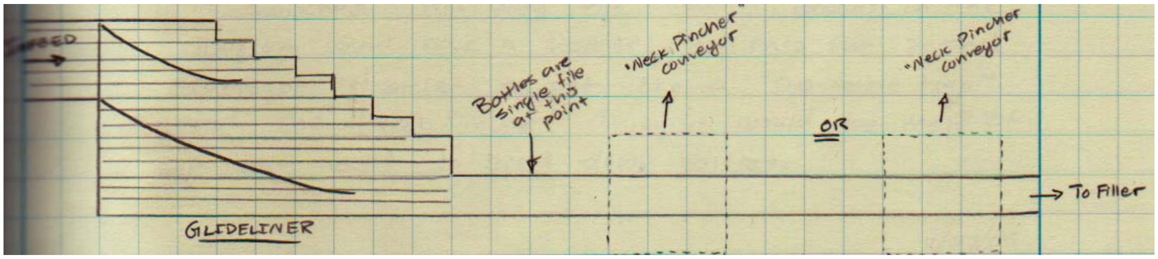


Figure 60 - Possible Neck Pincher Layout

- The two different boxed dotted areas indicate that a small version of the “Neck Pincher” could be placed at any point on the line as a more sophisticated bottle trap then what currently exists. The bottles would travel on the “Neck Pincher” for a very short period of time, only to ensure all down or misaligned bottles have been rejected.
- The locations have their fair share of pros and cons. Having it close will give plenty of time to fill any gaps created before getting to the filler but there is a small chance of bottles falling down after the “Neck Pincher” conveyor. Having the “Neck Pincher” closer to the filler will have just the opposite. It will ensure no bottles make it into the filler in the down position but will not leave much room to close any gaps created during the process.
- In order to address the problem of not having gaps closed the “Nick Pincher” conveyor could be angled downward in order to have gravity assist the motion and hopefully add enough force to close any gaps. Could also implement something similar to Bud’s where the bottles move from one conveyor at one speed to another conveyor at a different speed.
- There is already a location after the Glideliner where the bottles pass from one conveyor to another that could be used for the second process in the diagram.
- Assuming the “Neck Pincher” conveyor doesn’t create any gaps in the bottles the positions of the two could be switched. This way the second process in the diagram could have a steeper turn onto the second conveyor in order to act like a “Pre-Bottle Trap” and the “Neck Pincher” conveyor would be more of a last resort to eject down bottles.

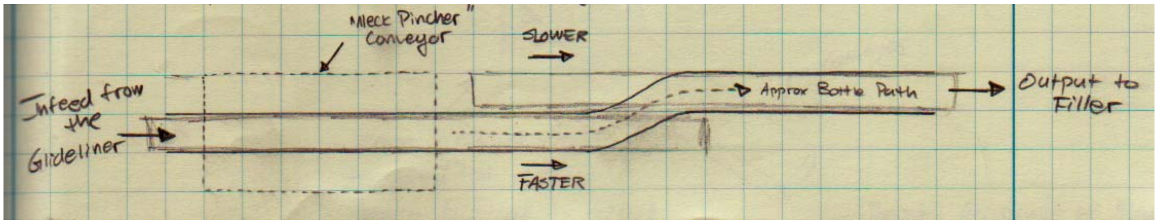


Figure 61 - Possible Neck Pincher Layout

- Active Down Bottle Rejecter
  - There are sensors installed currently that don’t seem to assist in removing down bottles, even though they are currently set up to detect down bottles and possibly trigger a reaction.

- This concept would be located directly after one of the Photo Eyes, once the bottom sensor is activated and the top two are not, indicating a down bottle a mechanism attached to a timer will trigger pushing the down bottle out of the line.
- One possible design concern is the speed in which the mechanism must operate, taking into account the interface of the mechanism with the bottle to ensure the glass does not shatter during the ejection. Also the travel the mechanism must go through needs to be taken into consideration.
- Rough Sketch:

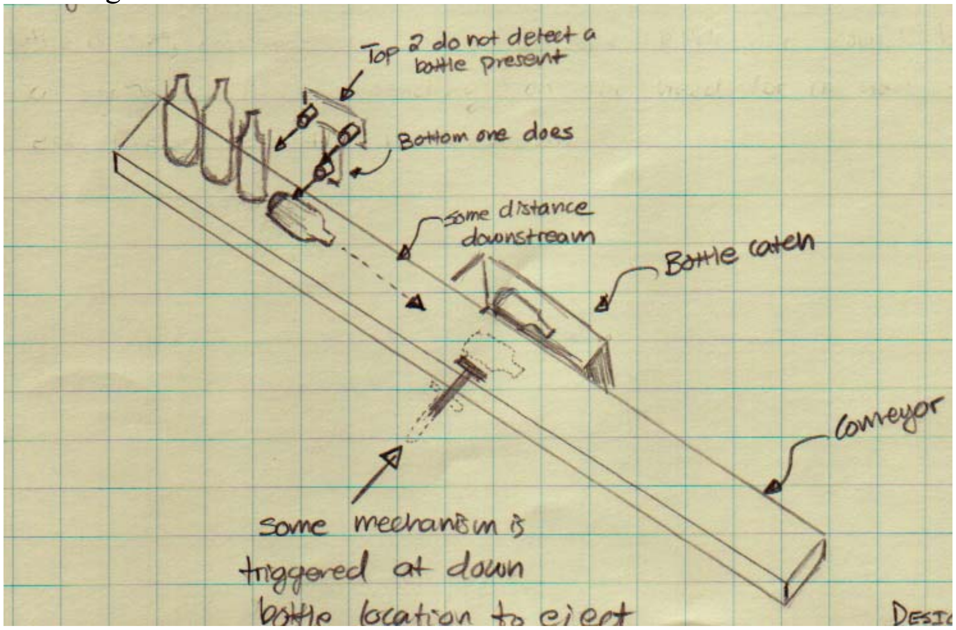


Figure 62 - Active Mechanism

- Removing a bottle with this method will obviously create a gap in the line which will need to be removed. There also needs to be a determination if actively removing the bottle will cause a bottle on either side of the down bottle to fall due to back pressure. There would be a check for a down bottle later in the line to ensure the ejection was a success, if it was not a success then the filler and conveyor would adjust accordingly and stop if the need arose for it.
- A similar method was discussed during the 11/28/05 PQP meeting which would involve an active mechanism such as this one but would not focus on ejecting the bottle fully. We believe the flying wedge needs the bottle to be laying down perpendicular to the conveyor belt in order to eject the bottle. With this we think that if an active mechanism focused on re-orientating a down bottle in order for the flying wedge to remove it would prove to be a benefit. Granted if the mechanism did fully eject the bottle it would be equally as good as the flying wedge removing it. This method would limit the complexity of the active mechanism while using devices currently implemented on the Gallo line. This device would have to be placed after the Photo Eye and before the flying wedge in order to work in this proposed way.

- Steep Curve Fix Method
  - From observing the methods used at the Bud plant in Merrimack, NH a possible fix to the current line became apparent. Where the bottles move from the "Acceleration" segment to the "Intermediate" segment there is a small curve to obtain this lane switch. Bud has a similar segment directly before their filler that is not only used as a gap remove but a final resort to eject down bottles. AT Gallo, based on the pictures we have, the curve looks very minimal which would not allow a bottle to eject while making the lane switch.
  - This fix would propose increasing the bend in the rails at the lane switch in order for the bottle to eject straight off the motion of the "Acceleration" conveyor.
  - Rough Sketch:

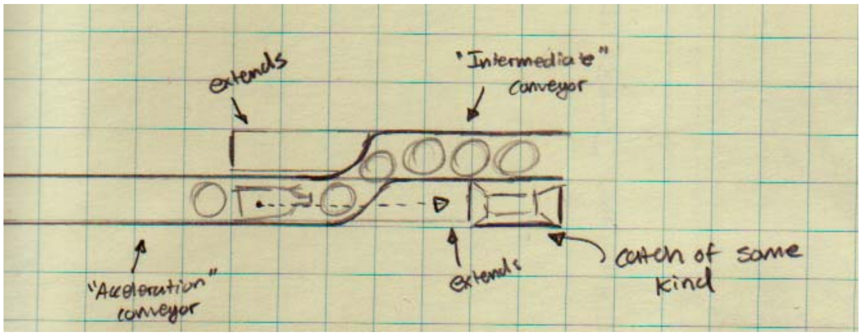


Figure 63 - Steep Curve Fix

  - The down bottle could either continue sliding off the conveyor and into the trap directly after or a curved rail could direct the bottle off the side of the conveyor as the current traps are used.
  - This method would be located a good distance from where the bottles leave the Glideliner as a single file.
  - This method would be added to the existing traps and no existing methods would be removed. Could be added in conjunction with another new method if the need arises.
  - Method is very simple and straight forward but testing would need to be done in order to determine the effectiveness of the change.

- Angle Ejector Method

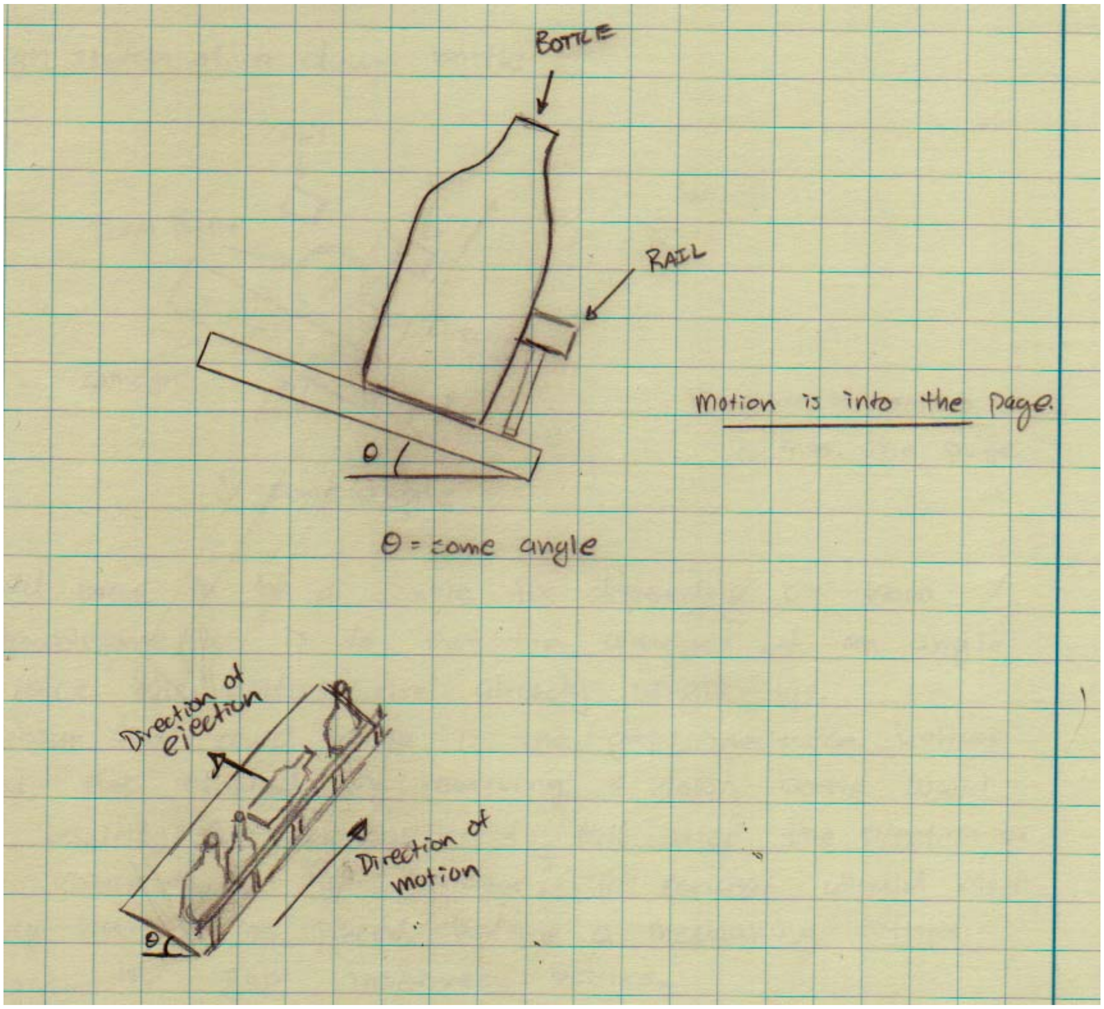


Figure 64 - NY Polar Method

- Based of an existing method used currently by the New York division of Polar Beverages where they remove one of the rails and tilt the conveyor as shown in the pictures above.
- This method would propose using the tilted conveyor but keeping both rails around the upright bottles and just high enough to allow the fallen bottles to slide underneath.
- This concept could be used in conjunction with an active mechanism to eject the down bottles or as a stand-alone bottle trap.
- Rough Sketch:

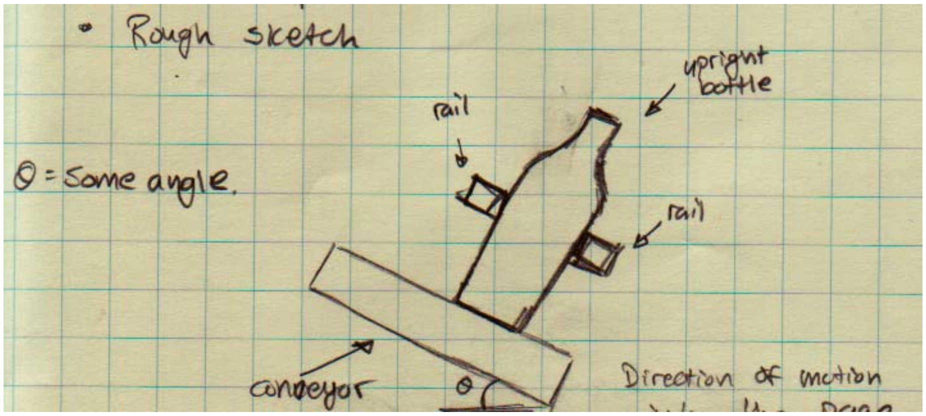


Figure 65 - Angle Ejector 1

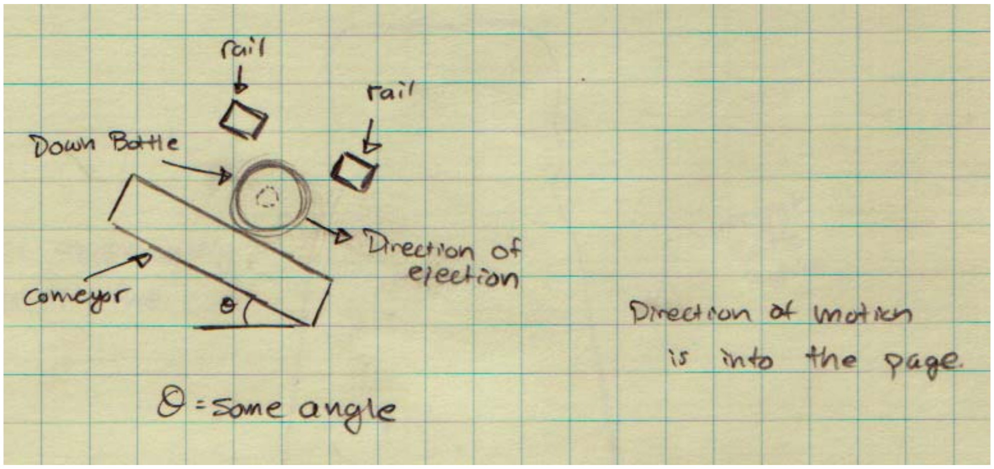


Figure 66 - Angle Ejector 2

- Could prove to be a simple fix depending on how troublesome it is to put the conveyor at an angle once the bottles are already single file.
- One issue that could arise is the gaps in-between bottles that are created by removing a down bottle. Would the resulting gap cause bottles to fall after the ejection on the return to a flat conveyor? The concept would most likely have to be placed before a mechanism that closes the gaps in-between bottles.

Appendix I

Design Review Agendas

- **Design Review #1 – January 17th, 2006**

Contacts Made

- Tom Booz
    - Beverage Department

- Mike Warren
    - Bottling Maintenance Controls
- Ingo Kirsten, KRONES

- Kent Vos
    - Packing Technology & Engineering

Contacts to be Made

- John Shulz
    - Bottling Maintenance General
- Companies with Glideliner installs
    - Mondavi
    - Anheuser Busch
- Maintenance team lead(s)
    - Carl Bennet
    - Mike Black
- Loel Peters
    - Bottling Maintenance Controls

Problem Areas in Focus

- Bottle Traps
    - Improvement / repairs to current traps
    - Opportunity for new traps
- Glideliner (no longer “pressure less” single filer)
    - Investigate the reason for not being pressure less
    - Possibilities of removing the 9 degree slant
- Maintenance issues
    - Address the trap before the filler and its rails
    - Bumps in conveyors
- Lack of historical data and information
    - Major milestone changes

Information Obtained During the First Week

- Glideliner is supposed to be a “pressure less” single filer according to KRONES
- The problem does not exist only in the portion in and around the Glideliner, there are major problems with the packager and the labeler
- Based on data obtained during a 24 hour period more bottles fall before the Glideliner as opposed to at or after
- Most of the “experts” on Line 11 have left Gallo
- Many changes have been made to the rails on the Glideliner over time, not always made with proper calculations

- KRONES has not been to see the line in at least 3 years
- The flying wedge does eject bottles
- Line 17 uses a similar pulling method as AB in Merrimack, NH
- Flying wedge pinches bottle on the right side
- Sensor directly before wedge has a possibility of interfering with the effectiveness of the flying wedge
- There are other companies in the area running Glideliners with both empty and full bottles

Questions to Answer

- Glideliner
    - Why were the rails changed from weight blocks to a full rail on the Glideliner?
    - Why is it no longer a pressure less single filer?
    - What will changing the rail orientation do for the process?
    - Is there any space available to extend the Glideliner?
    - Will removing the 9 degree slant and creating a "pulling" instead of "pushing" conveyor be beneficial to the process? Is it worth the effort needed to make the change?
- Controls
    - Which sensors are operational? Why are some not operational?
    - What was the reason for increasing dosing speeds?
- Dosing Areas
    - Are there possibilities for down bottle removal before approaching the Glideliner area?
    - How many down bottles occur before the twist washer? Can the problem be more contained?
- Traps
    - Will implementing the new trap with the abrupt geometry change pose problems? What would be the most optimal geometry for the rails?
    - Will making new rails pose new problems instead of solving old ones?
    - What is the cost benefit of fixing the current rails as opposed to creating new ones?
    - Can the current traps be fixed to work well enough to keep the filler efficient?
- Maintenance
    - What is the current maintenance schedule for Line 11?
    - What have been some of the major changes to the line (before the filler) in the past year or two?

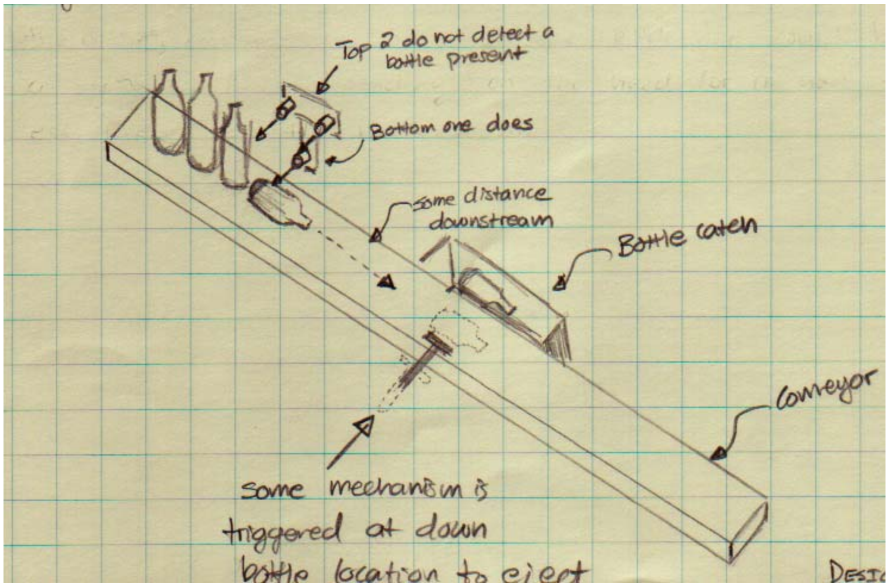
Possible Approaches

- Fix existing traps, primarily the trap directly before the filler
- Add new traps in the Glideliner area
- Develop a method for removing bottles in the Dosing areas

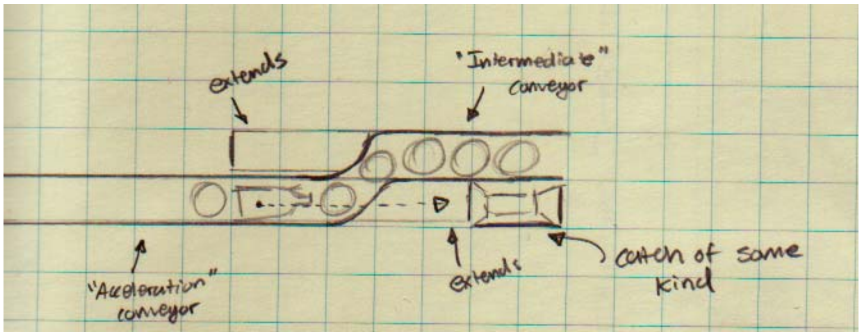
- Remove the 9 degree slope and propose an entire redesign of the line to achieve a pulling conveyor system as opposed to a pushing
- Adjust the rail orientation in the Glideliner area
- Speed and controls adjustment
- Reverting back to old methods of a pressure less Glideliner

Possible Design Concepts

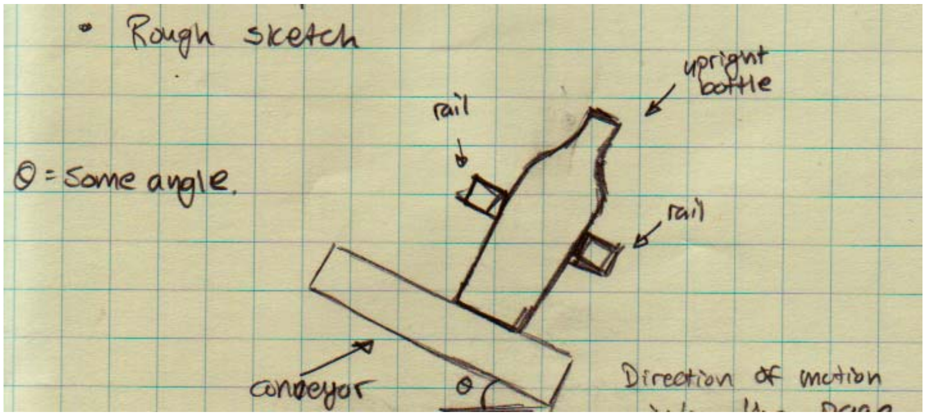
- Active Down Bottle Rejecter

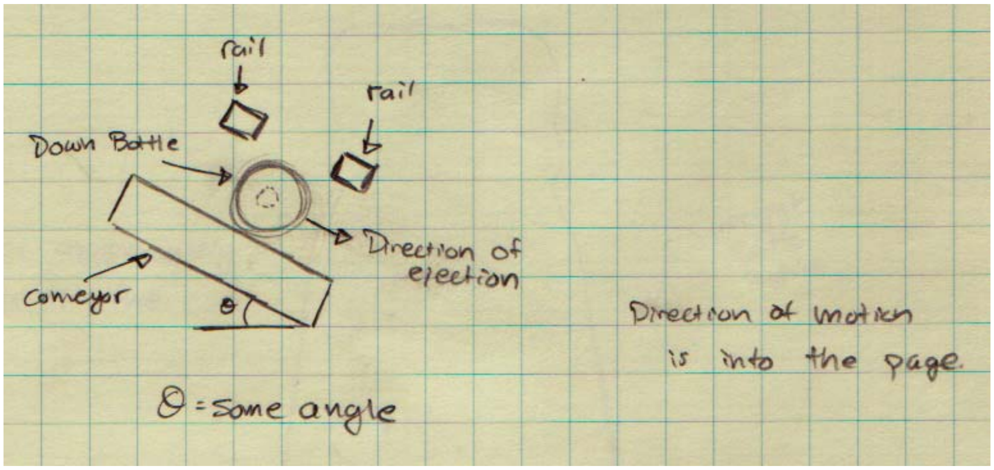


- Steep Curve Fix Method

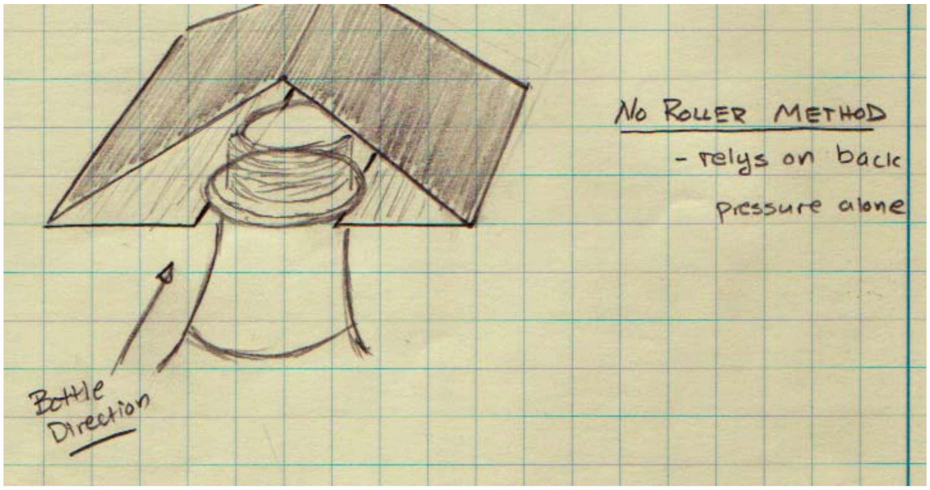


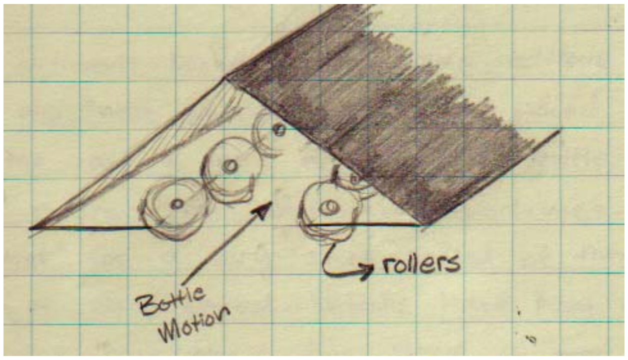
- Angle Ejector Method





- Neck Pincher Method





- **Design Review #2 – January 27th, 2006**

Problem Areas in Focus

- Bottle Traps
    - Improvement / repairs to current traps
    - Opportunity for new traps
- Glideliner (no longer "pressure less" single filer)
    - Investigate the reason for not being pressure less
    - Possibilities of removing the 9 degree slant
    - Possibility of removing all together and stay single file out of the twist washer
- Maintenance issues
    - Address the trap before the filler and its rails
    - Bumps in conveyors
    - Rail configurations from twist to filler
- Lack of historical data and information
    - Major milestone changes

Things Learned Since Last Review

- Backpressure before twist is quite small, around 3.52 lbs, still need to determine backpressure number for the single file portion after the Glideliner
- Still no one seems to know why Glideliner rails were changed to create a pressurized system
- According to operators they have a hard time deciphering if the rail change has been good or bad at the Glideliner
- One operator claims a man by the name of John changed the rails (maintenance guy), first assumption would be John Schulz but he didn't mention changing the rails when I spoke with him
- Bottles really don't fall AT the Glideliner, down bottles in the Glideliner are a result of the Dosing areas where the majority of the bottles fall before the filler

- Bottles falling in the Dosing areas that travel into the Glideliner cause more down bottles at the Glideliner but from observations all bottles that pass through the Glideliner get ejected
- Down Bottle Test
    - Total Down Bottles: 218
        - Before Twist: 88
        - Dosing Areas: 102
        - Glideliner: 28
    - Total Down Time: 101 minutes
        - Planned Down Time: 52 minutes
        - Unplanned Down Time: 49 minutes
    - Large number of down bottles in dosing area is a result of one instance where multiple bottles fell down and caused a chain reaction of other bottles falling, took three operators to clear out the down bottle problem before it got to the Glideliner

Observations

- Most down bottles in the Glideliner stem from the down bottles in the dosing areas, most don't fall in the Glideliner on their own
- Traps do work but doesn't seem like many bottles make it there, they seem to fall at the traps at low speeds due to starting/stopping of filler
- Jogs in the line seem to be the trouble spots leading up to the wedge/single file area
- Necking process is very short compared to others at lower speeds
- Directly after the twist a lot of bottles fall due to lack of packing, why not adjust controls to keep the dosing areas packed?
- The trap before the wall and the wedge work, trap before the wall took two bottles down on top of each other and ejected them. Wedge ejected one that was standing up and shot out the top
- Bottles down in the Glideliner sometimes have trouble ejecting underneath the rails due to improper heights

Questions to Answer

- Glideliner
    - Why were the rails changed from weight blocks to a full rail on the Glideliner?
    - Why is it no longer a pressure less single filer?
    - What will changing the rail orientation do for the process?
    - Is there any space available to extend the Glideliner?
    - Will removing the 9 degree slant and creating a "pulling" instead of "pushing" conveyor be beneficial to the process? Is it worth the effort needed to make the change?
- Controls
    - Which sensors are operational? Why are some not operational?

    - What was the reason for increasing dosing speeds?
- Dosing Areas
    - Are there possibilities for down bottle removal before approaching the Glideliner area?
    - Can the problem of down bottles before the twist washer be more contained?
- Traps
    - Will implementing the new trap with the abrupt geometry change pose problems? What would be the most optimal geometry for the rails?
    - Will making new rails pose new problems instead of solving old ones?
    - What is the cost benefit of fixing the current rails as opposed to creating new ones?
    - Can the current traps be fixed to work well enough to keep the filler efficient?
- Maintenance
    - What is the current maintenance schedule for Line 11?
    - What have been some of the major changes to the line (before the filler) in the past year or two?

<u>Possible Approaches</u>

- New Ideas
    - The twist is single file, why go back to a packing formation? (Stephan)
    - Remove jog in the lien and the 9 degree slope and head straight into the filler
    - Rail maintenance at trap before filler, straighten it out and replace white rails with newer ones
    - Remove trap before filler, get a better hold of bottle at single file, improve down bottle sensor after the wall, make path to filler from the wall a straight shot and improve trap before wall
- Add new traps in the Glideliner area
- Develop a method for removing bottles in the Dosing areas
- Remove the 9 degree slope and propose an entire redesign of the line to achieve a pulling conveyor system as opposed to a pushing
- Adjust the rail orientation in the Glideliner area
- Speed and controls adjustment
- Reverting back to old methods of a pressure less Glideliner

Appendix J

ProEngineer Drawings

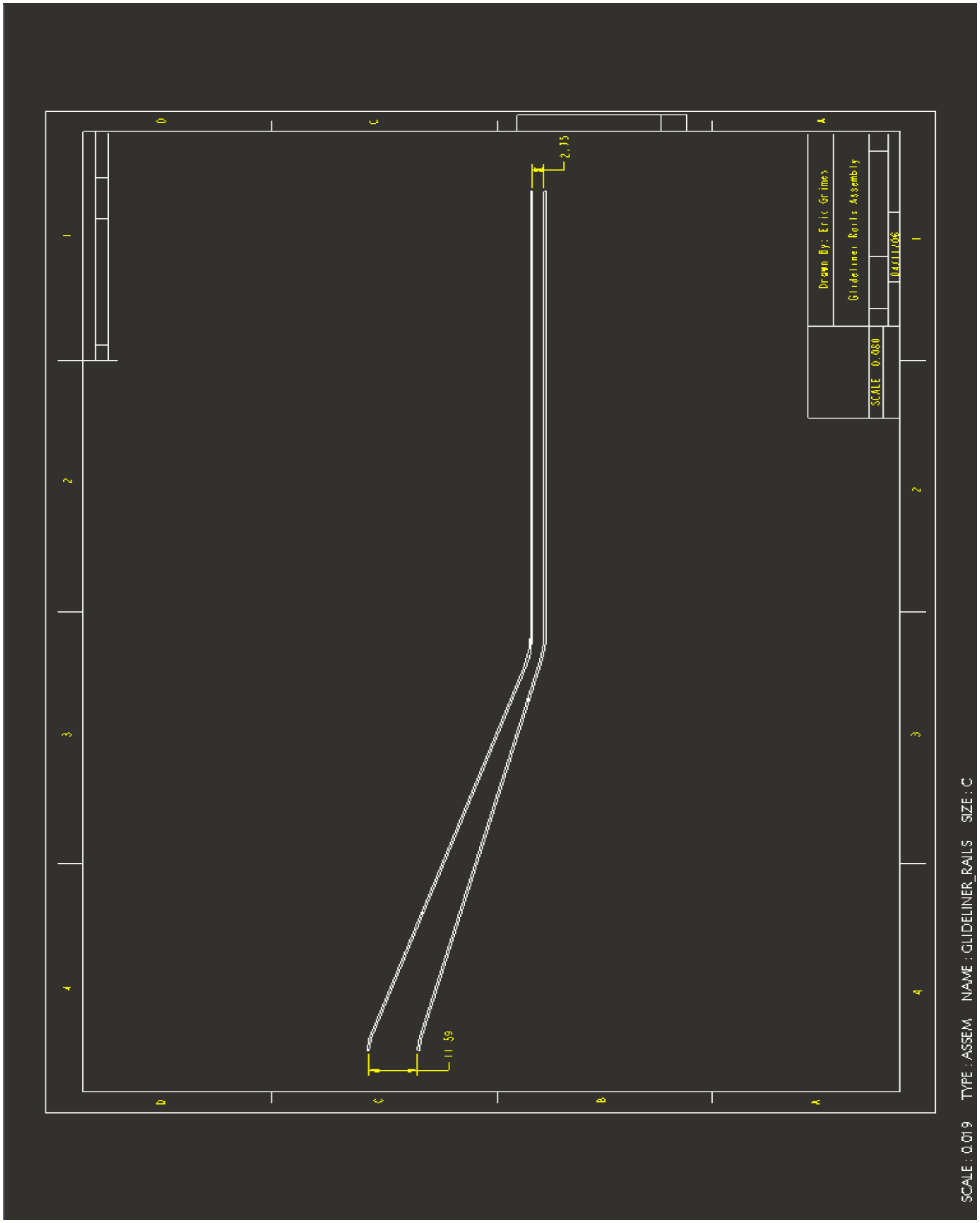


Figure 67 - Assembly Drawing of Glideliner Rails

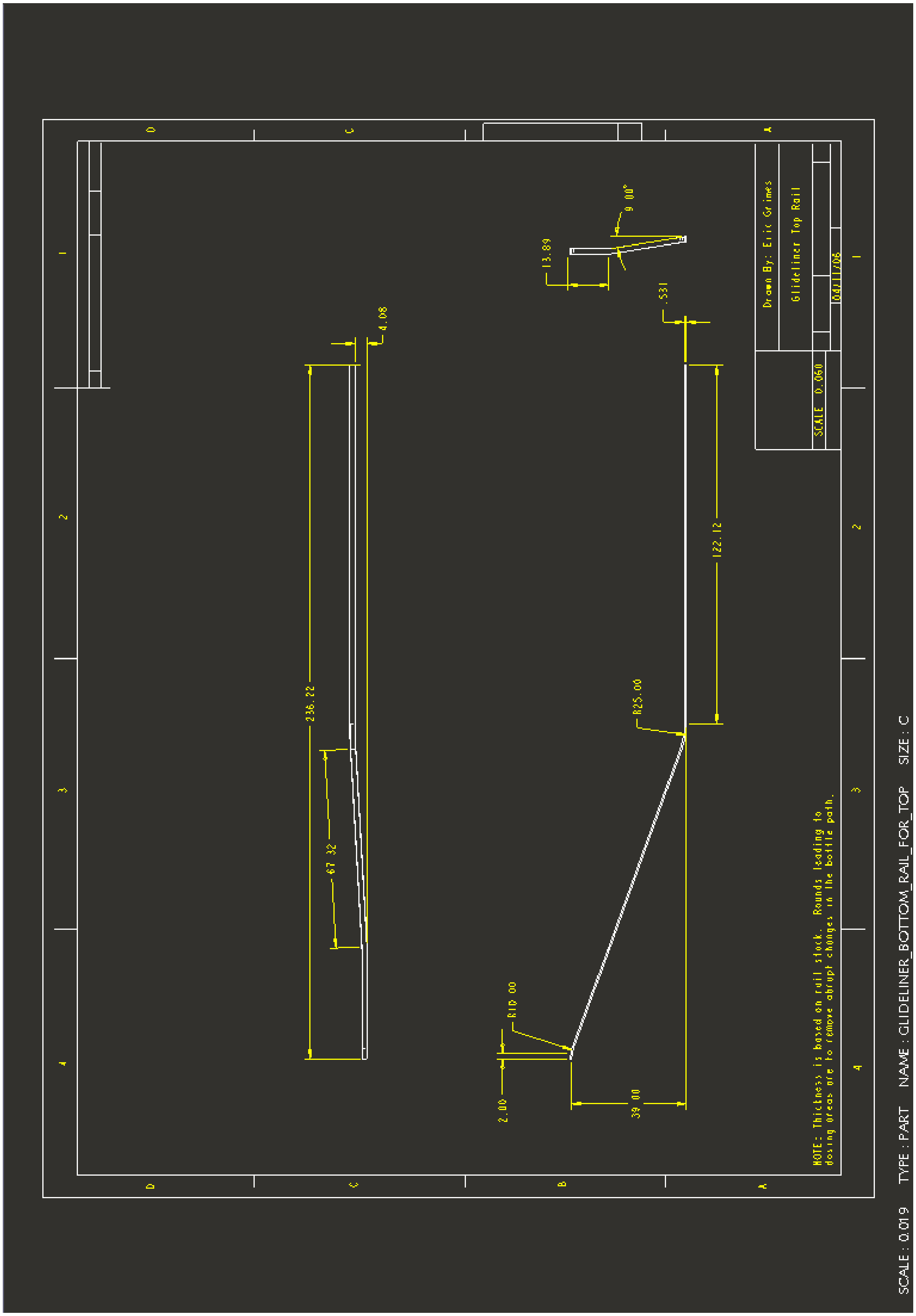


Figure 68 - Drawing of Top Rail

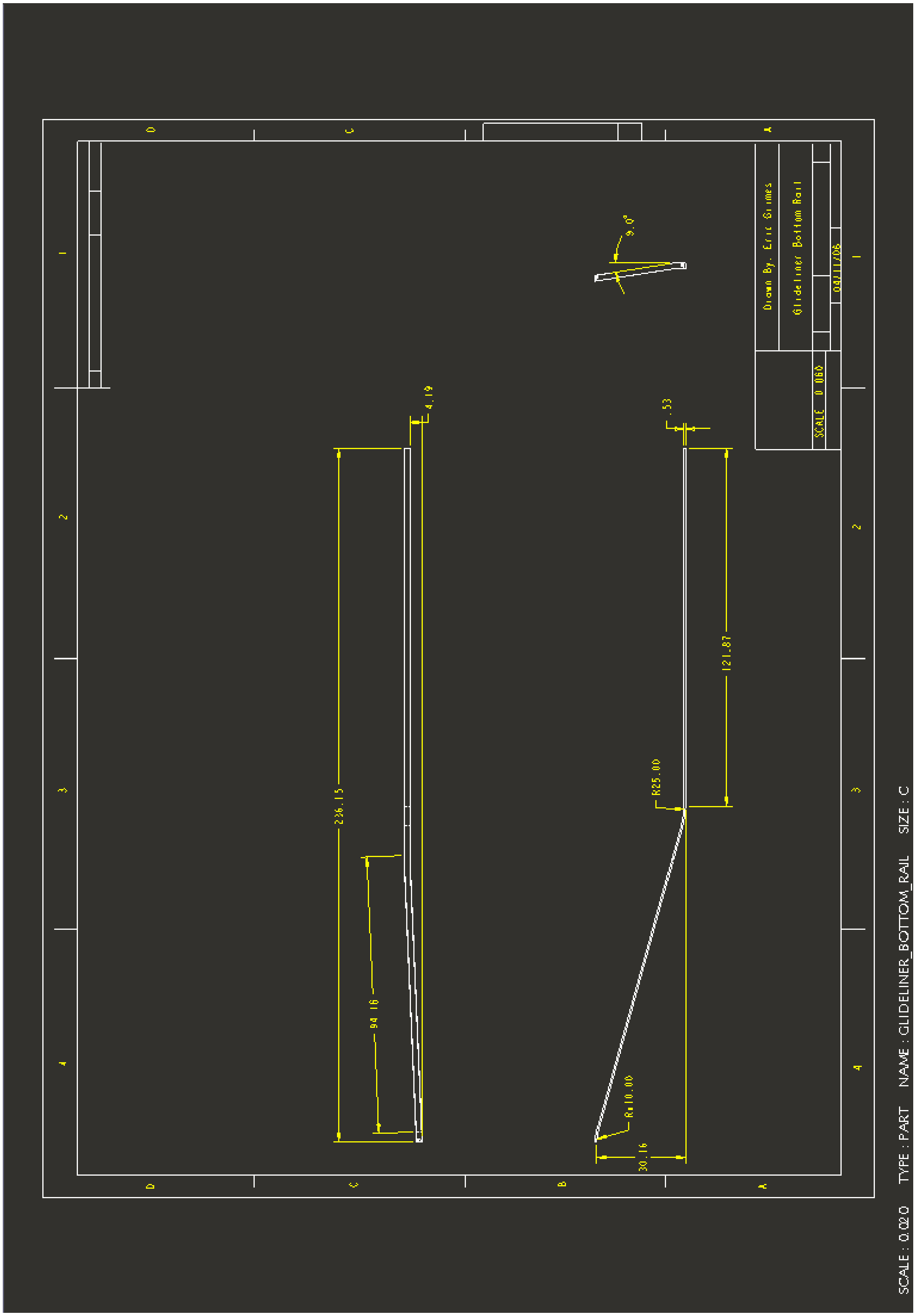


Figure 69 - Drawing of Bottom Rail