WINE CLUB SHIPMENT PACKAGE REDESIGN

by

EMILY E. PRESCOTT

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Checked by:_________________________ Approved by:_______________________

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Abstract

This report shows the design, manufacturing, and testing process for the product development of a wine club shipment package for Niner Wine Estates. Niner has two different shipment sizes, 4 bottles and 6 bottles, and wishes to improve their current package by giving it a more "high-class" feel. After the new package was designed and prototyped, it went through standardized quality testing to be cleared for commercial use. This testing is intended to simulate the distribution cycle the package will experience and subject it to potential hazards such as being dropped and vehicle vibration during transportation.

After the package passed simulation testing, it was then tested for assembly line capabilities due to the large quantity of shipments Niner must send annually. It was found that the 4-bottle package took a standard time of 41.52 seconds to assemble, and the 6-bottle package 48.46 seconds. Taking into account the respective demands of 4-bottle and 6-bottle shipments, this new package took about 76 hours annually to assemble and pack, which would cost Niner approximately $330 in additional labor fees. The new design also requires an additional 520 cubic feet of space for storage, but Niner's current warehousing facility has space available to accommodate for the 30% increase in spatial requirement.

While this new package design requires more time and more material to produce, the benefits of the package are intangible and are up to Niner's discretion. Niner Wine Estates expressed their satisfaction with the final product and is willing to accept the increase in costs in order to improve their brand identity through their wine club shipments.

Introduction

In the wine industry, it may take more than just taste testing to convince a customer to purchase a bottle or two of wine, let alone join a wine club. Once they do sign up to be a part of a winery's wine club, the only compelling factory to stay each year is if they enjoy the quality of each shipment they receive. At Niner Wine Estates in Paso Robles, they are constantly trying to increase their number of new wine club members as well as retain as many members as possible. In order to achieve this, they brand themselves with sophistication and high-class, but feel as though their wine club shipment packaging does not currently reflect the same luxurious level that their brand name deserves.

In order to improve the brand identity of Niner Wine Estate's wine club shipments and provide customers with a shipment that exudes higher class, an innovative primary package will be designed to be an aesthetic improvement and tested to ensure it is structurally sound enough to withstand its shipping environment.

The objectives of this project are as follows:

- Design and prototype a 4-bottle and a 6-bottle wine package
- Test packages against ASTM (American Society for Testing and Materials) standards to meet shipping and containment guidelines
- Test packages for assembly line capability

The objectives result with the following deliverables:

1. Prototyped packages
2. Cost analysis of package designs
3. Results from ASTM shipping standards testing
4. Data for assembly line capability

In order to properly meet the objectives and deliverables stated above, each package will first be designed and prototyped until it meets the aesthetic need. Next, it will be tested using shipping simulation and package quality testing machinery. Values obtained from testing will then be compared with ASTM standards to see if the prototyped package meets the predetermined requirements for shipment. Any redesign and retesting will be done if necessary until the product meets said requirements. When the final package is complete, a cost analysis of the product will be conducted and time studies on package assembly will be done in order to ensure that the package design will be suitable for a fast-paced, high-output environment.

The following report will discuss the background of the project, the design process, the experimentation and testing, cost implementation of the project, and finally an analysis on the new design.

Background

Niner Winery currently has two options for wine club shipments: cases of 4 bottles or cases of 6 bottles. The winery makes three wine club shipments per year, and having around 2,000 wine club members, that makes around 6,000 packages that need to be assembled and shipped annually, which means ease of assembly is key. The current shipping method is placing the bottles in the expanded polystrene molds shown on the following page in **Figure 1**, then stacking the molds on top of each other and placing them in a final box for shipping.

Figure 1 - Niner Winery Current Shipment Method [15]

This method focuses on the safety and security of the bottles during transportation, and less about the aesthetics and brand appearance of the shipment. Niner Winery wishes to change the concept of the shipment from simply being about sending bottles to being about sending a complete package. Being in a wine club is an exclusive membership; they want the packaging that the bottles are shipped in to reflect as such, but maximizing aesthetics and minimizing costs can be difficult. The current method uses about 11.56 square feet of corrugated fiberboard and weighs about 1.38 pounds. In addition to the corrugated fiberboard outer packaging, Niner also purchases thermoformed polystyrene molds that are custom-made to fit their packaging design.

When any product is shipped, the primary package that holds the product must go through testing to see if it meets predetermined standards that are stated by the American Society for Testing and Materials (ASTM). These ASTM standards state specific values that packages should meet in simulation testing if they are going to survive the shipment process. Some of these include vibration, shock, drop, crush, and incline impact testing. If a package is to go through one of these testing methods, it is prototyped multiple times and many data points are

collected in order to see if, on average, the package meets or exceeds the values stated in the ASTM standards. Due to the fact that the packages for this product are also intended to be an aesthetic improvement as well as the primary shipping containers, it is important that the packages are tested to be structurally sound and protective while also being visually pleasing to market the wine bottles inside.

Literature Review

Before delving into the package design and experimentation, it is important to understand the need for the product and if there has been any research or experimentation with this type of product before. In order to optimally design this package, it is important to understand more about the environment the package will be in, the purpose the package is supposed to fulfill, and the necessary quality standards the package must meet.

Shipping Wine

Majority of wine shipment packages are shipped using corrugated fiberboard, more commonly known as cardboard. Corrugated fiberboard comes in many different shapes and sizes, one option being what board style it is. The three main board styles are singleface, single wall, double wall, and triple wall, shown below in **Figure 2**.

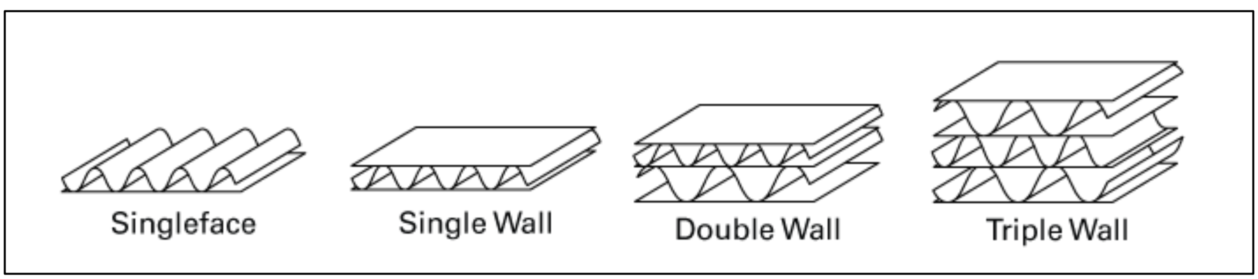

Figure 2 - Corrugated Board Styles [12]

Singleface, most commonly seen in coffee cup cozies, has minimal structural properties and is mainly used for its insulation or barrier properties. Single wall is the most commonly used type of corrugated fiberboard. While it has a wide range of uses, it is mostly used in packaging and shipping [17]. Double wall and triple wall are used when strong structural properties are essential. In addition to being offered in different board styles, corrugated boards are also offered in many different sizes of fluting, which is the arched, thinner layer in between the two outer walls. Larger flutes provide more strength and cushioning, while thinner fluting provides better printability and crisp folding. The most common flute sizes can be seen below in **Figure 3**. Flute C is the most commonly used flute size for shipping packages due to the fact that it's not too large of a flute, meaning it still has printable and foldable qualities, but the flute is still large enough to be structurally sound.

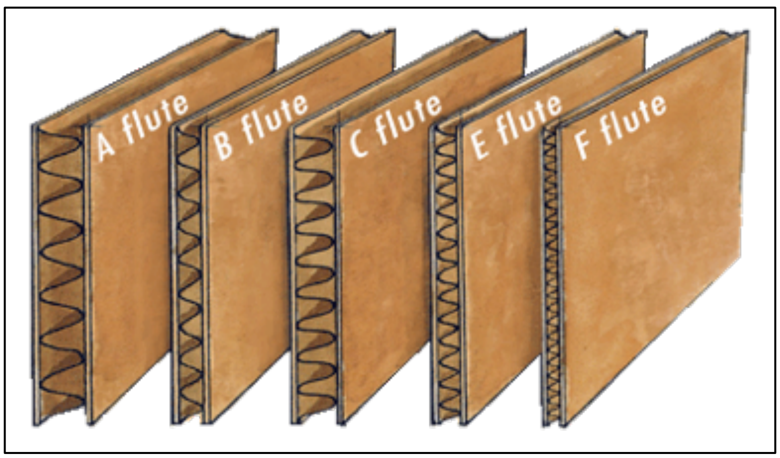

Figure 3 - Corrugated Flute Styles [11]

Because this product will be a standard shipping package, there is no need for anything more than single wall corrugated board. As for fluting, while C flute is most commonly used for shipping packages, this package design is expected to be more intricate than a standard box in order to obtain a high class and expensive appeal. B flute will be used, as it is the next size smaller from C flute; it still has good structural properties but can be folded cleaner and easier.

In addition to corrugated fiberboard, the packages will also need to be insulated in order to ensure the temperature of the wine does not greatly fluctuate during shipping. Long-term exposure of wine to heat can be detrimental to its sensory properties as well as to its physical and chemical stability, ranging from leaking bottles and pushed corks to a cloudy appearance [9]. If the wine itself is not damaged by heat, high temperatures can potentially alter its aging characteristics. In a recent study, 12-bottle wine cases were placed in a truck for shipment; some cases were placed under a thermal blanket to be protected from heat and others were left unprotected. The truck was subjected to temperatures from -13°C to 44°C. Data loggers in the bottle of wine showed the unprotected wine fluctuated from -13°C to 44°C, while the protected wine only fluctuated from 0°C to 27°C [9]. It can be concluded from this experiment that it may not be necessary for each individual bottle to be insulated, but simply the package as a whole.

As stated earlier, Niner Winery currently insulates their packages with expanded polystyrene molds. Expanded polystyrene is the most cost-effective and efficient material to use for insulation. Expanded polystyrene is cheaper, lighter, and insulates better than most other materials [14]. Polystyrene tends to be more difficult to recycle; many recycling centers will not accept polystyrene because of its very specific recycling process. This results with polystyrene ending up in the trash, filling landfills. Polystyrene does not biodegrade as quickly as other materials, which make companies look for a more recyclable, environmentally friendly option [15]. Some companies have found other alternatives, such as an "ultra-insulated" padding made from purified, recyclable, biodegradable absorbent cotton-enhanced textile fibers sandwiched between two layers of poly film [18]. The layer of poly film that comes into contact with the product is perforated in order to draw in and absorb any condensation the product may produce. This alternative may be slightly more expensive, but its recyclability makes it more appealing.

Due to the large volume of wine club packages that need to be shipped, the designed packages must be easy to assemble and pack. Minimizing glue and assembly steps is key to ensure the packages can be put together quickly. A package that takes 1 minute to assemble may not seem like much, but after assembling 2,000 packages, time adds up, and saving time saves money. In addition to easy assembly, the packages must also be able to break down and lay flat. The large quantity of required shipments means a large number of boxes, ergo the flatter and more convenient the packages can break down, the easier they will be to store in large quantities.

While the packages need to be light and convenient, it is also important that they are sturdy enough to carry 6 wine bottles. Wine bottles come in many sizes, but the most common are 750ml, 1000ml, 1500ml, 2000ml, and 3000ml. Out of those sizes, 55.5% of wines that are sold at 750ml, 10.5% are 1000ml, 31.1% are 1500ml, the rest being at or under 1% each [10]. Due to the fact that the most common sized bottle of wine is 750ml and wineries primary sell 750ml bottles, this size will be focused on for the package design. In addition to coming in different sizes, wine bottles also come in different materials. When it comes to 750ml bottles, 99.5% are made of glass and 0.5% are made of PET (polyethylene terephthalate). Other size bottles, like 1000ml, are also provided in an aseptic carton [10]. Due to the fact that majority of 750ml bottles are glass, more caution and care needs to be taken during shipping to ensure that no damage is done to the product during transportation. For something as fragile as wine bottles, it is important that during quality and standard testing that the package is tested in multiple different scenarios to ensure that it has the highest probability of surviving transportation with minimal to no damage. In order to have a standard to test to, all packages will be tested against ASTM standards.

ASTM Standards

The American Society for Testing and Materials is one of the largest voluntary standards developing organizations in the world. ASTM acts as a basis for the development and publication of international voluntary consensus standards for things such as materials, products, systems and services [1]. ASTM standards are categorized into 6 different areas:

- A – Ferrous metals and products
- B – Nonferrous metals and products
- C – Cementitious, ceramic, concrete, and masonry materials
- D – Miscellaneous materials and products
- E – Miscellaneous subjects
- F – End-use materials and products
- G – Corrosion, deterioration, and durability of materials and products.

Category D is used for packaging and shipping standards. Overall, ASTM D4169 is a "Standard Practice for Performance Testing of Shipping Containers and Systems". Within ASTM D4169, it describes different potential hazard elements a shipping container can experience and how to test under those conditions, which can be seen below in **Figure 4**,.

Schedule	Hazard Element	Test
A	Handling—manual and mechanical	drop, impact, stability
B	Warehouse Stacking	compression
C	Vehicle Stacking	compression
D	Stacked Vibration	vibration
E	Vehicle Vibration	vibration
F	Loose Load Vibration	repetitive shock
G	Rail Switching	longitudinal shock
H	Environmental Hazard	cyclic exposure
I	Low Pressure Hazard	vacuum
J	Concentrated Impact	impact

Figure 4 - Simulation Tests for Package Hazards [1]

Based on the distribution cycle the package will undergo, ASTM D4169 provides a list of 18 different Performance Test Schedule Sequences, which can be found in **Appendix A, Figure 11**. These schedule sequences provide the order Schedules A through J should be conducted in in order for the package to experience the different hazards listed in an order that it would likely experience them during transportation. Based on the distribution cycle and required package characteristics, this wine bottle package will follow the schedule sequence of distribution cycle 3, "single package without pallet, less than truckload motor freight". This distribution cycle is as follows:

1. Schedule A – Handling (manual)
2. Schedule C – Vehicle Vibration
3. Schedule F – Loose-Load Vibration
4. Schedule J – Concentrated Impact
5. Schedule A – Handling (manual)

This distribution cycle is intended to simulate the environment the wine bottle package would experience during shipping. First is handling, which simulates worker handling of the packages and manual loading into trucks for transportation. Next, vehicle vibration simulates the random vibration a package will experience during motor transportation, and loose-load vibration simulates the vibration a non-palletized package will experience. If the packages were palletized, it would have followed Schedule D, stacked vibration. During stacked vibration, a package experiences both static and dynamic forces: static force due to the constant weight of a stacked package, and dynamic force due to the random bouncing and vibration from the vehicle. If the packages are not palletized and is standing alone, they will only be experiencing a dynamic force, hence Schedule F of loose-load vibration. Next the packages undergo concentrated impact

testing, which simulates any impacts the packages may experience during transportation. Finally, the last simulation is handling, to once again simulate worker handling of the packages and unloading from transportation. The wine bottle packages must pass each one of these scheduled tests in order to be cleared for commercial use. If they fail during any test, the distribution cycle testing stops, the packages must be redesigned, and testing starts again from the beginning of the distribution cycle simulation.

Design

In order to design the 4-bottle and 6-bottle wine package, it is important to know what is expected from it and what limitations it may have. First, the intention of the redesign is to provide Niner Winery with a package that has an improved presentation from their current design. This means the package has to be different than other packages; it cannot be just another ordinary box. While it should be a new an innovative design, its primary purpose is to contain and protect the wine inside – if it does not do this, the package cannot be cleared for commercial use. The wine bottles that will fill these packages are 11" tall with a 3" circumference, weighing about 3 pounds each. The 4-bottle package should be able to hold around 12 pounds, and the 6-bottle package should be able hold around 18 pounds.

Package Development

A bottle's preferred shipment method is standing straight up rather than being shipped on its side. In order to prevent the package from falling over during shipment, there should be an even distribution of bottles throughout the package. For the 4-bottle package, this means having the bottles arranged 2x2, and the 6-bottle package arranged 2x3. This will provide a sturdier base for the packages by making a more evenly distributed surface area. If the bottles were arrange

1x4 and 1x6, the chances of the package tipping over during shipping would increase, putting the safety of the wine bottles at risk.

After keeping all of this into consideration, the design concept can be seen below in **Figure 5**. The package would open up like a book, holding and even amount of bottles on each side. This would be able to work for both packages, having either 2 or 3 bottles on each side. One aspect of the package that can make-or-break its commercial use is whether or not it can be assembled easily and stored in mass quantities without taking up too much space. This means it must be able to lay flat and be stackable, while also being a glue-free assembly process to make the packing procedure quick and easy.

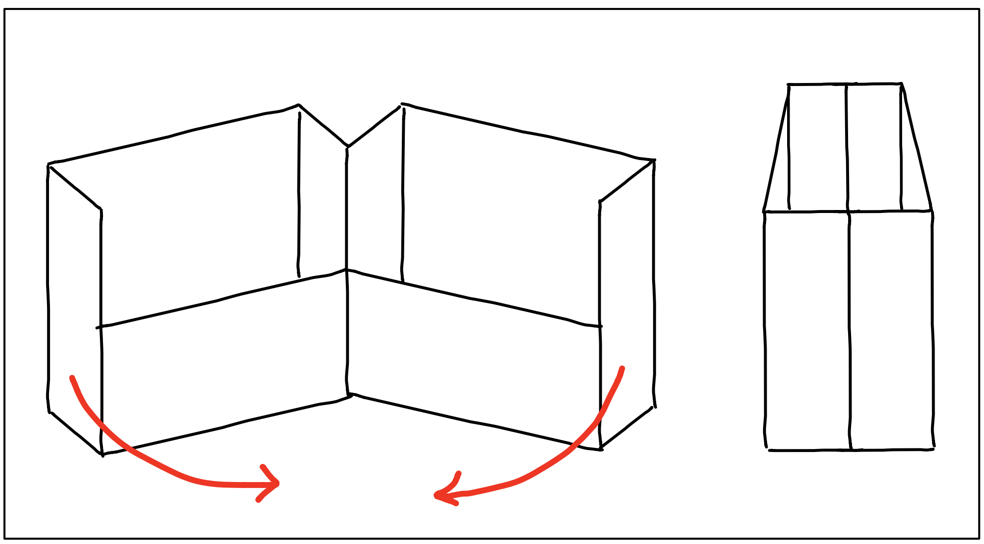

Figure 5 - Design Concept

In order to make the box lay flat and still require no additional gluing for assembly, the bottom of the box will need fold up and into itself. The first dieline that was prototyped can be seen on the following page in **Figure 6**. Only the left side of the "book" shown above in **Figure 5** is shown in the dieline in **Figure 6** in order to make it less complicated and easier to understand. The important faces of the package are numbered in orange and important edges are numbered in red. First, face 5 is folded upward so it lays flush with face 6. Next, face 7 is folded

upward so it lays flush with face 8. Edges 1 and 2 are glued together, and the 45° crease mark, highlighted in blue, allows face 3 to fold up lay flush with face 4, and face 9 to lay parallel on top of faces 3 and 4. Finally, with faces 5 and 7 folded up, the box is folded on the seam between face 6 and face 8, and face 9, while folded on top of faces 3 and 4, is glued to face 10.

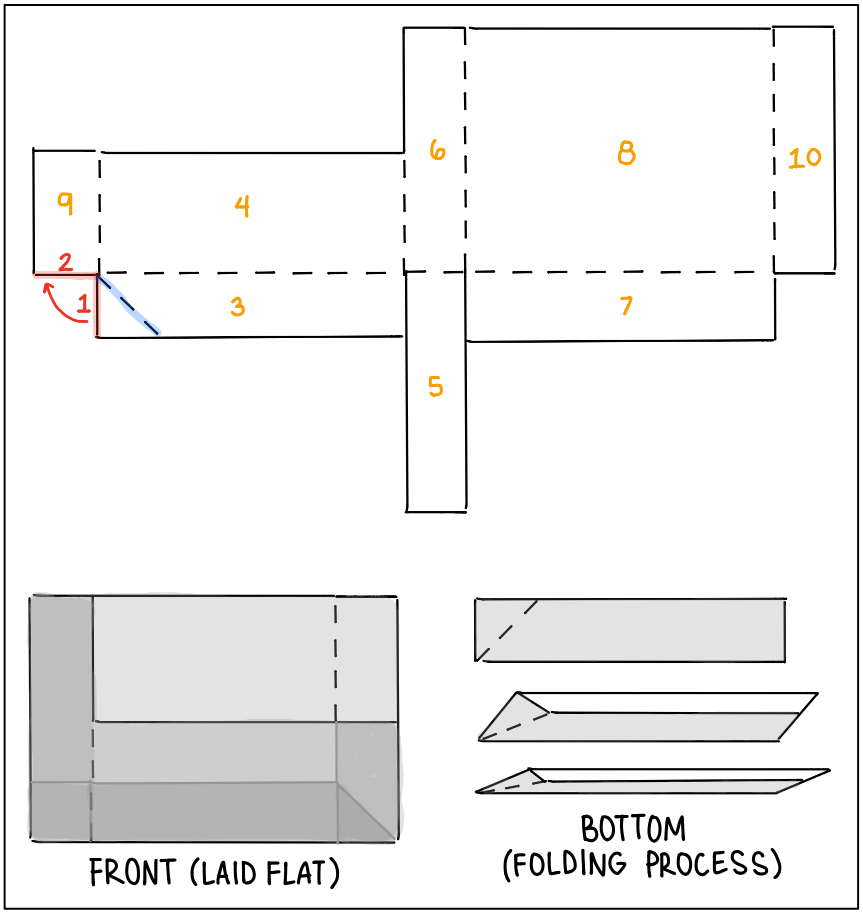

Figure 6 - Initial Design Layout

A transparent view of when the box is laid flat can also be seen in **Figure 6**, along with a bottom view of the folding process. Faces 5 and 7 are to reinforce face 3 and prevent the package from bottoming out under the weight of the wine bottles. For assembly, opposite corners of the box are pushed together, making face 3 pop down and into place. Face 5 and face 7 are then folded down to reinforce the bottom surface and help the package maintain its shape. Because

face 3 is only attached to 2 out of 4 sides of the bottom, both faces 5 and 7 are necessary in order to reinforce the two remaining sides of the bottom of the package.

After prototyping this initial design, the box did not lay as flat as desired. As it can be seen in the transparent view in **Figure 6** on the previous page, there is a lot of overlap of material near the edges of the box, which prevents it from laying flat. A redesign was done in order to minimize the amount of material used in hopes to make the box lay flatter, making it easier to store in large quantities. The redesign can be seen below in **Figure 7**.

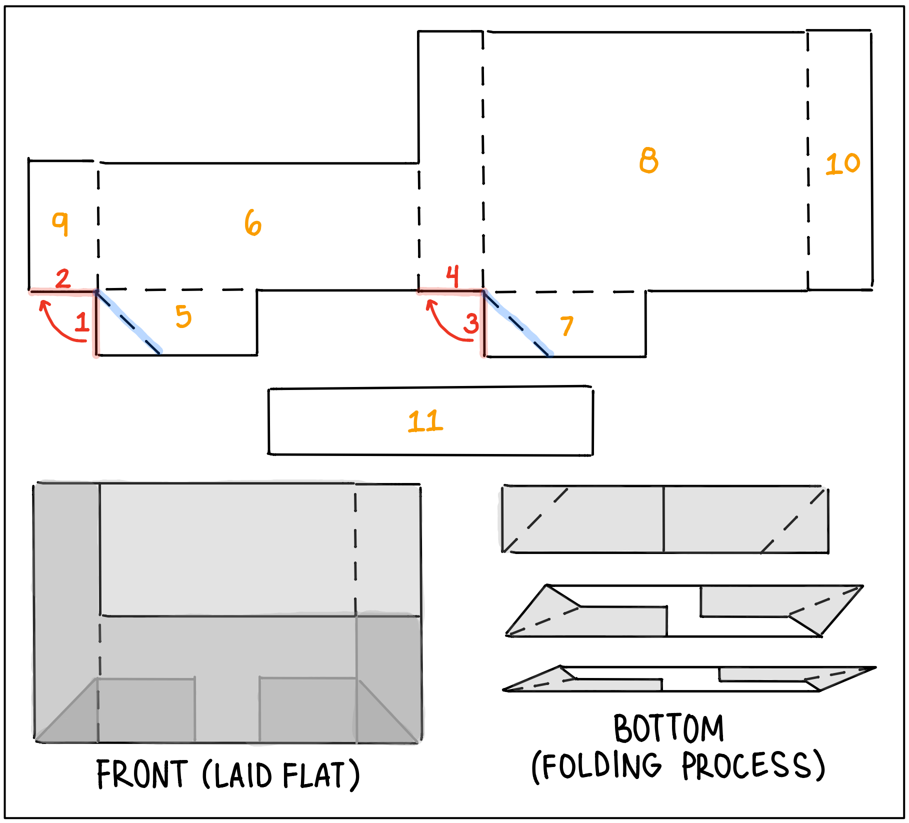

Figure 7 - Redesigned Layout

This new design removes faces 5 and 7 from the old design in **Figure 6**, and splits face 3 in half from **Figure 6** and distributes it evenly across the bottom. As shown in **Figure 7** above, the bottom of the box folds down in a similar manner to the original design, but instead there are now two even faces, 5 and 7 in **Figure 7**, that split taking up the bottom of the box rather than

one long face, like face 3 in **Figure 6**. The redesign is assembled the same way the original design was put together, except instead of there being two connected faces that reinforce the bottom of the package, 5 and 7 in **Figure 6**, there is one separate piece that is inserted after the box is popped into place, face 11 in **Figure 7**. Only one additional face is necessary to reinforce the bottom of the package in this redesign because faces 5 and 7 in **Figure 7** are connected to all 4 sides of the bottom of the package. One additional face, face 11, is all it takes to prevent the package from bottoming out. If neither the initial design nor the redesign had reinforcement faces, a comparison of the resulting bottoming out between each respective design can be seen below in **Figure 8**. The displacement in the initial design in much larger than that of the redesign, therefore justifying the new design of the bottom of the package.

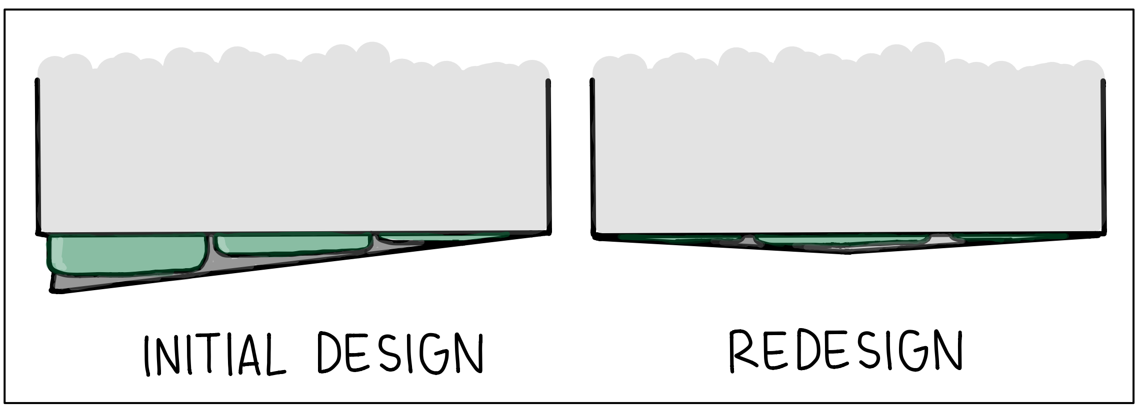

Figure 8 - Displacement of Package Bottom

The next step is ensuring the bottles do not touch each other during shipping – excessive vibration can cause the bottles to repetitively hit each other, putting them at risk for breaking. The bottles will be secured around the body and the neck by placing layers of corrugated fiberboard with holes cut out for each respective bottle, holding them in place. When it comes to insulation, the secondary shipping box that this package will be placed in will be insulated in order to prevent the need for costly insulation that is molded to the shape of the bottles.

Final Design

The final dimensioning of the package, when closed, is 6.5 inches wide, 10.375 inches in length, and 11.75 inches tall. The dimensions of specifically the package dieline can be seen in **Appendix A, Figure 12**. Similar to the current package Niner Winery uses, the same package will be used for both 4-bottle and 6-bottle shipments, omitting the middle bottle from each side in 4-bottle shipments.

In addition to the package, there must be additional cushioning inside in order to prevent the bottles from touching and rattling during shipping. If the bottles were to shift during shipping, their chances of breaking greatly increase. Two reinforcing bottom inserts have been added, as well as two inserts for the necks of the bottles from each side in place, and two inserts that fold into partitions, separating the bodies of the bottles. These necessary inserts must also be included in the dieline. The complete dieline can be seen in **Appendix A, Figure 13,** and the final product can be seen below in **Figure 9**.

Figure 9 - Final Product

Methodology

In order to test this package for functionality and clear it for commercial use, it first needs to pass ASTM testing. As stated earlier, the package will follow the testing schedule of distribution cycle 3, which is as follows:

1. Schedule A – Handling (manual)
2. Schedule C – Vehicle Vibration
3. Schedule F – Loose-Load Vibration
4. Schedule J – Concentrated Impact
5. Schedule A – Handling (manual)

Unfortunately, Cal Poly does not have the required machinery to test for Schedule J, concentrated impact testing, so this specific schedule must be skipped. Once the package passes ASTM testing, the final design will be testing using time studies to see how quickly the package can be assembled and filled.

ASTM Testing

Schedule A – Drop Testing

The testing procedure in ASTM D5276 was followed in order to conduct this testing schedule. Before the drop test was conducted, each face of the box was labeled as shown in **Figure 10** on the following page. Drop testing requires dropping the package on specific faces, edges, and corners, so having the package specifically labeled is essential. According to ASTM D4169, for an assurance level of 2, a package between 0 and 20 pounds should be dropped at a height of 15 inches.

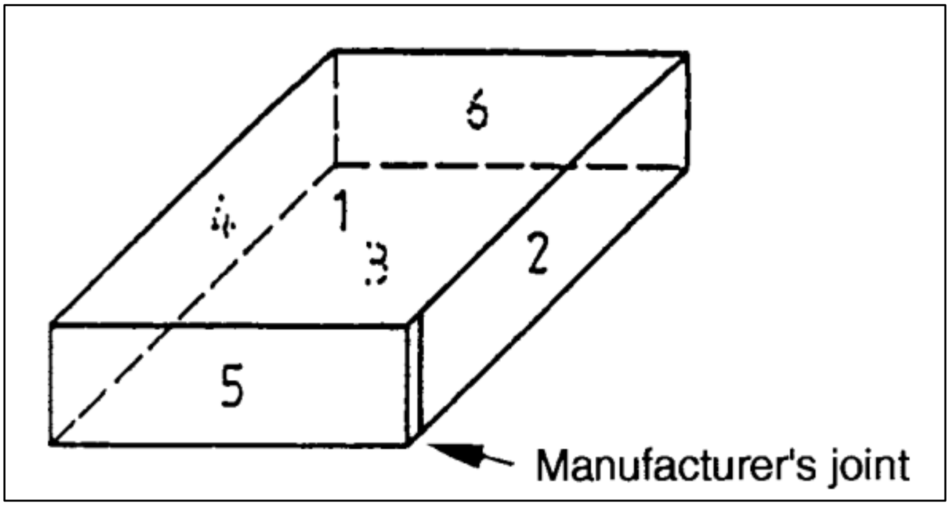

Figure 10 - Labeled Package Faces

The Lansmont Precision Drop Tester was set to a height of 15 inches, and the following drop sequence for the package was performed:

DROP #	DROP ORIENTATION	FACE CHOSEN
1	top	1
2	adjacent bottom edges	2-3
3	adjacent bottom edges	5-3
4	diagonal opposite bottom corners	3-4-6
5	diagonal opposite bottom corners	2-3-5
6	bottom	3

Table 1 - Schedule A Drop Sequence 1

The orientations that were chosen were specifically picked in order to disperse the number of drop impacts around the entire box, reducing any potential localization of drop damage. Before each drop, the box was lightly held in place on the dropping platform to prevent it from falling or tipping before it was dropped. After each drop, the box was stopped after it hit the ground in order to prevent any tipping, additional falling, or double bouncing. After the box hit the ground, any and all damage was documented. According to ASTM D5276, three sample

specimens should be tested for performance evaluation. In order to pass drop testing, the predetermined acceptance criteria are that the product must be damage-free and the package must be intact. The package design passed each round of drop testing, and the specific results from testing can be found **Appendix B**.

Schedule C – Vehicle Vibration Testing

The testing procedure in ASTM D4728 was followed in order to conduct this testing schedule. To determine the ability for the package to withstand the vertical shipping environment for each possible shipping orientation, an electro-hydraulic table was used to simulate vibrations from truck transportation. For an assurance level of 2, the total duration of testing should be 4 minutes on each side, making a total of 24 minutes.

In order to prepare the electro-hydraulic table for testing, guide poles were put into position to not be directly in contact with the package, but to be close enough to prevent the package from shifting too much during vibration. A preprogrammed simulation, "Truck Assurance Level 2", was selected and the package spent 4 minutes on each face experiencing random vibration. ASTM D4169 only requires one round of specimen testing for performance evaluation. After testing, no bottles were broken and the package remained intact. Results can be seen in **Appendix C**.

Schedule F – Loose-Load Vibration Testing

Next, the package's ability to withstand repetitive, low-level shocks was to be tested. The testing procedure in ASTM D99 was followed in order to conduct this testing schedule. Since the package will be shipped on its predetermined bottom orientation, this test only consists of testing on the bottom face. According to ASTM D4169, for an assurance level of 2, the package must be tested for 20 minutes.

Similar to Schedule C, Vehicle Vibration Testing, the electro-hydraulic table was prepared with guide poles in order to prevent the package from over-shifting. The same preprogrammed simulation, “Truck Assurance Level 2”, was selected and the package spent 20 minutes on its bottom face experiencing random vibration. ASTM D4169 only requires one round of specimen testing for performance evaluation, and after this round of testing no bottles were broken and the package remained intact. These test results can be seen in **Appendix D**.

Schedule A – Drop Testing

The same procedure from the first round of drop testing was repeated, but the drop orientations were changed in order to test the rest of the package that had not yet been affected by the first round of drop testing. These orientations chosen can be seen below in **Table 2.** Each drop was again from a height of 15 inches, except the final drop. ASTM D4169 requires that the final drop in testing be from twice the height and the drop orientation be the face that the package will most likely be dropped on in the distribution environment. Therefore the package was dropped from a height of 30 inches on its bottom face.

DROP #	DROP ORIENTATION	FACE CHOSEN
1	vertical edge	5-4
2	adjacent side faces	6
3	adjacent side faces	2
4	top corner	1-4-5
5	adjacent top edge	1-4
6	bottom (30” drop height)	3

Table 2 - Schedule A Drop Sequence 2

After each drop, the box was stopped after it hit the ground in order to prevent any tipping, additional falling, or double bouncing. After the box hit the ground, any and all damage

was documented. According to ASTM D5276, three sample specimens should be tested for performance evaluation. In order to pass this final round of testing, the predetermined acceptance criteria are that the product must be damage-free and the package must be intact. The package passed each round of drop testing, and the specific results can be found **Appendix E**.

Assembly Testing

After the package passed the final drop test, the design was cleared for commercial use and assembly testing could begin to see how long it would take to assemble and fill each package. First, the current design was tested in order to find the standard time it takes to assemble and pack a 4-bottle package and a 6-bottle package. Ten sample times were taken with different performance ratings based on the operator performing the assembly. Next, the new design was tested in order to find the same standard times for assembly and packing, and again ten sample times were taken. These time studies can be found in **Appendix F** along with the calculations for each standard time value.

Results and Discussion

The designed package passed ASTM testing for distribution cycle 3, which means it can withstand human error during manual loading, random vibration during transportation, and human error during manual unloading. This testing was essential in order to allow the package to be used commercially, but the additional time testing was done in order to compare this new design with the current design.

Comparing Methods

The new entire die line uses 9.375 square feet of corrugate, weighing approximately 1.03 pounds. In addition, this die line is very square in shape, making it an easily repeatable pattern for mass-production and resulting in less wasted corrugate per printed sheet. This new design will also require being placed into a secondary insulated shipping container, which will double the amount of corrugate being used. The insulation on the secondary shipping container will use approximately the same amount of polystyrene as the custom molding of the current process.

Lying folded and flat, the package is dimensioned at 34.28 inches wide and 11.75 inches tall. The material overlap results in a package thickness of about 0.5 inches. With these dimensions, Niner could hold all 6,000 of their annual wine club packages in about 700 cubic feet of space. For insulation, having a 0.25 inch thick layer of polystyrene around the primary shipping container would result in about 178 cubic inches per box, and require about 620 cubic feet of space for 6,000 shipments. The secondary shipping container would require about 750 cubic feet of space, giving a total of about 2,070 cubic feet.

Comparatively, Niner's current polystyrene molds are 13 inches wide, 18 inches long, and 2 inches tall. The material is 0.0625 inches thick, and when in a set of 10, measure at a stacking height of 3.125 inches. This means their insulation molds take up about 600 cubic feet of space annually. Their secondary corrugated packaging takes up about 950 cubic feet, making a total required amount of space around 1550 cubic feet. A comparison of these numbers can be seen on the following page in **Table 3.**

PART	OLD DESIGN (ft^3)	NEW DESIGN (ft^3)
Primary shipping package	–	700
Insulation	600	620
Secondary shipping package	950	750
TOTAL	**1550**	**2070**

Table 3 - Comparative Spatial Requirements

As it can be seen from this table, the new design uses about 520 more cubic feet of space annually, which is about a 33% increase in required space. In addition to different spatial requirements, the new design takes slightly longer to assemble and pack. A comparison of the standard times between the current and new design can be seen below in **Table 4.**

# OF BOTTLES	CURRENT DESIGN	NEW DESIGN
4	24.97 sec	41.52 sec
6	26.32 sec	48.46 sec

Table 4 - Standard Assembly Times

With 40% of the wine club shipments being 4-bottles shipments and 60% being 6-bottles, this results in an annual time of 42.97 hours total for the current design, and 76.14 hours total for the new design, which is about a 77% increase in assembly time.

Cost Analysis

Niner Winery currently ships all of their wine club packages out of their warehouse, and has the housing capacity to withstand a 33% increase in storage requirements. When it comes to labor increase, the new design requires an additional 33.17 hours to assemble and pack per year. With their warehouse employees being paid $10 per hour, this will cost about an additional $330 per year.

While the new package design uses about the same amount of polystyrene for insulation, there is no longer a need for custom molding, eliminating additional tooling costs per year. In addition, the new design does use about 50% more corrugated fiberboard, but corrugate is a very inexpensive and easily manufactured material. This new design would be relatively simple for Niner Winery to implement. This new method does not require any specific tooling as before; they simply need to provide their corrugated package provider with the final die-line (Appendix A, Figure 13), and preassembly instructions prior to reception.

Conclusion

The new proposed design does take slightly more time to assemble and is more expensive than the current design, but the intention of the redesign was not to minimize costs or optimize the assembly process. Niner Winery was looking for a new and creative way to advertise their brand through their wine club shipments, and making aesthetic improvements tends to increase cost. After presenting Niner with the increased figures, they believed this new design was plausible and appealing.

In an academic environment it becomes customary that saving money is good and spending more money is bad. When it was first discovered that this new design would take up more space and cost more, the initial reaction was that it was a bad design; it would not be accepted and implemented. From years of being immersed in an academic program where we constantly look for ways to optimize and improve processes, it becomes easy to believe the only way to do so is through ways that are quantifiable: by saving time or money. After analyzing the pros and cons of the package design, the aesthetic improvement and appeal of the package outweighed its negatives.

For further improvement of this package design, minimizing material would be the next step. Due to the fact that this design does use more corrugated fiberboard than the current design, it could be tested so see how much the material could be minimized while still passing ASTM testing. This package also uses polystyrene, which has great insulation properties but does not have the best environmental impact. Further research could be done on environmentally-friendly insulating materials in order to make this package 100% recyclable

Appendix A – Package Design

D4169 – 09

TABLE 1 Distribution Cycles

DC	Distribution Cycle	First	Second	Third	Fourth	Fifth	Sixth	Seventh
			Performance Test Schedule Sequence (see Section 9 for Test Schedule definition)					
1	General Cycle—undefined distribution system	Schedule A Handling	Schedule D Stacked Vibration	Schedule F Loose-Load Vibration	Schedule G Rail Switching	Schedule J Concentrated Impact	Schedule A Handling	
2	Specially defined distribution system, user specified (see Appendix X2)			select from Schedules A through I				
3	Single package without pallet or skid, LTL motor freight	Schedule A Handling —Manual	Schedule D Stacked Vibration OR Schedule C Vehicle Stacking plus Schedule E Vehicle Vibration	Schedule F Loose-Load Vibration	Schedule J Concentrated Impact	Schedule A Handling—Manual	. . .	
4	Single package with pallet or skid, LTL motor freight	Schedule A Handling —Mechanical	Schedule D Stacked Vibration OR Schedule C Vehicle Stacking plus Schedule E Vehicle Vibration	Schedule F Loose-Load Vibration	Schedule J Concentrated Impact	Schedule A Handling—Mechanical	. . .	
5	Motor freight, TL, not unitized	Schedule A Handling	Schedule D Stacked Vibration	Schedule E Vehicle Vibration	Schedule J Concentrated Impact	Schedule A Handling	. . .	
6	Motor freight, TL, or LTL—unitized	Schedule A Handling	Schedule D Stacked Vibration OR Schedule C Vehicle Stacking plus Schedule E Vehicle Vibration	Schedule J Concentrated Impact	Schedule A Handling	Schedule B Warehouse Stacking	. . .	
7	Rail only, bulk loaded	Schedule A Handling	Schedule D Stacked Vibration	Schedule G Rail Switching	Schedule A Handling	. . .	. . .	
8	Rail only, unitized	Schedule A Handling	Schedule D Stacked Vibration	Schedule G Rail Switching	Schedule A Handling	Schedule B Warehouse Stacking	. . .	
9	Rail and motor freight, not unitized	Schedule A Handling	Schedule C Vehicle Stacking	Schedule E Vehicle Vibration	Schedule G Rail Switching	Schedule F Loose-Load Vibration	Schedule J Concentrated Impact	Schedule A Handling
10	Rail and motor freight, unitized	Schedule A Handling	Schedule D Stacked Vibration	Schedule G Rail Switching	Schedule J Concentrated Impact	Schedule A Handling	Schedule B Warehouse Stacking	
11	Rail, TOFC and COFC	Schedule A Handling	Schedule G Rail Switching	Schedule D Stacked Vibration	Schedule F Loose-Load Vibration	Schedule A Handling	. . .	
12	Air (intercity) and motor freight (local), over 150 lb (68.1 kg), or unitized	Schedule A Handling	Schedule D Stacked Vibration	Schedule I Low Pressure[A]	Schedule E Vehicle Vibration	Schedule J Concentrated Impact	Schedule A Handling	
13	Air (intercity) and motor freight (local, single package up to 150 lb (61.8 kg). Consider using Practice D7386 for single parcel carrier shipments.	Schedule A Handling	Schedule C Vehicle Stacking	Schedule F Loose-Load Vibration	Schedule I Low Pressure[A]	Schedule E Vehicle Vibration	Schedule J Concentrated Impact	Schedule A Handling
14	Warehousing (partial cycle to be added to other cycles as needed)	Schedule A Handling	Schedule B Warehouse Stacking	. . .	. . .	. . .	. . .	
15	Export/Import shipment for intermodal container or roll on/roll off trailer (partial cycle to be added to other cycles as needed)	Schedule A Handling	Schedule C Vehicle Stacking	Schedule A Handling	. . .	. . .	. . .	
16	Export/Import shipment for palletized cargo ship (partial cycle to be added to other cycles as needed)	Schedule A Handling	Schedule C Vehicle Stacking	Schedule A Handling	. . .	. . .	. . .	
17	Export/Import shipment for break bulk cargo ship (partial cycle to be added to other cycles as needed)	Schedule A Handling	Schedule C Vehicle Stacking	Schedule A Handling	. . .	. . .	. . .	
18	Non-Commercial Government shipments per MIL-STD-2073-1			Refer to Annex A1 for Test Schedules applying to DC-18.				

Figure 11 - ASTM D4169 Distribution Cycles

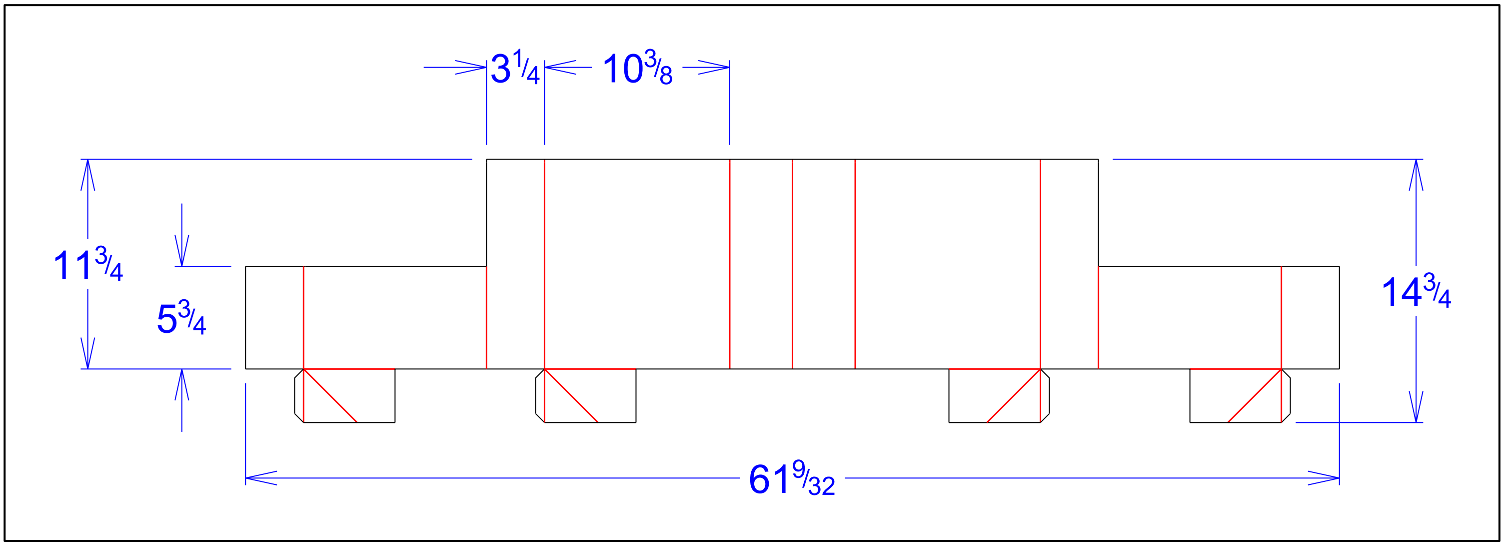

Figure 12 - Package Dimensions

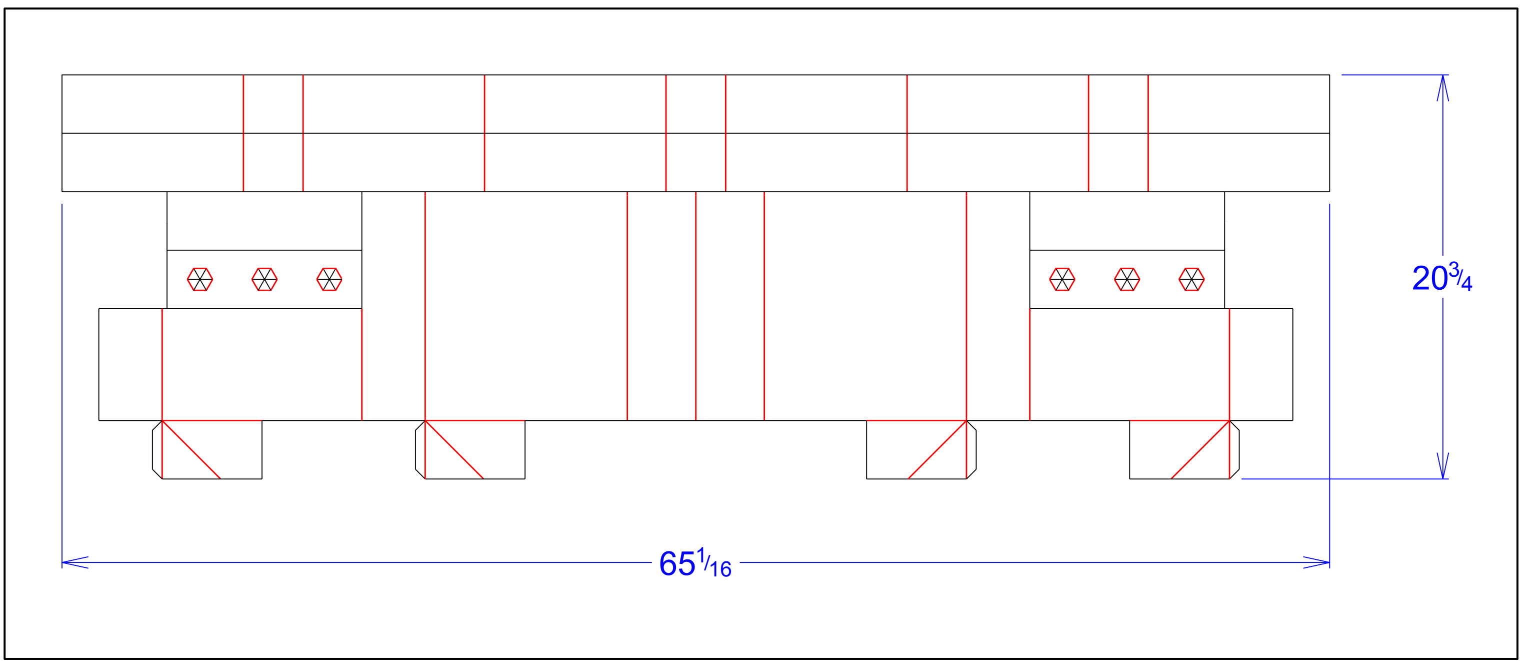

Figure 13 - Package Dieline

Appendix B – Schedule A (First)

Round 1	Orientation	Labeled Orientation	Observation
1	top	1	no apparent damage
2	adjacent bottom edges	2-3	slight edge damage
3	adjacent bottom edges	5-3	no apparent damage
4	diagonal opposite bottom corners	3-4-6	corner smashed
5	diagonal opposite bottom corners	2-3-5	corner less smashed
6	bottom	3	no apparent damage

Table 4 - Schedule A (First) Round 1

Round 2	Orientation	Labeled Orientation	Observation
1	top	1	scuffed edges
2	adjacent bottom edges	2-3	crushed edge damage
3	adjacent bottom edges	5-3	slight edge damage
4	diagonal opposite bottom corners	3-4-6	corner indented
5	diagonal opposite bottom corners	2-3-5	corner crushed
6	bottom	3	bottom edge indented

Table 5 - Schedule A (First) Round 2

Round 3	Orientation	Labeled Orientation	Observation
1	top	1	no apparent damage
2	adjacent bottom edges	2-3	no apparent damage
3	adjacent bottom edges	5-3	crushed edge
4	diagonal opposite bottom corners	3-4-6	corner smashed
5	diagonal opposite bottom corners	2-3-5	corner less smashed
6	bottom	3	no apparent damage

Table 6 - Schedule A (First) Round 3

Appendix C – Schedule C

Time	Orientation	Observation
4 min	Face 4	no apparent additional damage
4 min	Face 2	no apparent additional damage
4 min	Face 1	no apparent additional damage
4 min	Face 6	no apparent additional damage
4 min	Face 5	no apparent additional damage

Table 7 - Vehicle Vibration Testing

Appendix D – Schedule F

Time	Orientation	Observation
20 min	Face 3	bottom is slightly damaged

Appendix E – Schedule A (Last)

Round 1	Orientation	Labeled Orientation	Observation
1	vertical edge	5-4	damaged edge
2	adjacent side faces	6	scuffing on face
3	adjacent side faces	2	no apparent additional damage
4	top corner	1-4-5	indented corner
5	adjacent top edge	1-4	crushed edge
6	bottom (30" drop height)	3	**PACKAGE PASSED**

Table 8 - Sequence A (Last) Round 1

Round 2	Orientation	Labeled Orientation	Observation
1	vertical edge	5-4	bulging side
2	adjacent side faces	6	no apparent additional damage
3	adjacent side faces	2	no apparent additional damage
4	top corner	1-4-5	crushed corner
5	adjacent top edge	1-4	edge slightly damaged
6	bottom (30" drop height)	3	**PACKAGE PASSED**

Table 9 - Sequence A (Last) Round 2

Round 3	Orientation	Labeled Orientation	Observation
1	vertical edge	5-4	slight edge damage
2	adjacent side faces	6	no apparent additional damage
3	adjacent side faces	2	scuffing on face
4	top corner	1-4-5	slightly crushed corner
5	adjacent top edge	1-4	indented edge
6	bottom (30" drop height)	3	**PACKAGE PASSED**

Table 10 - Sequence A (Last) Round 3

Appendix F – Assembly Time

Element Description			Cycles										Summary Data			
			1	2	3	4	5	6	7	8	9	10	SUM	AVG	R	N
1	4-Bottle Assembly and Packing	R	100%	100%	90%	90%	100%	100%	90%	90%	95%	95%	950%	95%	95%	-
		T	24.61	25.13	24.89	23.29	23.74	24.59	24.08	23.63	23.86	23.32	241.14	24.114	-	22.9083
2	6-Bottle Assembly and Packing	R	100%	100%	90%	90%	100%	100%	90%	90%	95%	95%	950%	95%	95%	-
		T	25.68	27.04	26.41	24.39	25.18	24.36	25.54	26.19	24.80	24.59	254.18	25.418	-	24.1471

Final Answer	
Allowance	Standard Time
109%	24.97 seconds
109%	26.32 seconds

Figure 14 - Standard Assembly Time for Current Process

Figure 12 shows 10 cycles measured for each package. Five people assembled and packed the wine bottles packages, and each person has their own respective performance rating. The average assembly time is then multiplied by the average performance rating to get a normal time. This normal time value is then given an additional allowance of 9% to arrive at the final standard time. The same process is followed for the new design process in **Figure 13** below.

Element Description			Cycles										Summary Data			
			1	2	3	4	5	6	7	8	9	10	SUM	AVG	R	N
1	4-Bottle Assembly and Packing	R	100%	100%	90%	90%	100%	100%	90%	90%	95%	95%	950%	95%	95%	-
		T	41.61	40.58	39.20	39.52	41.78	40.06	39.92	38.87	40.16	39.24	400.94	40.094	-	38.0893
2	6-Bottle Assembly and Packing	R	100%	100%	90%	90%	100%	100%	90%	90%	95%	95%	950%	95%	95%	-
		T	48.32	47.29	45.04	46.84	46.27	47.15	45.93	46.71	45.84	48.60	467.99	46.799	-	44.45905

Final Answer	
Allowance	Standard Time
109%	41.52 seconds
109%	48.46 seconds

Figure 15 - Standard Assembly Time for New Process

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