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Investigation and Improvement of the Conveyor System at a Bottle Packaging Operation.

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Investigation And Improvement Of The Conveyor System At A Bottle Packaging Operation

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by

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ABSTRACT

Investigation And Improvement Of The Conveyor System At A Bottle Packaging Operation

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This investigation examines the bottle packaging conveyor system and its impact on the overall efficiency at a bottle packaging plant in Anderson, South Carolina. The purpose of this study is to demonstrate the existing opportunity to reduce bottle unit cost, increase productivity, decrease the risk of work related injuries, and improve line reliability along with employee moral with the conveying system alone.

Data were gathered for this study in three ways: One, bottle packaging line lead operators were required to document the start and stop times of the conveyor system on their respective lines for six weeks. Two, a conveyor machine operator was required to document the start and stops of the conveyor system itself along with the cause for the same six weeks. Three, a packaging conveyor system project form was randomly submitted to 51 employees, soliciting their opinions and suggestions for the conveyor system.

Conclusions of the study show opportunities for improvement and an overwhelming disapproval (88%) of the current system. Three improvement proposals were determined based on all the data collected.

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CHAPTER 1

INTRODUCTION

In the early 1800s, the world entered the industrial age and began manufacturing goods. Finished goods can be anything from an automobile to a hamburger at a fast food restaurant. Raw materials are shipped in, processed, and ultimately turned into a sellable good. These goods can be warehoused or sold immediately after production.

In Anderson, South Carolina, there is a bottle packaging plant where nutritional supplement products are manufactured. There are 13 manufacturing lines where raw materials (pills) are placed into bottles, capped, labeled, and sent to the distribution warehouse via a conveyor system.

Due to various reasons such as production or machine malfunctions, the conveyor system may do down, this in turn causes a manufacturing line to have to wait on access to the conveyor system. When a line has to wait on the conveyor system for access the following things occur:

1. Excessive material handling.
2. Increased chance of injury.
3. Reduction in line reliability / efficiency.
4. Increased cost.

Excessive Material Handling

Even though line operators don't have access to the system, their line is still in operation. In order to keep up they will sometimes stack trays of bottles on their workstation tables and if they fill up before access is gained, line operators may have to physically stack trays on a pallet. If this happens, then the service technician has to manually transport the pallet to the distribution warehouse. Naturally, if the line has to consistently wait on the system, this excessive material handling can increase the chance of injury, especially back injury to the line operators or anyone assisting in handling the trays.

Increased Chance of Injury

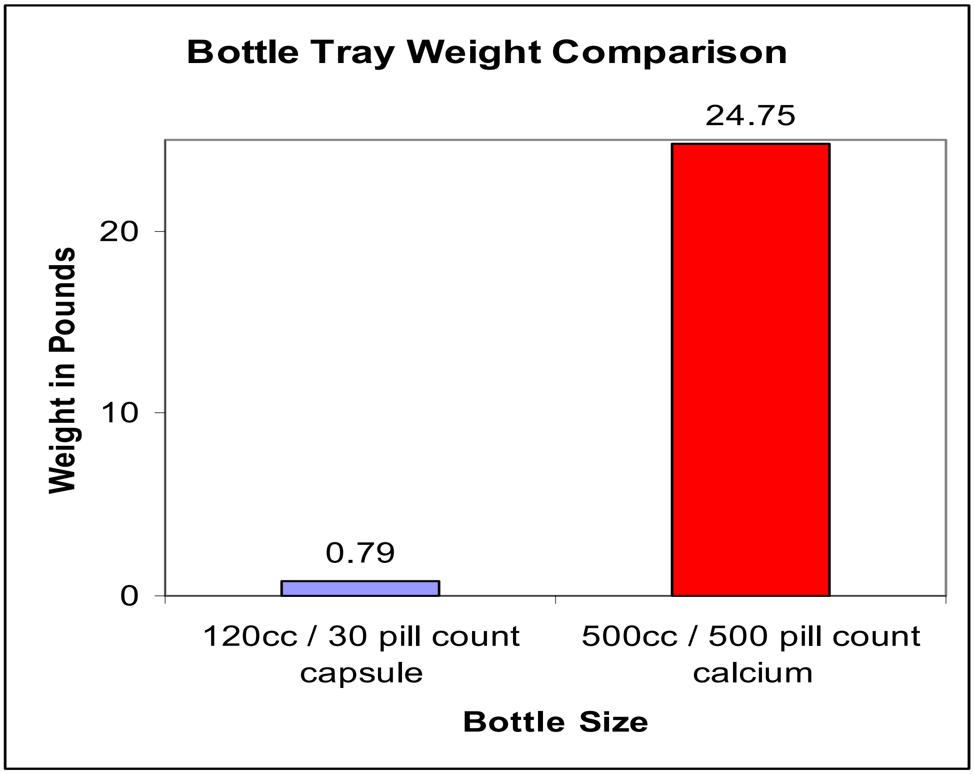
There are numerous bottle sizes with each varying in pill count depending on the item. The pill weight also varies depending on the item. Some weigh as little as 100mg, while others may weigh more than a gram. Combining these variables and one can understand how fast a tray of bottles can become pretty heavy, especially with repetition and excessive handling. The following is a table displaying approximate bottle tray weights of standard bottle sizes using approximate pill counts of the same product.

Table 1
Bottle Tray Weight

Bottle Size	Approx Pill Count	Approx Pill Weight (in grams)	Number of Bottles per Tray	Approx Tray Weight (in pounds)
50cc	30	0.001	24	1.58
75cc	50	0.001	12	1.32
120cc	70	0.001	12	1.858
200cc	110	0.001	12	2.90
250cc	150	0.001	12	3.96
300cc	160	0.001	12	4.22
500cc	250	0.001	15	8.25

The following is a chart displaying the significant weight variance of bottle trays depending on pill count, product, and bottle size using actual products.

Figure 1 Bottle Tray Weight Comparison



Even though a tray of bottles is well within the OSHA load constant of 51.5 lbs, with every line operator being female and an average age of 45, there is a potential risk for a wrist injury or even greater risk of a back injury as line operators have to bend over to stack a pallet.

According to the Anderson plant human resource department, in 2002 there were 6 back and wrist injuries resulting in 17 missed work days and 11 days of employees on light duty, doing tasks outside of their normal duty because of the injury. These were the top two causes of on the job injuries in the plant and this correlates directly with the excessive material handling due to inefficiencies of the conveyor system.

Reduction in Line Reliability / Efficiency

Reliability is a measurement of a line's productivity, and efficiency. The Anderson plant has a reliability software program that includes labor standards. Line performance is calculated from the following variables:

Run rate: The minimum speed a line is allowed to process bottles.

Scheduled minutes: The lines total number of available runtime.

Scheduled downtime: The time allowed for a line not to be in operation. There are only two circumstances that qualify: Break time, and changeover.

Unscheduled downtime (UDT): Any time the line is down that is not scheduled.

Uptime: The total amount of minutes the line is in operation.

(Scheduled minutes - Unscheduled downtime)

Reliability: The measurement of a lines performance. (Run rate * Uptime)

Bottles Per Scheduled Minute (BPSM): Number of bottles produced within a line's total amount of available runtime.

The following is a table displaying each line's production, unscheduled downtime, reliability, and bottles per scheduled minute for first shift 2002.

Table 2
Line Reliability by Production Line

Line	Bottles	UDT	Reliability	BPSM
1	2,217,119	15,840	74.18%	29.4
2	1,511,115	14,608	76.15%	19.3
3	1,562,286	16,037	71.66%	29.3
4	3,511,680	17,930	76.65%	39.3
5	2,611,724	34,374	60.81%	32.6
8	123,019	1,954	77.77%	8.1
9	4,512,711	21,272	67.13%	61.9
10	4,412,642	19,292	87.21%	73.7
11	5,319,786	21,418	74.59%	85.9
12	5,124,794	30,974	62.32%	62.8
13	4,160,675	27,470	63.25%	56.9
14	6,045,148	15,627	80.59%	102.9
15	2,207,436	23,601	55.23%	39.3
Totals	43,320,135	260,397	72.73%	50.6

From the reliability formula it is easily deduced that any increase in unscheduled downtime will result in a decrease of line reliability. When line operators are waiting for conveyor access, they will stack trays onto their workstations or on a pallet depending on the wait time. However, if the conveyor is not accessible within a few minutes, the line's pack off table will fill up while the line operators are stacking trays, and once the table is full, there is more room for bottles to travel. This causes the line to stop and creates unscheduled downtime as the line operators use the downtime to catch up.

The constant stacking and repetitive moving of bottles because they don't have access to the conveyor system can lead to frustration which can lead to poor employee performance and low morale. This could also cause a decrease in line reliability because poor employee performance would lead to either more unscheduled downtime or not attaining a run rate.

Increased Cost

Although line reliability is the measurement of a line's performance, unit cost is the ultimate and most important measure in any manufacturing operation. An increase in unscheduled downtime, a decrease in BPSM or the cost of worker's comp benefits of any injured employee has a direct impact on bottle unit cost. The inefficiency of the conveyor system could cause any one or any combination of these events.

Problem Statement

The purpose of this investigation is to demonstrate the existing opportunity to reduce bottle unit cost, decrease the chance of injury and worker's compensation claims, increase productivity, and improve line reliability as well as employee moral by improving the conveying system alone.

Objectives of Investigation

The objectives of this investigation are to gather data by various methods as evidence of opportunity and to formulate 2-3 plans for improvement with the conveyor system and / or process based on the data collected.

Assumptions

The following assumptions are made in this investigation:

1. All data gathered in this investigation are accurate.

2. All company data gathered were with the company's consent.
3. All back and strain injuries were the result of the conveyor system alone.
4. All data gathered within the investigation timeframe can be used to represent a full calendar year for calculation purposes.

Limitations

The investigation was limited by:

1. The 12 week amount of time used to collect data.
2. The amount of contract proposals submitted for conveyor system improvement.

Definition of Terms

Bottles Per Scheduled Minute (BPSM): Number of bottles produced within a line's total amount of available runtime.

Changeover: A term used to describe the scheduled downtime that occurs when a line changes from one product run to another.

Conveyor System: A method of transferring material from location to another.

Conveyor System Operator: Job title of an employee at the Anderson plant. (Grade 1)

Filler Operator: Job title of an employee at the Anderson plant. (Grade 2)

Line Lead: Job title of an employee at the Anderson plant. (Grade 3 or 4)

Line Operator: Job title of an employee at the Anderson plant. (Grade 1)

Line Reliability: An individual line's performance.

Maintenance Technician: Job title of an employee at the Anderson plant. (Grade 5-7)

OSHA: (Occupational Safety and Health Administration)

Photoeyes: Sensors used to detect the presence of an object, by using a light beam that is broken by the object.

Reliability: The measurement of a lines performance. (Run rate * Uptime)

Reliability Software: A software program used to evaluate a manufacturing line's performance.

Return on Investment (ROI): The income that an investment provides in a year.

Run rate: The minimum speed a line is allowed to process bottles.

Scheduled minutes: The lines total amount of available runtime.

Scheduled downtime: The time allowed for a line not to be in operation. There are only two circumstances that qualify: Break time, and changeover.

Service Technician: Job title of an employee at the Anderson Plant. (Grade 2)

Touchscreen: A monitor screen that can detect and respond to something, such finger or stylus, pressing on it.

Unit Cost: The cost of a given unit of a product.

Unscheduled Downtime (UDT): Any time the line is down that is not scheduled.

Uptime: The total number of minutes the line is in operation. (Scheduled minutes – Unscheduled downtime)

CHAPTER 2

REVIEW OF LITERATURE

Conveyors have been around for about 103 years. What started as a solution to unload wood shingles from rail cars turned in to a billion dollar industry. There are various types of conveyor systems that can be used in numerous manufacturing or distribution applications. For example there are screw conveyors systems, bulk conveyor systems, unit handling conveyor systems, trolley conveyor systems, pneumatic conveyor systems, automated monorail systems, and overland conveyor systems, to mention a few. Each system has unique properties and various systems can be combined to form more complex systems.

Type of Conveying System at Bottle Packaging Plant

At the bottle packaging plant there is an automated roller conveyor system. This system is very complex and was installed by a contracted company as their brand product. The conveyor system allows trays of bottles to be loaded and move along the conveyor at set intervals. The trays are sent through shrink wrap machines and stacked by operators to be received by the distribution warehouse. The system is accessible at the end of each manufacturing line where employees are able to place finished goods. Each line consists of five employees who perform delegated tasks:

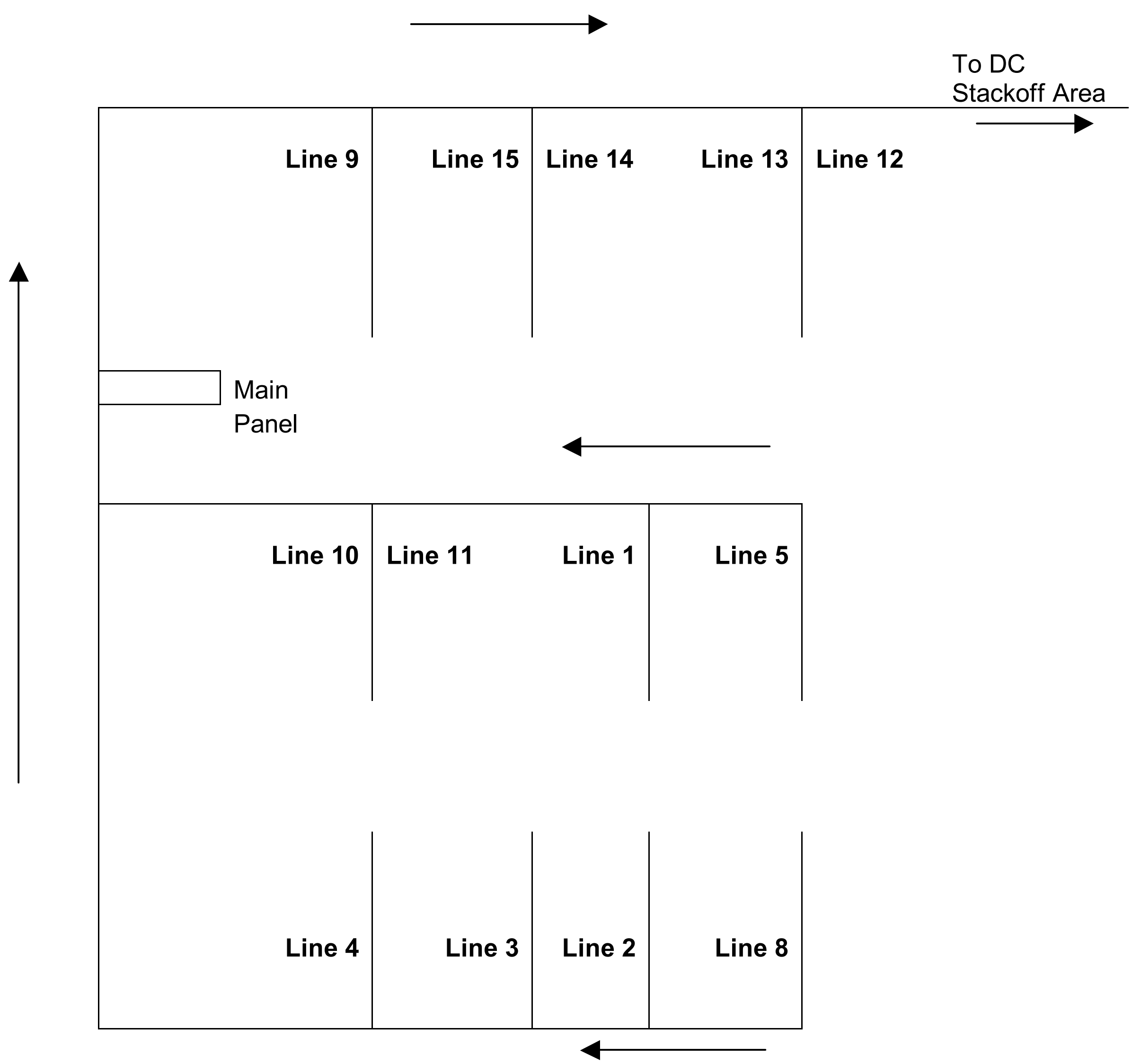
> Line Lead: Oversees overall line operation, responsible for all batch paperwork, and ensures line is operated per labor standards.
>
> Filler Operator: Responsible for correct set-up of filler; machine that places pills into bottles.

Service Technician: Responsible for keeping line stocked with pills, caps, bottles, and any other necessary items.

Line operator (2 per line): Responsible for placing finished bottles onto trays where the bottles are sent to distribution warehouse via the conveyor system.

The following is a current diagram of the manufacturing lines and the conveyor system at the bottle packaging plant.

Figure 2 Diagram of Conveyor System at the Anderson Plant



The conveyor system is responsible for allowing each line to place its goods on the system without any time lost waiting for access. There is also a conveyor system operator whose job is to clear all jams and troubleshoot any system malfunctions. Any problems the conveyor system operator can't solve are reported to a maintenance technician. This sounds pretty simple, but there are a few variables to consider:

1. The rate at which each line is processing the bottles.
2. The size and weight of the bottles.
3. Any existing jams or trouble on the main drive or lanes where the bottles travel.
4. There are also some lines that share access to a lane that feeds the main drive.

All of these variables can lead to a line having to wait on the system before the line operators are able to load bottles again.

CHAPTER 3

PROCEDURES AND METHODS

The objectives of this investigation will be accomplished by collecting data in two ways:

1. For three months accurately track how long and often manufacturing lines are waiting on conveyor system access. Whenever there is no access, each line will have an employee record the stop and start times of the conveyor system. The conveyor system operator will also record all the system downtime due to jams and machine malfunctions.
2. Allow employees to give feedback on the conveyor system and its performance. A packaging conveyor system project form will be generated and randomly submitted, asking employees questions regarding the conveyor system. These questions were derived from interviews with employees who use the equipment and one employee who acts as a liaison with the original installers of the conveyor system.

CHAPTER 4

ANALYSIS AND DISCUSSION

The data collection analysis will be broken into three areas of focus:

1. Analysis of the data collection from the employees of each line.
2. Analysis of the data collection from the conveyor system operator.
3. Analysis of the packaging conveyor system project form.

Analysis of the Data Collection From the Employees of Each Line

For three months data were tracked by employees on each line. These employees recorded the start and stop time of the conveyor system only when they were not able to use it. From the data it was determined that on average there are 52 minutes lost daily due to the ineffectiveness of the conveyor system.

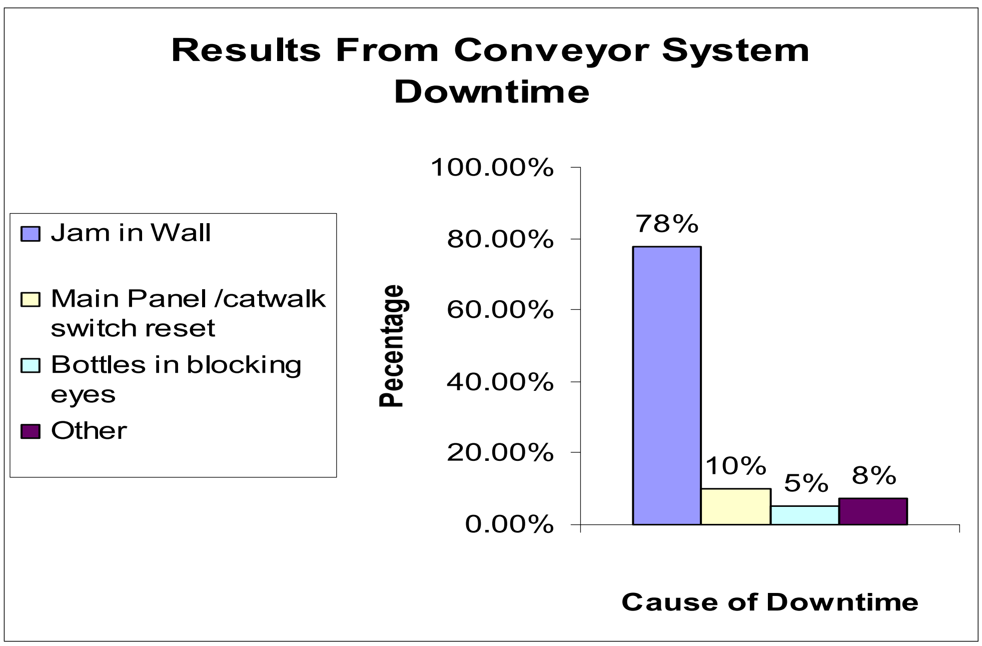
Table 3
Average Downtime Minutes by Line

Line Number	Average Downtime Minutes
1	18
2	19
3	25
4	32
5	30
9	35
10	38
11	42
12	125
13	99
14	87
15	76
Total	626
Average Minutes	52

Analysis of the data collection from the conveyor system operator

In the same timeframe, the conveyor system operator also tracked any downtime due to conveyor system operation. This would include any jams, machine malfunctions, etc… From the data it was determined that there were three major causes of conveyor system downtime, with 8% of all downtime due to "other" or problems that occurred as one time instances with no regularity.

Figure 3 Results From Conveyor System Downtime



1. *Jams* – this occurs when a tray of bottles from one line gets jammed with another tray either from a different line or the same line when trying to access the main drive, or there may a jam on the main drive itself as trays travel through the conveyor system. This normally occurs at the intersection of the back lines with the main drive or when trays get turned sideways. The amount of downtime to clear the jams ranged from as little to 1 minute up to 24 minutes

depending on the jams location and the number of trays involved. These jams almost always require a maintenance technician or the conveyor system operator to clear the jam either from a ladder or a lift. Once cleared, the system can be reset, either from the corresponding line of the jam or the main panel to continue use. Jams accounted for 78% of all conveyor system downtime. The majority of the jams occurred on the high speed lines (lines 9 – 15) when two lines are sharing an access line to the main drive.

2. *Main panel reset* – this occurs when there is a problem on the main drive due to either jams or sensors being blocked. This problem usually requires a reset of the corresponding button on the line and/or main panel of the conveyor system. Main panel resets accounted for 10% percent of all conveyor system downtime.
3. *Bottles blocking sensors (eyes)* – this occurs when a tray of bottles, due to timing or location, happens to block any one of the numerous sensors in the conveyor system. With the sensors blocked, the conveyor system will shut off and not allow any more trays to be inserted. This problem usually requires a simple reset of the "clear jam" button on the corresponding line, which in turn will allow the system to move the tray and restart normal operation. If that does not remedy the problem, a maintenance technician or the conveyor system operator may have to physically move the tray(s) either from a ladder or lift to allow the system to reset. Once cleared, the system can be reset either from the corresponding line of the jam or the main panel to continue use. Bottles blocking sensors accounted for 5% of all conveyor system downtime.

Analysis of the Packaging Conveyor System Project Form

Packaging conveyor system project forms were handed out to approximately 100 employees from every aspect of the packaging operation that may have any involvement with the conveyor system. Fifty-one of these surveys were randomly selected using standard sampling procedures. The purpose of the data collection form was to gather input and possibly quantify employee morale and the performance issues of the conveyor system from an employee perspective. There were 10 questions on the data collection form with the possible answer being always, sometimes, never, and not applicable (N/A). The following results were tabulated from the data collected.

Table 4
Results From Packaging Conveyor System Project Form

	Always	Sometimes	Never	N/A
1. Packing Conveying System is reliable.	6%	10%	84%	0%
2. Line operators have to constantly stack of bottles.	18%	80%	0%	2%
3. Conveyor jams are real easy to find and fix	4%	53%	18%	25%
4. Our equipment (ladders, lifts, etc..) is safe enough to fix jams.	11	49%	18%	22%
5. Whenever the system is down, I have aches and pains from stacking off bottles the following day.	59%	29%	0%	12%
6. It is common to have to stack off 2-3 times a day because of the conveyor system being down. (stack off in this question means actually placing trays on pallets)	33%	61%	0%	6%
7. Sometimes we have to shut off the packing table because we have run out of space to stack off.	22%	55%	13	10%
8. I am often frustrated because I frequently have to wait on the conveyor or have to stack off bottles.	43%	43%	0%	14%
9. I often feel I have to work twice as hard when the conveyor system is down.	70%	18%	0%	12%
10. I think the conveyor system needs to be improved.	88%	10%	0%	2%

CHAPTER 5

SUMMARY OF RESULTS

The results of the data collected can be summarized into two major areas:

1. Estimated Lost Bottle Production due to Conveyor System Downtime.
2. Employee feedback from survey results.

Estimated Lost Bottle Production Due to Conveyor System Downtime

With an average of 52 minutes daily being lost due to the conveyor system, and given the average department bottles per scheduled minute (BPSM), and using the department reliability data, one can infer that there could have been an additional 402,680 bottles produced in 2002 from the following calculation:

Conveyor system downtime minutes = 52

Department Reliability = 73% or .73

Department Bottles Per Scheduled Minute (BPSM) = 51 (rounded)

Approximate number of workdays in a year = 208

Annual Additional Bottles = Conveyor system downtime minutes * Department Reliability * Department BPSM * Approximate number of workdays in a year.

402,680 = 52 * .73 * 51 * 208

If the packaging department consists of 78 employees, and in 2002 there were 43.3 million bottles produced, one could infer that each employee represented approximately 555,128 bottles and 402,680 additional bottles would equal about .73 employees. If the average employee salary including benefits in 2002 was $30,000, one could also infer that these additional bottles equal approximately $22,000 in real money using the following calculation.

Annual Additional Money = Number of Bottles per Employee / Additional Bottles * Average Employee Salary.

$22,000 = 555,128 / 402,680 * $30,000

Feedback From Packaging Conveyor System Project Form

From the project form results, it can be easily deduced that the majority of employees:

1. Are often frustrated and fatigued due to the ineffectiveness of the conveyor system.
2. Believe the conveyor system needs to be improved.

CHAPTER 6

RECOMMENDATIONS / PROPOSALS

Using the data gathered from both actual conveyor system downtime and employees feedback from the survey, there definitely exists some opportunity to improve the conveyor system. The author will present three different proposals to remedy this problem. Each proposal will be different, varying in cost, complexity, and effectiveness.

1. Re-engineer the conveyor system.
2. Install cameras and safety ladders at usual jam locations based on data gathered by the conveyor system operator.
3. Reprofile lines based on BPSM data to reduce conveyor system downtime.

Re-engineer the Conveyor System

This is the most expensive, yet the most effective way to eliminate conveyor system downtime and increase the efficiency of the conveyor system. An independent contractor was contacted, and submitted a proposal to re-engineer the conveyor system. The proposal consisted of adding 10 additional photoeyes for jams at the predetermined congestion areas, along with implementing new software to allow operators to interface with the system using a centralized touchscreen. The software will make the conveyor system capable of learning and changing based on input. For example if line 2 is running at 20 BPSM and line 14 is running at 100 BPSM, line 14 would have approximately 5 times more time to access the conveyor system, rather than each line sharing the same amount of time which is the current operation. It would also allow operators to shut off access to the system if the line is not in operation due to changeover or any other reason. This would add even greater flexibility as when a line is shut off, its access time would be redistributed throughout the system. This proposal has a capital cost of $80,000, but the gains in efficiency along with the possible elimination of employee injuries and worker's compensation claims would provide an estimated 3.6 year return on investment (ROI) based on the 2002 volume of bottles produced. This ROI is strictly dependant on volume. For example if the 2003 annual production numbers are greater than the 2002 numbers, the ROI would be sooner and vice versa if the 2003 numbers are less than the 2002 numbers. However for $80,000 the problem is forever fixed and the system now has the ability to adapt to any amount of production. The ROI can be determined using the following calculation:

Annual Additional Money with no conveyor system downtime = $22,000

Cost of Conveyor System Proposal = $80,000

ROI = Cost of Proposal / Annual Addition Money

ROI = $80,000 / $22,000 = 3.6 years

<u>Install Cameras and Safety Ladders at Usual Jam Locations Based on Data Gathered by the Conveyor System Operator.</u>

A less expensive and less efficient proposal would be to purchase cameras and ladders and place them at the usual locations for jams or bottles blocking sensors. These cameras would be viewed from a monitor mounted on the main conveyor panel. Although this proposal would not eliminate the occurrences downtime, it would significantly reduce the time required to clear or fix any conveyor system problems. For example, if it usually takes 10 minutes to find and clear a jam of trays at the intersection of lines 14/15 and the main drive, the time could be reduced to 1-5 minutes with the installed equipment because now the operators can determine where the jam is using the monitor and immediately get to the jam with the ladders in place without having to notify a maintenance technician or the conveyor system operator. This upgrade would cost approximately $5,000 and would provide an estimated ROI of 8 months based on the 2002 volume of bottles produced. The ROI can be determined using the following calculation:

Annual Additional Money with no Conveyor System Downtime = $22,000

Percent of Conveyor Downtime due To Jams = .69

Fifty Percent reduction in conveyor downtime due to jams = .5

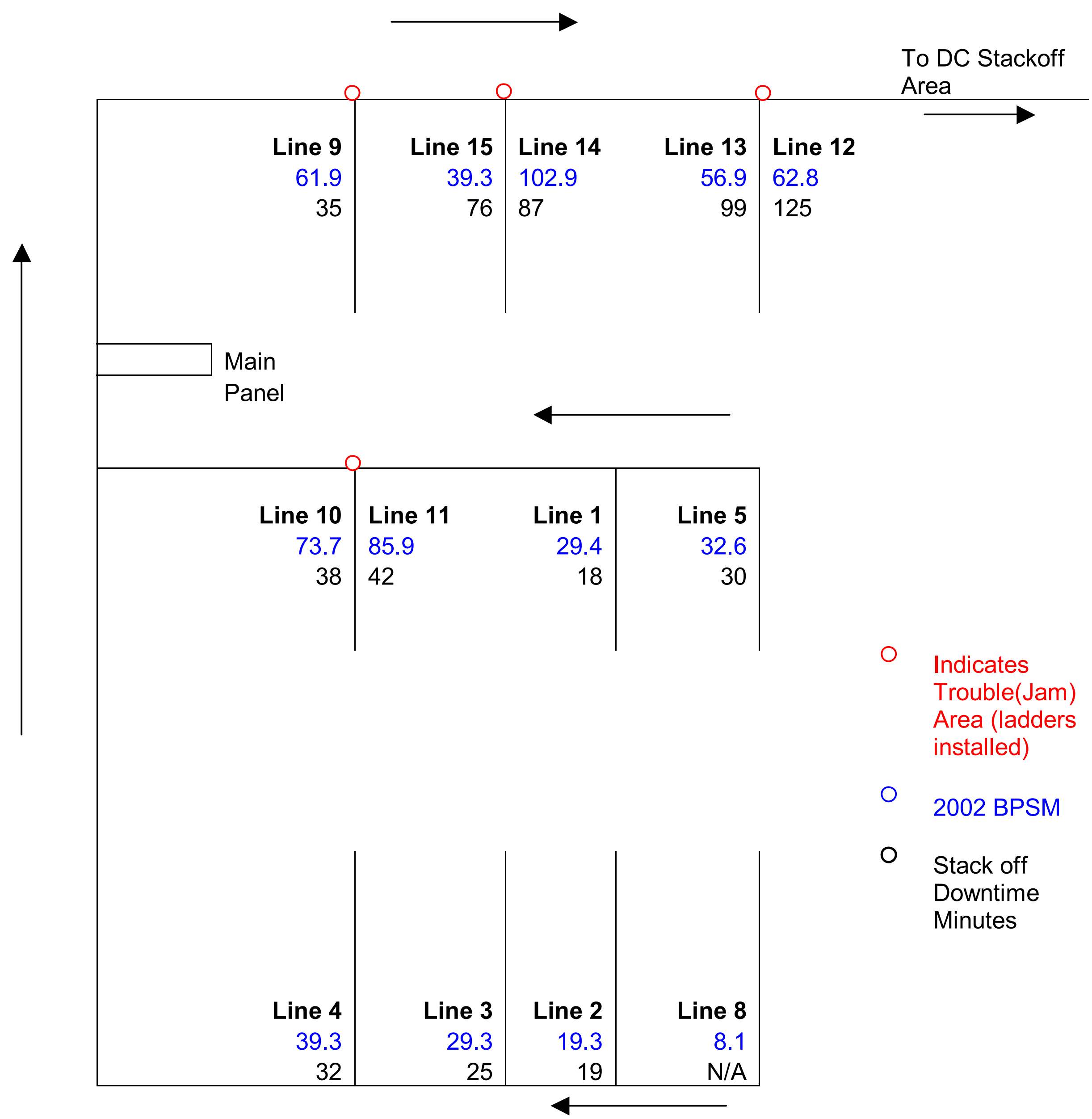
New annual additional money = $22,000 * .69 *.5 = $7590

Cost of Upgrade = $5000

ROI = Cost of Upgrade / New annual additional money

ROI = $5000 / $7590 = .66 years or approximately 8 months.

Figure 4 Plant Layout With Upgrades



<u>Reprofile Lines Based on BPSM Data, to Reduce Conveyor System Downtime</u>

This would be the least expensive and least effective means of reducing conveyor system downtime. Lines would be reprofiled to ensure maximum use of the conveyor system. For example, if line 14 runs 120cc bottles averaging about 30,000 bottles produced daily and never has access to the conveyor system and line 15 runs 500cc bottles averaging about 15,000 bottles produced daily and always has access, line 14 would now run 500cc bottles and line 12 would run 120cc bottles. This switch in profiles would definitely decrease the amount of time employees would have stack off bottles, but it would make the whole packaging operation less efficient due to the machine capability of each line (lines 2-5 uses older technology than lines 9-15) and would produce fewer bottles even if the conveyor system operated perfectly.

CHAPTER 7

CONCLUSION

In conclusion, it has been determined that are multiple opportunities to improve the existing conveyor system and the majority of employees are less than happy with system including some of them being injured because of the system's inefficiency. It has also been determined that the packaging operation's downtime, reliability, and unit cost can be improved by simply making the conveyor system more efficient. Three possible solutions have been developed and proposed to eliminate or reduce conveyor system downtime, depending management's decision, any of these proposals could be implemented in a short amount of time.

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APPENDICES

Appendix A: Additional Figures

Figure 5 Average Employee Age by Job (grade)

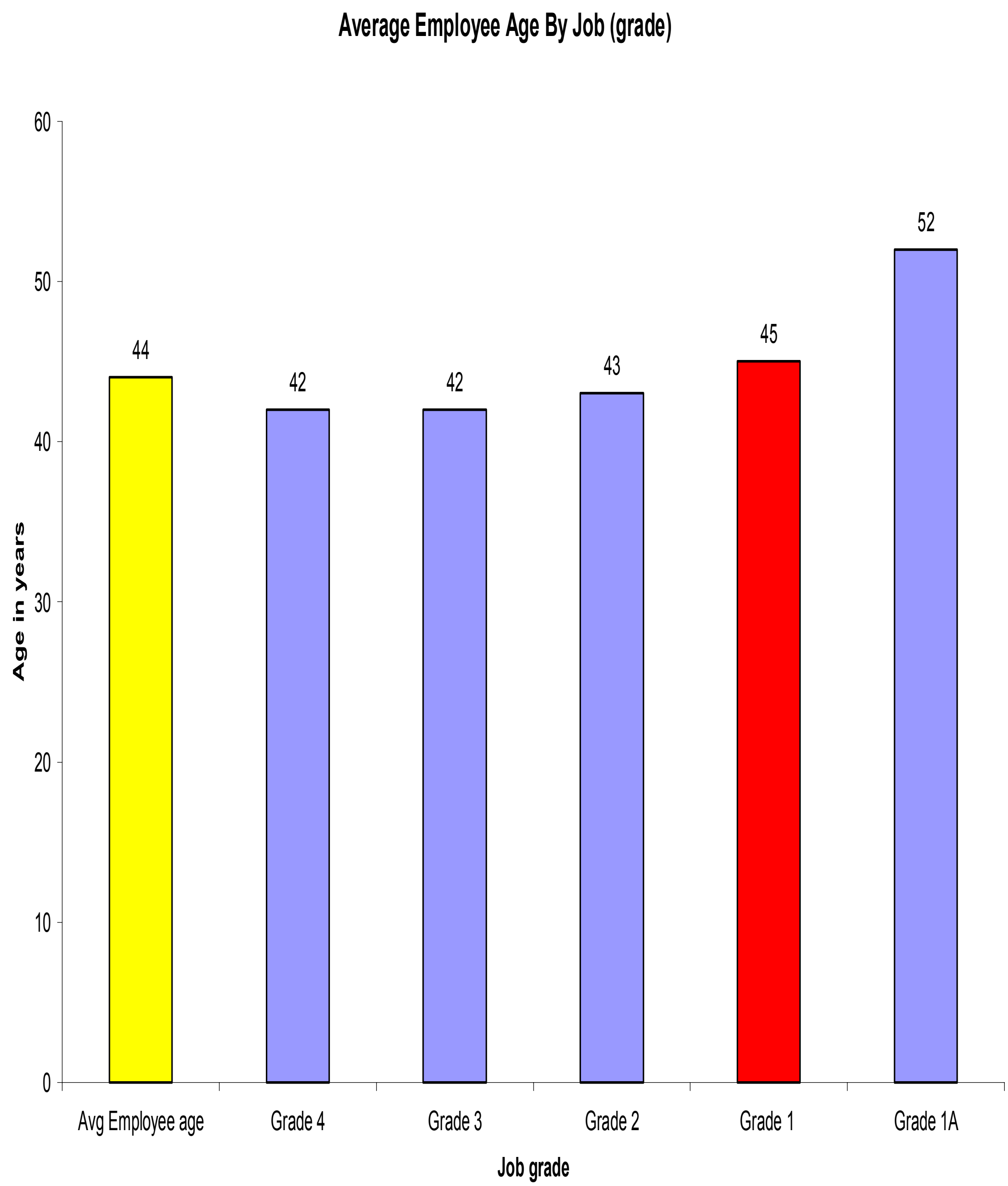


Figure 6 2002 Reported Accidents at Nutricia

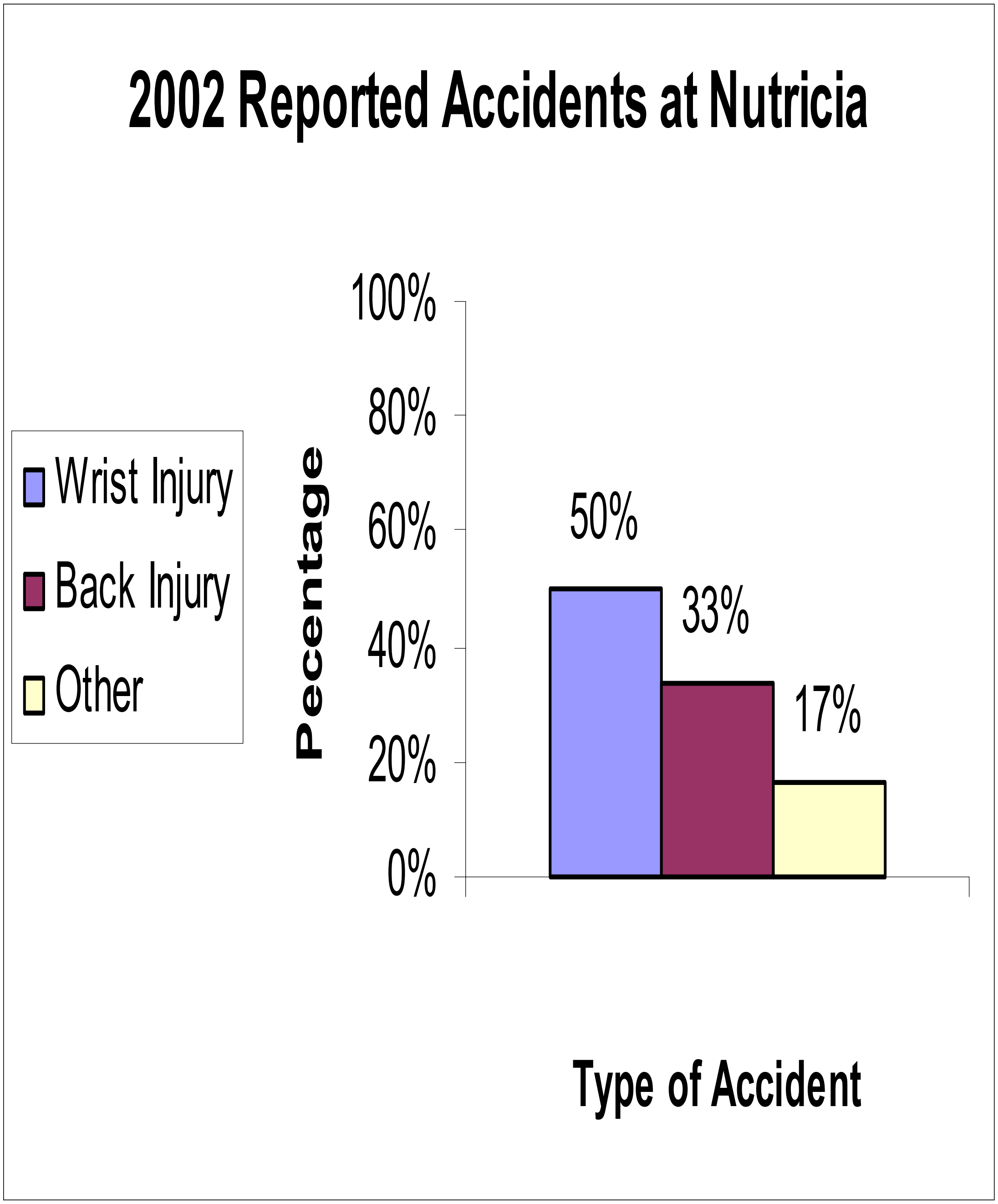


Figure 7 2002 Production by Line

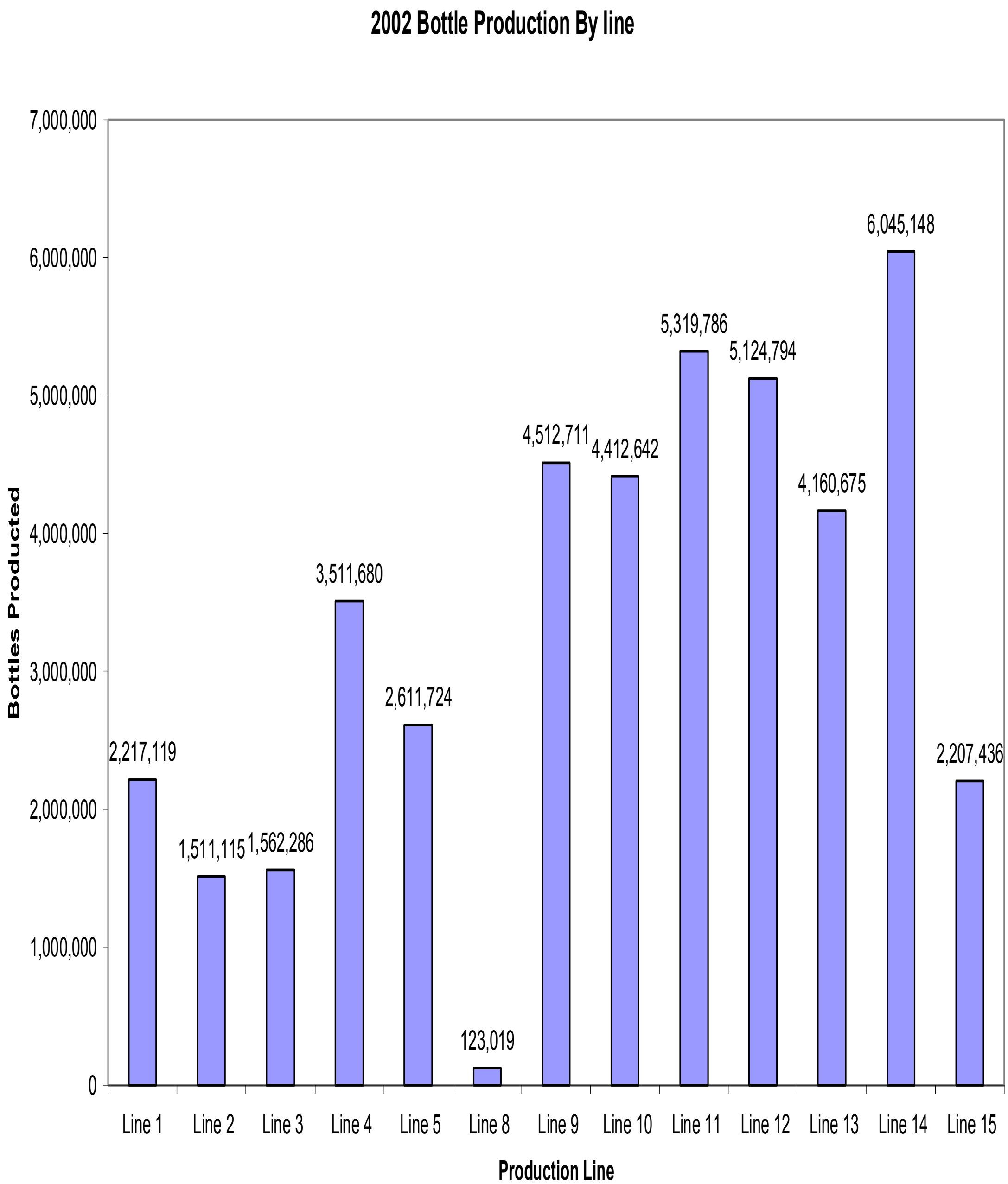


Figure 8 2002 Unscheduled Downtime by Line

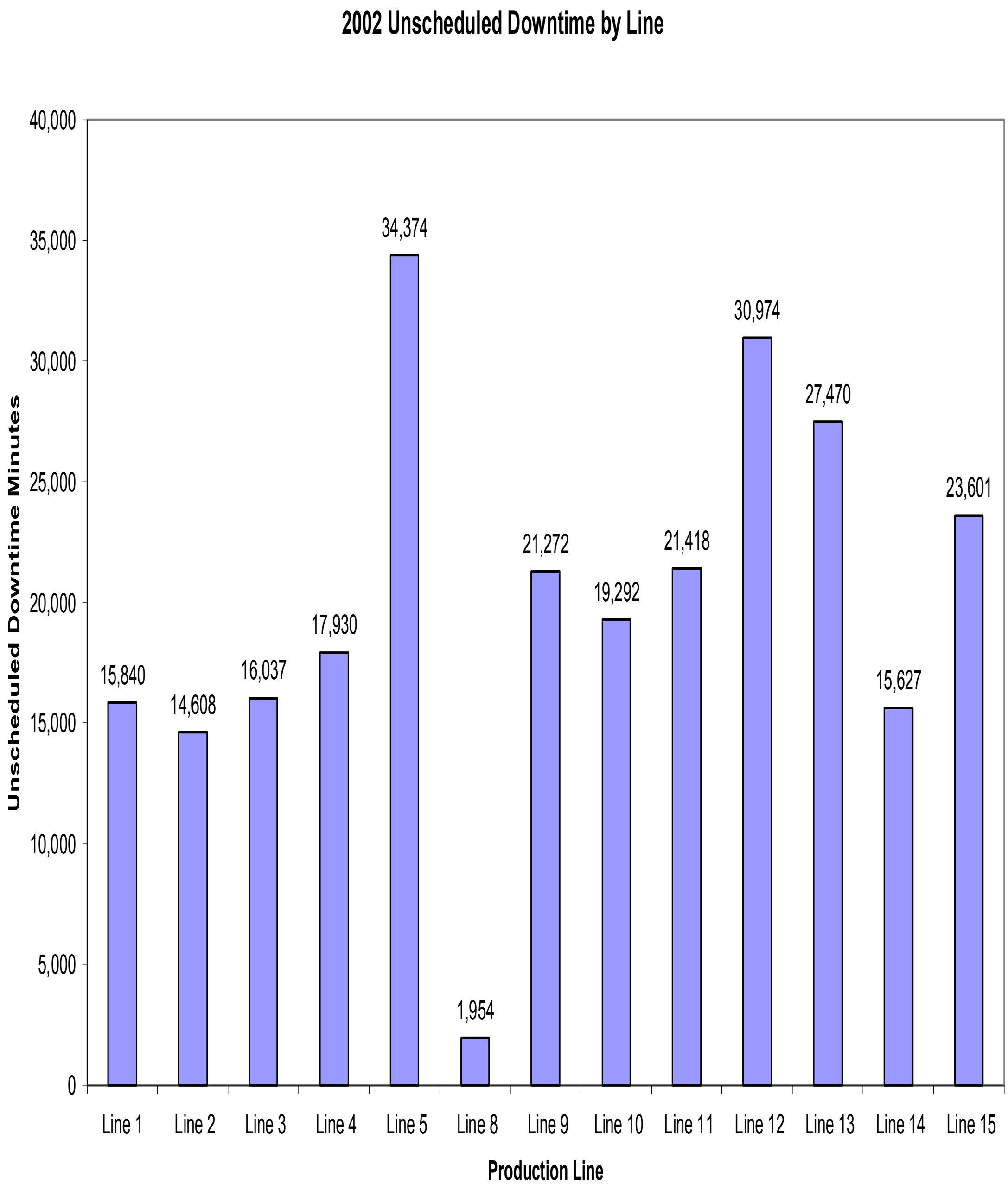


Figure 9 2002 Line Reliability

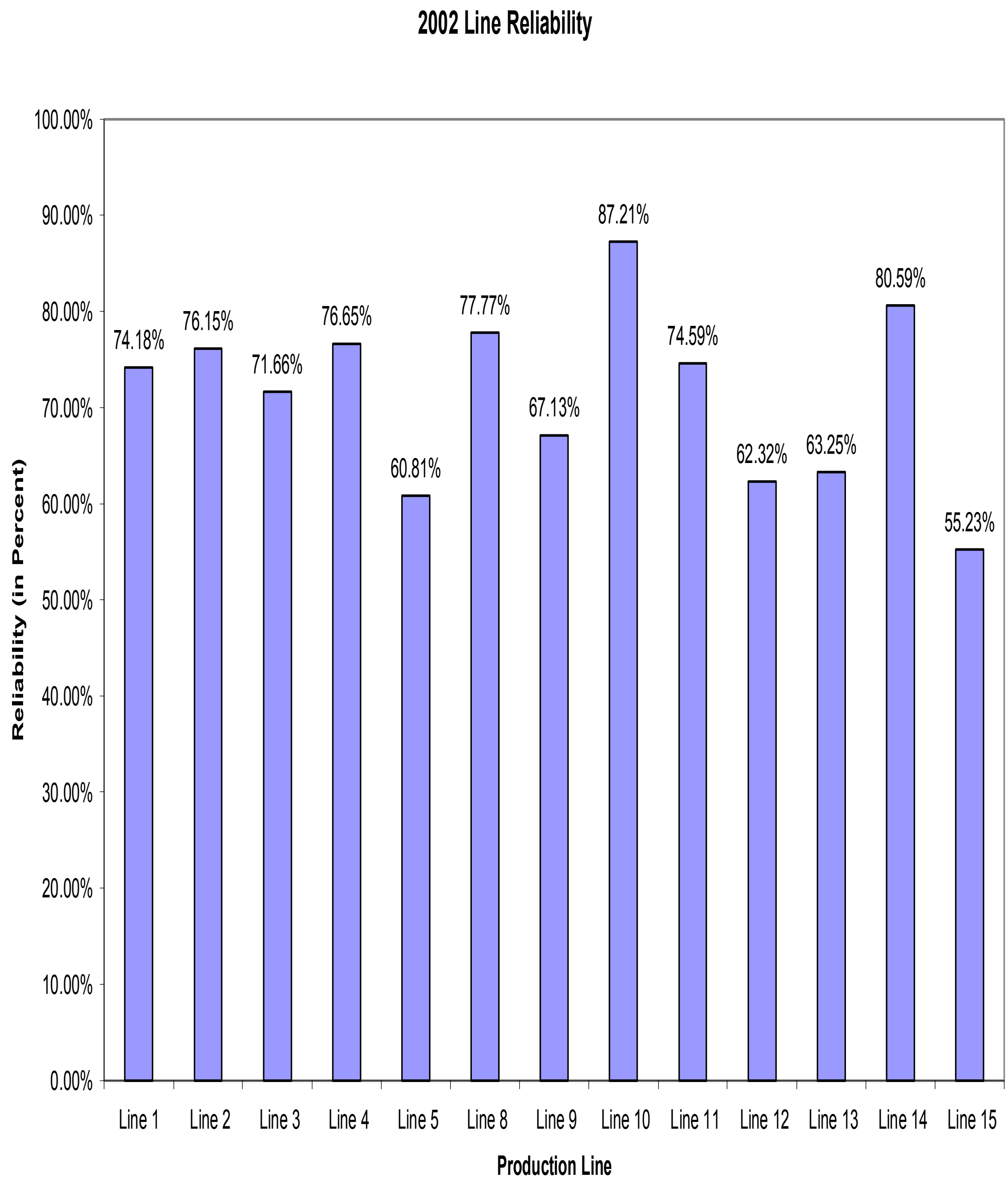


Figure 10 2002 Bottles Per Scheduled Minutes (BPSM) by Line

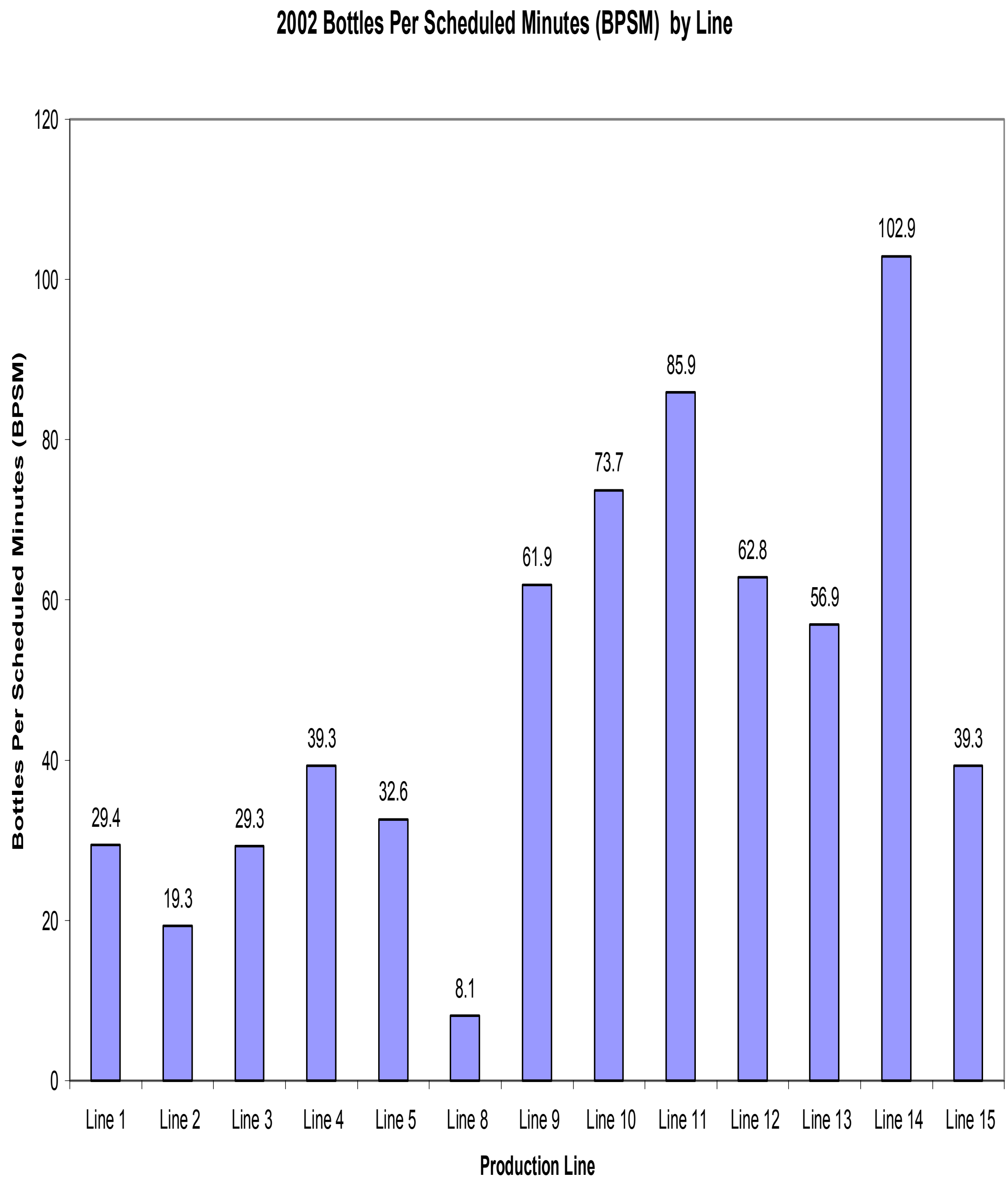
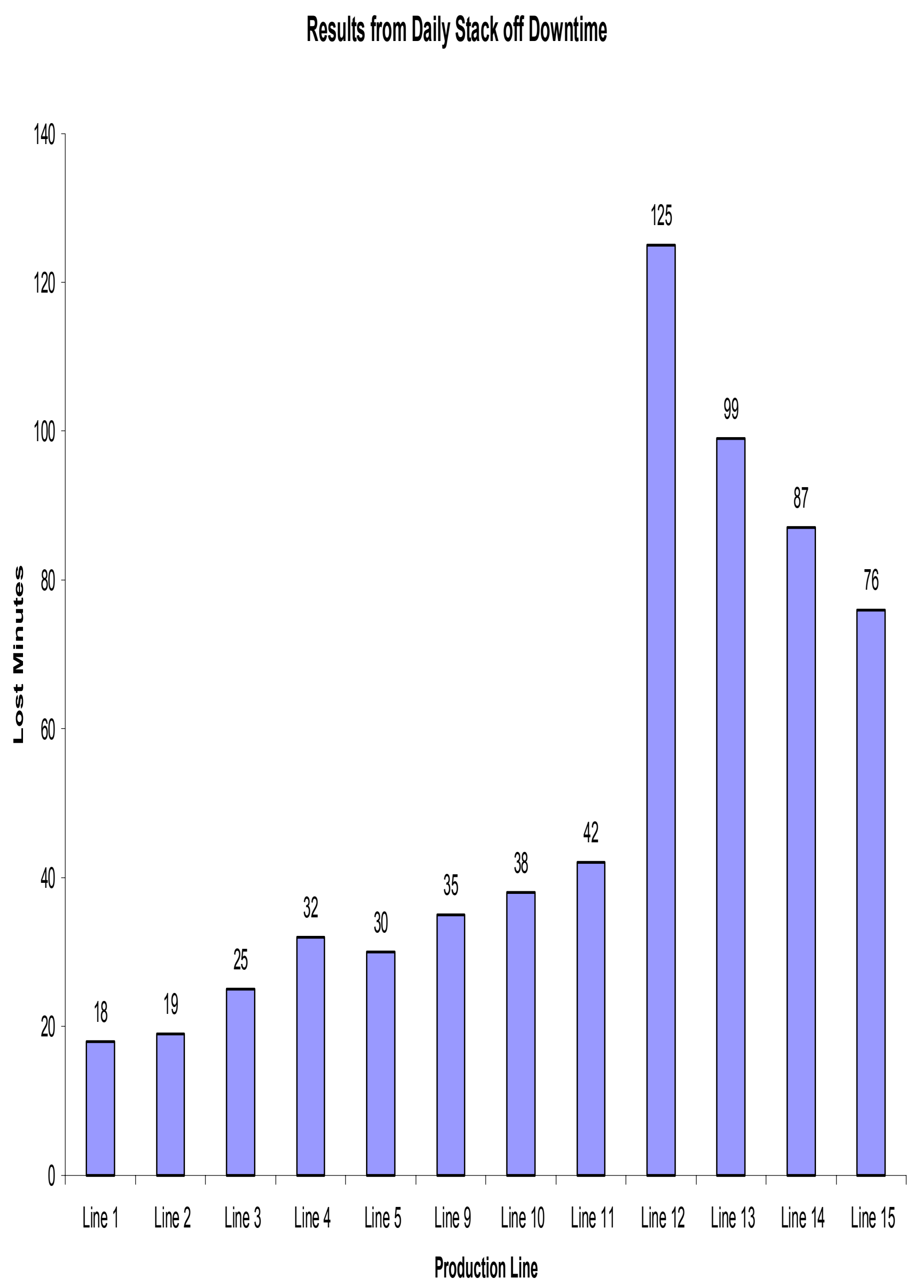


Figure 11 Results From Daily Stack off Downtime



COMPANY APRROVAL FORM

I hearby grant Dirk Fugate permission to complete a project / thesis on improving the conveyor system at this manufacturing facility.

2/6/04 Plant Manager

Manufacturing Manager

CONVEYOR SYSTEM DOWNTIME BY LINE FORM

LINE #

DATE:

STACKOFF START TIME	STACKOFF STOP TIME

CONVEYOR SYSTEM DOWNTIME FORM

DC OPERATOR: ______________________

DATE: ______________________

START TIME	STOP TIME	REASON:

Appendix C: Packaging Conveying System Project Form

PACKAGING CONVEYING SYSTEM PROJECT FORM

DATE: _________

DEPT: _________

JOB GRADE: _________

Please answer the following 10 questions.
(Check N/A for questions that don't apply.)

	Always	Sometimes	Never	N/A
1. The Packaging Conveying System is reliable.				
2. Line operators have to constantly stack off bottles.				
3. Conveyor jams are real easy to find and fix.				
4. Our equipment (ladders, lifts, etc..) is safe enough to fix jams.				
5. Whenever the system is down, I have aches and pains from stacking off bottles the following day.				
6. It is common to have to stack off pallets 2-3 times a day because of the conveyor being down.				
7. Sometimes we have to shut off the packing table because we have run out of space to stack off.				
8. I am often frustrated because I frequently have to wait on the conveyor or have to stack off bottles.				
9. I often feel have to work twice as hard when the conveyor is down.				
10. I think the conveyor system needs to be improved.				

ADDITIONAL COMMENTS:

VITA

DIRK L. FUGATE

Personal Data:	Date of Birth: April 17, 1973 Place of Birth: Abingdon, Virginia Marital Status: Single
Education:	Public Schools, Roanoke, Virginia East Tennessee State University, Johnson City, Tennessee; Electronics Engineering Technology, B.S., 1997 East Tennessee State University, Johnson City, Tennessee; Engineering Technology, M.S., 2004
Professional Experience:	Graduate Assistant, East Tennessee State University, College of Applied Science and Technology, 1997 – 1998 Production Engineer, Five Rivers Electronics Innovations, Greenville Tennessee, 1998 – 2000 Supervisor, Kemet Electronics Corporation, Greenville, South Carolina, 2000 – 2002 Team Leader, Nutricia, Anderson, South Carolina, 2002 - 2004