PRODUCTS LIABILITY

An Interactive Qualifying Project Report

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by

Lee Walter Caron

Eric George Girard

Jesse Howard Mills

VincentMathew Christian Malfa

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Approved:

Professor Raymond R. Hagglund, Advisor

Professor Mikhail F. Dimentberg, Advisor

Abstract

This Interactive Qualifying Project centered on the concept of determining liability as applied to the design, implementation, and testing of publicly and privately consumed goods. Three sources were researched and used as a foundation for an understanding of products liability law. Three cases were then examined and analyzed using principles learned in engineering coursework, followed by an application of the knowledge gained from the preparatory legal sources to determine which party was at fault in each case.

Table of Contents

List of Figures

1. <u>Art of Advocacy Skills in Action Series</u>

Produced by Matthew Bender and Company, Inc.

An opening statement can be a very powerful tool if used properly. Attorney's can use the opening statement to paint a picture of their side of the case by, in effect, telling a story. The opening statement is an attorney's primary tool of persuasion. This aspect of the trial process was not given much thought until a revolutionary study revealed that 80% of jurors cast the same final vote that they would have after the opening statement. Prior to this study attorneys would open with an apology to the jury, a show of pity towards them, or simply recite the witness list. Opening statements were trite, apologetic, tentative, unimaginative, or worst of all, just waived. Now, however, they have taken on a whole new role and attorneys use a whole new approach to reach the jury for the first time in the case.

When giving an opening statement, it is important for the lawyer to keep certain points of style in mind. In order to keep the attention of the jury, it is best if the information in the opening statement is presented as a story about the client in soft-spoken, intimate tones. Also remember that a good story has a who, what, where, when, why, and how, and so should a good opening statement. It is of the utmost importance for the lawyer to deal directly with the jury so they feel involved in the events of the incident. As with any story, it is important to quickly establish the protagonist so the jury can view the events through their eyes from the beginning. If the attorney makes the jury understand the series of events from the point of view of his client, then he has set them up to view all presented evidence from that perspective, thus allowing the jurors to better understand his side.

When telling the story of an opening argument, the content of the telling is just as important as the style of the telling. An attorney should take this time to stress several points to he jury. The jury must know, above all else, the plaintiffs point of view and what the law in question actually is. If something is said that will be important to remember later or is a keystone point, the attorney should come right out and tell the jury that it is important. Similarly, if there are any legal or scientific terms that may come up often in the course of the trial, a good attorney will most likely define them simply to the jury during the opening statement. Be careful when employing these elements, however, for overuse may make a jury believe that they are being lead.

Similarly, as it is important for the attorney to tell the jury his side of the case in detail and with precision, it is also important to inform the jury of what the defending side will likely set forth. This is done for the purpose of dismissing key defense points as not important in light of the plaintiff's information. However, an attorney must be careful not to attack the defendant directly so as not to come across aggressive or argumentative, but to rather dance around the information and lightly brush it aside. Something else that an attorney must remember not to do is present arguments. Though arguments are not allowed to be presented in the opening statement this can be sidestepped by phrasing things carefully, such as "…the evidence will show…"

The opening statement is the primary tool of persuasion for an attorney, and should, in the end, have established liability, credibility, and damages along with telling your complete side of the story. Credibility will, in the end, be the keynote of the argument so an attorney must take care to not damage it in his dealings by attacking the defense if it does not fit into his argument.

Once an attorney has gained experience, he will develop strategies that work well for him in the opening statement procedure. Another common way to present the information is one that trades intimacy for assertiveness. Rather than a long buildup or set up of the players, the attorney would jump right into the story and identify the protagonist as he enters the story. This style relies more on the effect the attorney has on the jury than the information he puts across. The lawyer would use changes in voice inflection, speed, and volume to accent the importance of a point rather than the direct approach. This particular style would leave the details for the body of the trial and would be the more non-emotional approach on the part of the lawyer.

The direct examination is viewed as the easiest part of a court case from the attorney's point of view. It is the most calculated, structured part of the case. The attorney has had ample time to prepare the exact questions he or she wants to ask, and what points he is aiming to establish by asking them. He has had time to prepare his witness and instruct the witness how to answer and what to expect from the opposing attorney during cross-examination.

The only aspect of a direct examination that separates an excellent one from an average one is the content of the examination. As mentioned, the examination is structured; it is easy for the attorney to put together questions to ensure that his or her point is amply displayed. One must understand that to have a good direct examination the content must be interesting to the jury, because they will have only a limited attention span. If the attorney were to lose the attention of the jury even the most convincing point of the examination could be lost in the bottomless abyss of boredom. This is the reason why every direct examination should start with a very interesting question, eliciting a stimulating answer. The purpose of this is to narrow the jury's attention on the conversation between the attorney and his witness. If the attorney strikes while the iron is hot, he or she will have a better chance of maintaining the jury's attention throughout the examination.

An attorney should also be aware that establishing the credentials of his or her witness is vital to an effective examination. One should not leave the jury to question the credentials of the witness while vital points are being made. Establishing the credentials of the witness allows the jury to trust the witness and the answers they give as the truth. It allows for a larger attention span because they will be more interested in what a trusted witness has to say rather than a witness whose integrity remains in doubt.

The use of visual aids to help the jury understand exactly what a witness is talking about is also very useful. If the jury can see for themselves the formulas and thought processes by which a witness came to their conclusion it is very helpful in driving home the point that is being made. The most important aspect of using these visual aids is to make sure that the attorney positions them so as to allow him- or herself and their witness to review the aids while talking to the jury about them. This is so the jury feels that they are part of the analysis being made and that they are being allowed to review the same material the witness has had and being allowed to arrive at the same conclusion as the witness.

Perhaps the most influential parts of a direct examination are the first and last points made, so care should be taken to ensure that these are major points, the most convincing arguments that the attorney is trying to make. By doing this you captivate the attention of the jury so they will hear and understand the remainder of the examination.

The last point made should be major as well because this is probably the point the jury will most vividly remember when the go to deliberations at the end of the case.

Contrary to the direct examination portion, the cross examination is probably the most difficult portion of the case. In this part the attorney must present himself in front of the jury and the court and try to disprove what the opposing camp has just argued. This, needless to say, can turn into a disaster. Unlike a direct examination, the cross examination is a battle of wits and wills. The key to a successful examination is to be aggressive with the hostile witness and assert dominance over him or her right away. This way the message is sent that the attorney is in control, not the witness. Being slightly more animated than usual is also a positive attribute, however one must be careful not to be melodramatic. Being animated is a tip-off to the jury that the attorney doesn't wholly agree with what the witness is saying. This will cast doubt on the witness without badgering him or her.

Once dominance is established a good attorney will seek to introduce the witness as an advocate of the other side's counsel; that he or she is in collusion with the other side. If the witness is an expert and is paid to testify, it may be worthwhile to inquire about the specifics of the witness's bill. This casts doubt upon the integrity of the witness's testimony if he or she is foreseen to have been "bought" by the other side, rather than as a witness who knows the facts and discerns no difference between the opposing parties in the case.

One aspect of a cross-examination that is similar to that of a direct examination is that it is absolutely imperative that the attorney obtain and hold the attention of the jury. The attorney can use reasonable theatrics to obtain the jury's attention while he or she asserts dominance over the witness. The attorney must disprove the points and arguments raised by the other side to maintain the attention of the jury and also steal the credibility of the witness built by the direct examination. The attorney must use his most convincing point at the end of his examination to leave the jury with a witness that has just had his or her credibility destroyed and thus destroying the points raised by the opposing counsel.

Unlike direct examination, an attorney is allowed to use both open ended and leading questioning techniques during cross-examination. Open questions can be beneficial to the attorney asking them, if he is confident of the answer. On matters of strictly established facts, there is no harm in letting the witness speak freely. However, an attorney is taking a big risk by asking an open-ended question that he or she does not know the answer to. Although these situations should be avoided, the attorney must be prepared for the possibility of a surprise answer, and how to handle it so as to appear unfazed.

A leading question is effectively a way of making a statement for which the witness is asked to give affirmation. However, there are times when the witness may be either unresponsive or uncooperative. In these situations, it may be beneficial to restate the question, have the court reporter read back the question, or, in an extreme circumstance, request that the judge demand an answer.

The most effective way of asserting dominance over a hostile witness is straight out interrogation. If you leave the witness with an open-ended question he or she may be able to explain their answer in such a way that is unfavorable to the attorney's cause. Straight interrogation only allows for acknowledgements that are devoid of any explanations that can disarm the attempt to destroy the credibility of the witness. To invoke this tactic efficiently the attorney must control the content of the interrogation, this becomes easy if dominance has already been established. The attorney must also control the pace in order to establish a pattern of response from the witness, thus asserting more dominance over the witness. It may be necessary to undermine the proficiency of a witness's professional activity; if it can be demonstrated that an expert witness did not do sufficient research or investigation to render an objective opinion, then this can discredit the witness's testimony. If such a circumstance occurs, it may be possible to blame the witness's subjectivity on the other attorney's desire to win.

The closing argument is where the attorney must bring everything together. He or she must instill in the jury why his points are correct, why they are believable, why the opposing counsels points are moot or incorrect, and what sort of finding is appropriate. To reach these ends the attorney must keep the jury's attention, he or she must have interesting things to say, and must say them in a way that is interesting for the jury.

It is advantageous for the attorney to not regurgitate witness testimony; they have already heard it once. Reviewing the points and arguments of the case are what need to be discussed. To make this easier an attorney should take a warmer, more intimate approach to the jury. One tactic is to abandon the podium and not use any notes. This way the jury does not feel that they are being lectured by the attorney, but rather feel that the attorney is having a discussion with them. This establishes more credibility with them in the waning moments of the court case. The jury will get the feeling that they are not being misled and that they are being spoken with rather than spoken at.

A topic that is difficult to address without being overzealous is damages. An effective approach to dealing with this topic is to be straightforward, detail each specific damage, quantify the amount of money sought, and give a reasonable explanation for why this amount is proper and fair. The attorney can make use of visual aids to help the jury clearly see each part broken down and the total sum so that they feel they know where the amount of money sought is coming for. The will at least know that the number they may award was not picked out of the sky, but rather thought out and calculated. Another method of presenting the issue of damages is to speak not about the physical aspect of human mortality, but rather to give the jury a brief glimpse of what it is really like to be helpless, or permanently incapacitated, or whatever analogy may be appropriate to the situation.

In conclusion of the closing statement an attorney may seek to remind the jury of their duty to their community to provide a just verdict, he may also stress that their decision is absolute and final. Sitting on a jury is not merely a matter of civic duty, but rather a burden for each of those 12 men and women to carry for the rest of their life: what does their decision mean not the attorney's, not to the witnesses, not to the media, but to the victim.

One of the most publicized cases of product liability centered on the classic Ford Mustang. The models from 1964.5 to 1970 had a drop-in gas tank that comprised the floor of the trunk. The car was also designed with only the rear seat between the cab and the trunk. This had the side effect of allowing flames and gas to spew forth into the cabin in the event of a rear end collision. In a rear end collision, the drop in tank was easily ruptured and pushed up and through the back seat of the car. This design flaw lead to

Ford being sued more then 70 times for this particular problem. The death rate for rear end collisions in these cars has been found to be 3 times greater than the average. Lee Iacocca said, "…trade up. Its time to dump that old Mustang."

2. An Engineer in the Courtroom

by William J. Lux

Choosing a career path as an engineer has several inherent responsibilities unique among other professions. In addition to providing for one's self and family and doing one's best in all endeavors, an engineer has an obligation to his employers, his conscience, and to society to see that products are "reasonably safe" and free from defect or dangers in their intended uses. Any engineer is vulnerable to the possibility of participating in lawsuit as a defendant, as the United States legal system looks for culpability; those responsible for the very existence of a product involved in some type of accident always warrant some investigation. But also, there is a place for an engineer to sit behind the plaintiff's table and lend an expert opinion or testimony to the proceedings.

Understanding the legal system, and how and why it works is critical to the effectiveness and security of the modern engineer in the courtroom. Any engineer who is found liable in a product liability suit must fall into one of two categories: either he or she was responsible for a defective product, or he or she didn't tell the story well enough. There is no reason for either of those to be an issue.

Most legal proceedings involving an engineer's testimony pertain to "accidents", a term with many broad definitions. For the engineer's purposes, an accident may be defined as "an unexpected occurrence that causes loss or injury which can be expressed in economic terms." Although there are times when "accident" can simply express a lack of intention, or a matter of chance, the "accidents" for which an engineer will see the inside of a courtroom will necessarily have two components: a party who seeks retribution, and a way to quantify what that retribution.

Accidents come in many forms, and many specific types therein. An attempt at a complete list might read: collisions; loss of pedestrial traction; loss of control; struck by an object; suffocation; electrocution; poisoning; shock; entanglement; abrasion; burns; mechanical failure; struck by projectile; environmental factors; homicide; other. That list, while long, is only the most basic level in a structure of possible events. Collisions, for example, may be between two moving vehicles or one moving vehicle and one stationary object. There is not a single form of accident that cannot be broken down as such, and in most cases to more than just two types. As laws, societal values, and technology changes, the great catchall accident category "other" is filling up, and will no doubt lead to even further classifications.

To begin examining an engineer's role in legal proceedings, it is important to recognize why anyone goes to court: disagreements. Issues that are irreconcilable through ordinary negotiations are a part of human nature, and the legal system provides an arena for their resolution. If all disagreements could be avoided, then no issues of product liability would ever see the inside of a courtroom. However, neither the engineer nor the consumer can be single-handedly responsible for such harmony; rather there is an implicit agreement that each side will be responsible in their endeavors. For the engineer this is a matter of thoroughness in the design, testing, and production of a product. A product must meet the buyer's expectations; must not be unreasonably dangerous; must not be defective; must warn of hidden dangers; must be manufactured to spec; must not be misrepresented; and must include proper and complete instructions. On the other hand, the consumer must do their part; they must read instructions; must not misuse a product;

and must do maintenance. Unfortunately, a great many product liability cases lie not in the product itself, but rather in dangerous use, operation, or lack of maintenance.

A person or business entity that is the target of a suit has a right to respond to the charges, to the end goal of establishing or disproving strict liability. The term strict liability refers to the fact that direct contact, or privity, is not necessary to assign blame. Rather, an unintended defect is sufficient to deem a defendant culpable. Generally speaking, the court doctrine on strict liability states that the cost of an accident should be assessed to those most able to have prevented or avoided the accident, which is sometimes read as the cost should be assessed to the party most able to pay damages. This in turn led to the "deep pockets" practice of litigation, little different than the way in which an "ambulance chaser" operates.

For an engineer, avoiding litigation is a simple concept in theory: don't have any accidents involving your products. In practice, this is not so simple. There are certain steps that can be taken throughout the design, testing, and production processes which can help safeguard against liability. These steps are as follows: Avoid hazards in the first place by identifying dangerous elements of a design and eliminating them. Protect against unavoidable hazards with devices such as shields and guards. Also, warnings of potential hazards (such as warning stickers) or impending hazards (such as airplane stall warnings) are effective ways of placing the burden of safety on the operator. In circumstances where hazards are out of the control of design specifications, attempt to foresee human errors; protect against rollovers and collisions with devices such as restraint belts and rollover protection bars. When planning and designing safety systems, protecting the people involved should be the chief consideration.

One important consideration is that humans are fallible, so the more responsibility toward safety that the operator is given, the more likely there will be an accident. Although warnings and instructions may relieve an engineer of accident liability in the eyes of the law, it may still take a long and tedious litigation process to determine that innocence.

There are several guidelines that an engineer can follow to avoid accidents. In all cases, the specifications, performance, precautions, and cost of a product are a balance between needs of the producer and the needs of the purchaser. The first step to accident avoidance is to clearly specify safety measures, and to insure that those specs are met in both the task specifications as well as the final product. Testing to determine how and where failures occur is critical, as is failure analysis; car accidents will happen, regardless of brake lights and turn signals, so seatbelts and supplemental restraints are tested and implemented. Simulated failures may also be necessary to complete this testing. Along the same lines, a study in accident probability, effects, and severity may provide useful feedback for revamping the design. An objective viewpoint, such as from an independent contractor, is useful because it gives a sample of the type of scrutiny a product would receive during litigation proceedings.

From time to time, it may be necessary for an engineer to review his or her methodology in designing and testing products. However, with an eye toward a product’s prospective uses and environments, possible misuses, and the necessary instructions and warnings for safe operation, there is little else than can be done to protect the consumer from his or her own self.

An engineer can be a very useful witness for an attorney; this usefulness can be accentuated by an understanding of pre-trial and trial processes. The litigation process occurs prior to an actual trial. This process shapes what the trial will be about; it establishes charges, damages, what points will and will not be contested, and who will be presented as witnesses during the trial. The litigation process is often referred to as a game, because both sides are jockeying for better strategic position going into the trial.

The litigation process is started by a claim being filed by the plaintiff; this is accompanied by a request for trial and redress of damages. The defendant is informed of the claim filed against him/her and they have a certain time frame to respond to the charges. They simply answer yes or no to each charge, if the answer is yes then the matter is settled and litigation ends there, if not, and the answer is no then the defendant is required to list its defenses and the litigation process continues to the next step, the discovery process.

The discovery process has several steps in which each side exchanges information and they build their own cases against each other. It usually starts with interrogatives, which are a set of questions each will ask the other. These questions are usually very basic questions about what happened the day the injury occurred, background information on the plaintiff and defendant. Each side has a certain amount of time to answer these interrogatories.

Each side then asks the other for requests for production. This is a request for the other side to provide the basis for its evidence, such as assembly prints, photographs, and technical reports. The plaintiff will usually make a request for admission; this is rarely done by the defense. This is a set of statements that the plaintiff contends to be true and the defense will usually admit the truth of these statements. These admissions can be later used by the plaintiff as evidence, and if the plaintiff later proves the defendant was untruthful in its admissions the judge and jury may look upon them unfavorably.

The parties also do physical inspections of the accident scene and the machinery involved so that they can become more familiar with the nature of the accident and injuries.

The final step in the litigation process is depositions. These are statements, given under oath, by potential witnesses. These statements are used by both sides to help them prepare questions for the witness if and when they take the stand during the trial phase.

The trial phase is the phase that most engineers are more familiar with. The first step is the jury selection, which is particularly important because a jury can be chosen to the advantage of one side or the other. Once the jury is chosen the trial actually begins, with the plaintiff presenting first. This is done because the defense is only required to answer what the plaintiff presents, due to the burden of proof. Opening statements, from each side are followed by presentation of evidence and witnesses. Both sides give their closing arguments as a final word to persuade the jury to their side. The jury then receives the charge from the judge, the jury deliberates and then gives its verdict.

An engineer can be very helpful to an attorney and can fill many roles other than expert witness. The engineer can act as an adviser to the attorney concerning technical aspects of the case. Besides knowing technical information concerning the product in question, including the development process, manufacturing process, quality and testing of the product, the engineer can advise the attorney on the state if the art in the field and proper technical publications on the product. The engineer can advise the attorney on the proper usage and application of the product, perform quantitative tests, or oversee the tests to provide information to the attorney on the products capabilities as compared to manufacturer specifications. Perhaps of even greater value, an engineer can assist the attorney when examining and interviewing potential witnesses reading depositions for technical truth. The engineer can also suggest proper questions to ask witnesses, even himself for when the engineer is on the stand. The engineer can translate technical data and writing into common language so the attorney can have an understanding of the technical aspect of the accident. In the role of expert witness, accident reconstruction is an important ability of the engineer; he can put together a series of events in chronological order that lead up to the accident and subsequent injury.

The attorney can benefit most from a good deposition from his expert witness. A contradictory deposition and courtroom performance can spell ruin for any case. The key to a good deposition is honesty, be honest with every answer you give. “I don’t know” or “I don’t recall” is a truthful answer as well. Follow the guidance of the attorney; he knows what he needs to present a good case. Take your time when answering questions, even if the answer is obvious, think it through before responding. Do not volunteer information unless it is specifically asked for.

A trial under the US judicial system consists of several key components. Whether for a civil or criminal suit, the process begins with the selection of a jury. A jury is a group of six or twelve of the defendants “peers”, agreed upon by both sides, who are given the task of determining the matters of fact in a particular case. Though this is the beginning of the trial process, the actual trial begins with the lawyers opening statements.

During the opening statement, both sides are allowed to give the jury and overview of what the case is from their side's point of view.

The next and most involved step in the process is the presentation of the case. This occurs in two parts. First, the plaintiff is given the chance to present to the court. The plaintiff's lawyer (or the state attorney) will utilize several elements during this time in support of his case. They will make use of witnesses, evidence and information that tells the story the plaintiff painted during his opening statement. Various witnesses will be brought forth to testify and verify the scenario set forth by the lawyer, to discuss the worth of the plaintiff, to state the cause of the accident or potential prevention and provide any other eye whiteness accounts that are needed. They may also use medical evidence, "blanket evidence", proof of losses or any other information needed. Once the prosecution has rested, then the defense attorney is given his chance to refute the claims of the prosecution and prove is own series of events. Since the burden of proof is given to the plaintiff, the defense attorney will usually bring forth evidence to directly refute that presented by the plaintiff's attorney. Such evidence may be in the form of accident reconstruction, mechanical specifications, safety analysis or economical data.

Once both sides of the case have rested, they are given another chance to summarize their cases in the form of the final arguments. The plaintiff will first retell his side and address anything that he things the jury may questions after they have seen all the evidence. The defense side will then give his final statement, sometimes followed by a short answering statement by the plaintiff.

Now that the entire case has been presented to the jury, the lawyer's job is complete. The last stage of the trial process begins with the charge to the jury. The judge will give them very specific instructions (sometimes called a verdict sheet) on how to decide the verdict of that particular case. The jury's deliberation is where the review all information that they have been given and decide who is at fault, and for what.

During the trial process, there are many key players that lend their contributions. The one in charge of the court is the Judge, who acts like a mediator between the two sides. The judge's assistant is the court clerk who maintains the day-to-day activities and operations of the court. The court reporter takes depositions from witnesses as well making a record of what is said and done in the courtroom. The marshal (deputy) has the task of maintaining order and security in the courtroom itself. The most obvious participants are the attorneys that plead that case, and the jury that decides the final verdict

The proper conduct for the courtroom is mainly common courtesy. A witness should always dress formally, show respect, stand for the judge, use sir or ma'am and pay full attention. It is also important to remember to remain quiet and don't offer information unless you are asked a question and never direct that response to the jury.

When a question is asked, a proper response is short, to the point, and in laymen's terms so that the jury can easily understand. Above all, every one in the court must be truthful. A witness may be asked a question by anyone at anytime. When a witness is being asked questions on cross examination, the witness will pauses before answering so as to give the other attorney a chance to object. Be careful while answering cross-examination questions however. The attorney may try to make the witness admit wrongdoing or unprofessional conduct in the case by rewording or repeating questions. One of the key rules is to stay calm and quiet so as not to loose credibility with the jury.

If an argument does break out between other members of the court, it is the witness's duty to stay quiet and not respond to anything unless directed to by the judge. The most important thing about answering questions, however, is to always learn from the experience.

A key tool in the witness's arsenal is the accident reconstruction. When preparing the reconstruction the first thing that is done is the gathering of all evidence, including witness testimony. The problem with eye witness accounts are that any rationalization done by the witness since the event become skewed, so they can not be taken as definitive. All pieces of evidence must be taken into account, even if they don't fit at the moment. In the likely case that all the holes are not filed, it is important to make multiple scenarios and eliminate the unlikely cases such as ones that don't fit the timeline. When assembling the reconstruction, a witness should be sure to follow all the rules used to give verbal testimony so the jury can understand.

As an engineer in a court of law, it is important to know several key terms and tactics used in the courtroom. Legal terminology falls into three general categories, the first of which are those dealing with in court procedures, such as sidebars, direct examination, and burden of proof. There are also terms that deal with various types of legal processes, the most useful of which are litigation and mediation. The last type appears throughout legal proceedings, such as good faith, hearsay, irrelevant.

The major considerations when testifying in court is to always assist and listen to your attorney, and other officers of the court. Do not be overwhelmed by the process, just provide any information that you have and always think before you answer. You are a professional, called for your expert opinion on the matter at hand, and your demeanor should reflect that. Always do your best work, and you will not have to worry about it standing up under examination, and admit to any errors made because you are allowed to be human.

3. Products Liability in a Nutshell

By Jerry J. Phillips

Products, by their very definition pertain to tangible property, rather than services rendered. Hence it follows that modern product liability laws have their roots in the Sales Article of the Uniform Sales Act, which is now known as the Uniform Commercial Code. However, today the legal system recognizes that products and the liability laws governing them must extend to intangibles as well, such as electricity from an energy provider. When this is considered, it is easy to see the logic that product liability inquiries are not about the products per se, but more specifically whether or not the defendant is the party in the best position to prevent loss and/or injury.

Product defects fall into several categories, but the lines between those categories are often indistinct. Some of these categories include: problems with a product, negligible entrustment of sound product, misrepresentation of a product's attributes or abilities, or a product that can create a dangerous situation. Clearly, there are some products one expects to be somewhat dangerous, such as commercial demolitions ordinance. However, if the use of such a product somehow resulted in serious loss or injury, only a careful investigation could reveal whether the manufacturer was at fault for an actual defect, or the user for an occurrence of misuse. Concerns such as this have led to the simple basic doctrine of a product that is harmful in the context of its intended use is defective.

Different types of product defects include: manufacturing or production flaws; design flaws; warning or instruction flaws; misrepresentation. Again, the lines between these lines are confusing at times; can poor instructions or warning be considered a design defect? Are bullets defective if they are designed to kill?

There is no single law regarding conceptual standards for determining defects. Rather, the law has a certain sense of fluidity to adapt to individual cases. Often consumer expectations of a product may be compared to the actual experience in the case for a perspective on the possible defect. However, there are also cases where consumers are not expected to have any basis for examining a product, and expert testimony is required. Also, a seller can be found liable for negligence if he/she is selling a product which is known to be defective.

The risk-utility analysis is another method for determining liability and defect. Basically, the value of purchasing or using a product can be weighed against the likelihood that it will cause an injury or loss. For example, even the most careful of screening procedures will not prevent some small quantity of infected blood to be entered into a blood bank, and eventually infused into a person who is infected in turn. Yet the alternative to an infusion is usually fatal, so the risk-utility analysis proves worthwhile, and the blood bank's product is not defective.

For determining the state of risk-benefit, seven factors were written by Dean John Wade. These factors are as follows: usefulness and desirability; likelihood and probability of serious injury; availability of a safe substitute product; the manufacturer's ability to eliminate the danger at a relatively low cost while preserving the functionality of the product; the user's ability to avoid danger; the user's anticipated awareness of danger; and the feasibility on the part of the manufacturer to lower the risk by increasing price.

It is up to the individual courts to determine whether to consider consumer-expectation methods, or risk-utility analysis.

Plaintiffs eligible to seek recovery for product liability covers a wide range of individuals that have suffered personal injury, property damage, and in some cases for economic. Bystanders are in some cases the most likely to win a product liability case, given that they had absolutely no input as to the purchase, operation or upkeep of the defective product. A prime example of this that has not been explored is people affected by second hand smoke. Product liability suits are not limited to the person directly physically harmed, they also extend to family members and friends who witness a painful death or injury, and to rescuers that where hurt while affecting a rescue.

Possible defendants in product liability suits also cover a wide range of businesses, groups, and associations. The defendants must have some direct connection to the defect or flaw to be held liable for it. This would at first glance seem obvious, but courts have found a wide variety of defendants liable for very small connections, and relieved others from responsibility even though it seemed their fault. The first and most obvious defendant would be the final assembler of a product, as they are responsible for its final condition. Component manufacturers can be held liable if their product directly contributed to the defect, or contained the defect. In the case of a product assembled by a dealer, the manufacturer can be held liable if any instructions or training provided to the dealer was unclear or incorrect, and ultimately responsible for the defect. This principle can also apply to franchisees and licensees when the defect is within their protocol or licensed technology.

Any time a person or entity handles, inspects, or guarantees they become responsible for any defects, flaws, or risks associated with it. Examples of this can be found in pharmacists being held liable for failing to warn of the dangerous nature of drugs, if a trade association publishes a “best practices” paper that leads to an injury, or an independent tester certifies a product and the flaw was within the area of their testing.

This last point leads to an exception from the idea above. If the defect was not something the entity inspected, then they cannot be held liable for it. An example of this is when repair work is contracted; defects and flaws that are outside the scope of the contracted work are not the responsibility of the repairer. Another exception is when an entity cannot be expected to reasonably discover the flaw within the course of an inspection, such as a very slippery shower in a hotel.

As for the areas of building and lease operations, builders are responsible for defects in construction, as there is implied habitability in their work. You would never ask a builder to construct an uninhabitable house. Likewise, the lease operation implies that all leased items are fit for operation; otherwise they would not be available for rent.

In product liability cases that are centered on misrepresentation, reliance must usually be shown to prove the case, in other words the consumer relied upon the false statement when deciding to buy the defective product. While some amount of puffery is expected and allowed in commercials, experts cannot make such statements, as they’re opinion is held in higher regard by the consumer. While puffery might not necessarily be misrepresentation, it can go towards intended use and imply fitness for such a use.

Disclaimers and contracts are also limited in they amount of liability they can remove from the manufacturer. The general language is contractual obligations are stricken if unconscionable, oppressive, or unfair. Disclaimers must be visible and clearly worded, as well as presented at the time of sale, rather than upon delivery, such as in a manual. Disclaimers cannot be enforced against people who are not party to the contract, as they have had no say in the matter.

The plaintiff in a product liability case faces difficulty in providing enough proof to prove the defendant's product was defective. The plaintiff must prove the product to be defective at the time of the injury, that the defect is the cause of the sustained injuries, and the product was defective when it left the control of the defendant. The effect of this burden of proof makes it necessary for the plaintiff to further prove that alternate causes did not cause the accident. However, once the plaintiff defines a defect, the precise defect does not need to be identified.

This is a much less daunting task if the product is newer, in this case circumstantial evidence of the defect will be more readily accepted. Motor vehicle cases are a prime example. In one case where the suspension of a new car simply collapsed the plaintiff was able to prove the car was defective because it was 3 weeks old. The defendant was held accountable because the manufacture of that particular car was defective, causing the injury to the plaintiff.

In strict liability action is not required to disprove every possible explanation of the injury for the case to be presented to a jury. The plaintiff need only provide evidence from which a reasonable inference can be made about whether or not the product was defective or lacked sufficient safety features. Injury caused by a product when it is likely the proof is based on common knowledge. This is called an inference of causation.

The plaintiff is typically allowed to collect for damages incurred while performing an inherently dangerous task. Typically it is a fraction of the damages proportional to the chance of injury.

Sometimes the plaintiff is the cause of the injury, in this cause they must show that they were not the cause of the injury, if two or more parties are involved then the burden of proof on the parties must show the extent of their contribution to the accident. In these situations the plaintiff may be able to recover in full if he can prove the defendants conduct was a substantial cause of the his injury.

If defendants conspire to conceal a possible suit against their product or with a company that is in concert with one of these companies they become full liable for any injury caused to plaintiffs. Perhaps the most famous of all cases of this type is class action suits filed against asbestos manufacturers and customers of those manufacturers who withheld information regarding the health hazards of asbestos.

Absence of duty, lack of proximate cause and unforseeability are terms used by courts to explain the same concept. Sometimes they are used to reinforce one another. For example a car that is not equipped with airbags is not defective because the consumer could not expect an airbag to prevent injuries incurred in the case of an accident. Therefore the absence of airbags is not a proximate cause of the injury because the absence of airbags was unforeseeable. Sometimes forseeability is used to describe events that can be anticipated, proximate cause is used to describe an event that may have caused the end result. Before a manufacturer can be held strictly liable for a defective product the product must have been put to its forseeable use.

The plaintiff must also prove that he/she was not using the product in manner that was not intended by the manufacturer. However, unforeseeable misuse is not a problem of the plaintiff, but of the defendant. An example would be inadequate operating instructions provided by the defendant would make the plaintiff unaware of proper use and/or dangers in using the product. The plaintiff must prove their lack of guilt of forseeable misuse. Alteration of product by a plaintiff after manufacturer is a particularly difficult misuse case. An alteration may be the case of the accident making this unforeseeable by the defendant barring a recovery by the plaintiff. Therefore the plaintiff must prove the alteration did not cause the accident.

In order for the plaintiff to be able to collect damages from a defendant the plaintiff must prove the injury was unforeseeable and that his conduct did not cause the accident. In the cases involving plaintiff misconduct they typically fall into three major categories that can bar or limit the recovery. These three categories are contributory negligence, assumption of risk, and misuse due to alteration of the product.

These three are usually a defendant's defense to liability allegations. The burden of proof therefore lies with the defendant. The plaintiff must also prove that he/she is not guilty of any of the aforementioned defenses to be able to collect in full.

Comparative fault is widely adopted concept, there are three principal methods of comparison, the plaintiff can recover if he/her fault is less than the defendant, or if the defendant is at fault in any degree, the plaintiff may not recover if his/her fault is equal to or exceeds that of the defendant. The recovery is sometimes determined by the percentage of fault assigned to the plaintiff. Occasionally comparative fault is used to determine recovery in cases of misuse by alteration. Comparative fault is also used to analyze strict liability cases.

Evidence of unsafe and safe use may be used as a major guideline in deciding whether a product is defective or not. The defendant would present a clean track record to demonstrate a lack of defectiveness in their product; the plaintiff may try to present evidence of the contrary to prove the product was defective before the injury occurred. Spoilation is another way to prove a product liability; if the opposing side disposes of evidence that would have been presented by either side then the ruling is in favor of the side whose potential evidence was destroyed. A defendant may not be held liable, or the plaintiff receives full compensation because the product would have to be assumed defective.

4. Kenneth R. Bartow, Diane Bartow, and Nicholas A. Bartow vs. Extec Screens and Crushers, LTD., Extec of North America, and Extec of America

4.1 Background

The plaintiffs in this case are Kenneth Bartow, injured, Diane Bartow, Wife, and Nicholas Bartow, Son. Nicholas Bartow's action is brought by and through his mother. The defendants in this case are Extec Screen and Crushers Limited, located in Sheffield, England, Extec of North America, Located in Pennsylvania, and Extec of America, also located in Pennsylvania.

While employed by O'Connor Brothers construction, Mr. Bartow was attempting to complete routine maintenance on a gravel-screening machine. While in the process of completing this maintenance, Mr. Bartow fell from an indeterminate height and sustained several injuries, both major and minor. It is the contention of the Plaintiff that this accident was not his fault, but rather could have been prevented through design changes on the part of the machine's manufacturer.

There were 18 counts brought against the defendants, 6 per defendant. The counts are in reference to the Extec Screen Plant Machine, model #5000 S/N 3525. The counts are as follows:

1. Negligence, Design of the Machine; Extec Screen and Crushers Limited
2. Negligence, Design of the Machine; Extec of North America
3. Negligence, Design of the Machine; Extec of America
4. Breach of Implied Warranty of Merchantability, machine was not safe when delivered, lack of safety features; Extec Screen and Crushers Limited

5. Breach of Implied Warranty of Merchantability, machine was not safe when delivered, lack of safety features; Extec of North America
6. Breach of Implied Warranty of Merchantability, machine was not safe when delivered, lack of safety features; Extec of America
7. Breach of Express Warranty, company said safe in delivered warranty, apparently not so; Extec Screen and Crushers Limited
8. Breach of Express Warranty, company said safe in delivered warranty, apparently not so; Extec of North America
9. Breach of Express Warranty, company said safe in delivered warranty, apparently not so; Extec of America
10. Breach of Implied Warranty of Fitness for a particular purpose, relied on defendants to furnish a safe and suitable product; Extec Screen and Crushers Limited
11. Breach of Implied Warranty of Fitness for a particular purpose, relied on defendants to furnish a safe and suitable product; Extec of North America
12. Breach of Implied Warranty of Fitness for a particular purpose, relied on defendants to furnish a safe and suitable product; Extec of America
13. Loss of Consortium (Diane Bartow) loss of affection, companionship, support, guidance, services, maintenance from her husband; Extec Screen and Crushers Limited
14. Loss of Consortium (Diane Bartow) loss of affection, companionship, support, guidance, services, maintenance from her husband; Extec of North America

15. Loss of Consortium (Diane Bartow) loss of affection, companionship, support, guidance, services, maintenance from her husband; Extec of America
16. Loss of Consortium (Nicholas Bartow) loss of affection, companionship, support, guidance, services, maintenance from his father; Extec Screen and Crushers Limited
17. Loss of Consortium (Nicholas Bartow) loss of affection, companionship, support, guidance, services, maintenance from his father; Extec of North America
18. Loss of Consortium (Nicholas Bartow) loss of affection, companionship, support, guidance, services, maintenance from his father; Extec of America

The Bartows are seeking 14 million dollars per plaintiff, for a total of 42 million dollars. The defendants responded with affirmative defenses to the charges, which are as follows:

1. Barred by the applicable statue of limitations
2. Complaint fails to state a claim for which relief can be granted
3. All damages claimed were caused by personal acts
4. Complaint is barred by doctrine of Laches
5. Even if they can prove negligence on Extec's part, the Plaintiff's negligence was greater (Comparative Negligence statute, M.G.L c. 231, ss85)
6. Barred by assumption of risk
7. Barred by contributory negligence

4.2 General Accident Description

On December 16th, 1994, Kenneth R. Bartow, an employee of O'Connor Brothers, climbed onto the Extec Screen Plant Machine, Model 5000 (*figure 1)* carrying a ratchet in order to make necessary mechanical adjustments to the machine. While attempting to perform these adjustments, he fell from the machine and sustained serious injury to his back, as well as several less severe, yet chronic injuries, and other minor injuries. When Bartow was found he was not bleeding, and semi-conscious but incoherent. He was found lying in the vicinity of the central portion of the screen on the right-hand side of one of the discharge conveyors. His feet were faced towards the machine and his head away from the machine. His feet were approximately 3 feet from the machine. His shoulders were close to a pile of dirt 4-6 feet from the machine. The ratchet that he had been using was found on the ground 5 feet from him at his feet, with the socket still attached. It was estimated that he was lying there no longer than 1.5 hours before he was found.

Figure 1

As a result of his injuries, he is unable to return to full-time employment and lives in constant pain and has a 15-50 percent disability rating. His injuries have also left him impotent and he requires a catheter to urinate. He suffered compression fractures in his lumbar spine, which have mostly healed. As of April 13th, 1995 he had returned to work with O'Connor Brothers on a part time basis, (approximately 20 hours per week). He was not performing the same job he was prior to the accident but was receiving the same wage.

The Plaintiff claims that the machine has safety design flaws rendering it defective, and it is these design flaws that caused his injuries and subsequent losses. He claims that the machine comes from the manufacturer in this unsafe condition. The

Plaintiff claims that the machine requires regular adjustments and requires personnel to climb onto the machine to perform these tasks. Therefore, the Plaintiff is claiming damages for breach of express warranty, breach of implied warranty, and negligence in the design, manufacture, distribution, installation, repair, inspection and sale of the machine.

4.3 Investigation

The routine maintenance that Mr. Bartow was performing that morning was changing screens and tightening nuts on the screen box of the Extec Screen Machine. The Extec machine does not have an easily accessible way to get to the point where the maintenance must be performed. In spite of this, the safety manual and the general maintenance section of the owner's manual supplied with the Extec machine do not mention any dangers involved with changing the screens. Instructions on how to perform the maintenance are supplied, but no safety precautions or how to safely get to the screens to perform the maintenance are detailed. The manual also does not specify where someone should stand to perform this maintenance. The safety manual and the general maintenance section outline the following safety precautions:

Safety Precautions in manual:

1. Operator must be fully conversant with this instruction manual and comply with all warnings given on machine itself
2. Never operate machine unless all guards and access covers are correctly fitted, locked into position and secured tightly

3. Ensure that all personnel in the vicinity stand well clear before it is switched on and at all times when in operation. The only time the machine should be approached is when it is time to shut it off
4. Ensure the machine is stopped before clearing obstructions, making adjustments or performing repair work, switch off engine and remove ignition keys
5. Hopper feed conveyor, access covers must always be secured tightly when work on conveyor is completed and before machine is started
6. Wear hard hats and safety boots at all times

Warnings in the general maintenance section:

1. Machine must be off and keys removed
2. All adjustments to screen speeds, engine revs or hydraulic system must be done by Extec service engineers

The bolts Mr. Bartow was attempting to tighten regularly loosing due to vibration while the machine is in operation. This is expected from time to time and requires re-tightening to ensure smooth operation of the screen machine. The screens cannot be tightened or changed from ground level, and therefore require the operator to gain access to this section of the machine, by one of two means: with a ladder against the side of the machine, or by climbing up the conveyor belt until one has reached the distal end, stepping over the housing and onto a small yellow platform that extends 14 inches out of the surface (*figure 2*). Although the machine carries many

Figure 2

different visual warnings, none specifically pertain to not climbing the machine. This platform was hung from a steel frame member, not fastened by bolts or set screws and had a slightly inclined slope making it unsafe to stand on. The platform itself had no toe board, kick board, or lip or guardrail along its edges, it also had no warning labels indicating that a safety belt should be worn or where it should be fastened, and no net underneath to catch a falling worker. This platform, according to the manufacturer, is not a platform but part of the transportation frame that secures the tail conveyor when in traveling position. In effect, anyone standing on that part of the machine would be working outside of the manufacturer's guidelines, in addition to being devoid of any of the aforementioned safety features. Patrick McEnhill, an employee of Extec Limited, was asked if the screens could be changed from the yellow platform, he said that he would not recommend doing so due to the danger of falling from it.

OSHA (Occupational Safety and Health Administration) has several codes that outline safety requirements for workstations where falling from a height of 6 feet or greater is a concern. They are as follows:

29 CFR 1918.85

iii) Employer shall ensure that each employee on top of a container is protected from fall by fall protection systems meeting paragraph k of this section.

(3) Exception to above: Where employer can demonstrate that fall protection would be infeasible or create a greater hazard due to vessel design.

29 CFR 1910.132

Protective shields and barriers will be provided, used and maintained in reliable conditions.

29 CFR 1926.502

(1) Toeboards, when used as falling object protection, shall be erected along the edge of the overhead walking/working surface for a distance sufficient to protect employees below.

(2) Toeboards must be capable of withstanding w/o failure a force of 50 lbs. applied in any downward or outward direction at any point along the toeboard

(3) The toeboard shall have a height of 3.5 inches and no more than a ¼" clearance above walking/working surface. The toeboard must be solid with no openings over 1" wide.

29 CFR 1926.501

Workstations 6 feet or more above dangerous equipment shall have guardrail systems, personal arrest systems, or safety net systems.

The English house of Parliament also passed safety regulations concerning elevated workstation; these regulations were put into force on January 1st, 1992. The most applicable code states:

3.4.5) Means to access

Hand holds and steps must be designed, constructed and arranged in such a way that the operator uses them instinctively and do not use the controls for that purpose

The Extec machine measured 76" above dangerous equipment, yet the manufacturer's parts list does not cite any of the aforementioned safety features.

Companies in the same industry as Extec such as Finlay Hydrascreen, Rock Systems, Screen USA, Grasan, and The Screen Machine all install safety equipment, some as standard equipment, on their machines and use this fact in their advertising. For instance, The Viper 301 has walkways, which make the operation of changing the screens quick and easy. The Norberg SW348 comes with a maintenance platform to allow easy access to the areas that require regular maintenance. Ladders and handrails are also installed on both sides to increase safety. The Extec machine does not have any optional or standard safety devices.

Mr. McEnhill explained in his deposition that no human factors or biomechanical testing was ever performed by Extec LTD on their machines. Extec testing is limited to general inspection of guards; it was the British Government who ran all the safety tests.

Changing the screens on the Extec machine is a complicated process. O'Connor Brothers purchased a hydraulic lift so that a two person team could undertake the task safely, but this was rarely done because the machine was usually operated by only one person, working alone. To make the task easier for one man, an employee of O'Connor Brothers constructed a portable ladder (*figure 3*). This ladder could be attached to the Extec (*figure 4*) in order to climb up to the specific part of the machine where the adjustments were performed. According to Mr. Richard Bassett, he was the employee who constructed the ladder, and did so at Mr. Bartow's request and direction. This ladder was not recommended or approved by the manufacturer. However, the part of the Extec machine that Mr. Bartow was attempting to reach, known as a "transportation platform," has a diamond coated, nonskid finish. This probably led Mr.

Figure 3

Figure 4

Bartow to the assumption that this area was meant to be accessible to perform the adjustments. This platform, as stated earlier, is not easily accessible from the ground but is the only convenient place to access the screen's bolts from.

Other details of the accident reveal that Mr. Bartow was not wearing a hard hat at the time of the accident, nor had he tied himself off to an anchor on the machine using a safety harness (*figure 5*), as per O'Connor Brothers policy. Mr. Bartow had a manual ratchet with him to tighten and loosen the adjustment bolts, which may not have been the right tool for the application, as the bolts require relatively high torque to be applied by a hand tool. Because of this need for high torque, Mr. Bartow's usual procedure for dealing with these stubborn bolts was to press down on the handle with his foot to start the bolt moving. This was accepted practice at O'Connor Brothers, although it was considered somewhat dangerous due to the risk of falling from the platform. Since Mr. Bartow's accident, O'Connor Brothers now uses an air gun to apply the necessary amount of force to loosen the bolts.

Figure 5

The morning of Mr. Bartow's accident was cold and icy. At the time of the accident, the Extec machine had not been used yet that day, or even turned on to warm up. With regard to cold weather operation, Extec LTD assumed that the machine would not be used in cold and frosty conditions due to the fact that it would be too cold to effectively screen product. This was also the view of O'Connor Brothers, according to Mr. Bassett, who stated that the machine was not usually used once it got very cold.

According to the initial injury report, which was corroborated by both Mr. Bartow and Mr. O'Connor, Mr. Bartow fell from the ladder due to a build up of frost on the Extec machine. This is the method of injury that was originally reported, in writing, to the insurance company that provides O'Connor Brothers with workman's compensation coverage. The MSHA report of the incident stated that though the resulting injuries were serious, they were not life threatening and that a significant factor was frost on the machine. Harold Green, the O'Connor Brothers truck driver who found Mr. Bartow, reported that all metal had a build-up of frost that morning and that the Extec machine was no exception. However, Mr. Green was unable to confirm that the ladder had been attached to the Extec that day, but that he had seen it attached in the past. Mr. O'Connor reported that he was "almost certain" that the ladder was attached to the machine when he found Mr. Bartow. When Mr. Bartow was in the hospital for his injuries, he had restated to Ms. Drummond, a Worker's Compensation Claims Representative with Hartford Insurance, that he had fallen from the frost-covered ladder.

4.4 Analysis

Mr. Bartow has given two different accounts of how his accident occurred, first stating that he fell from the ladder, then later claiming that the accident occurred while he was standing on the upper platform. This second claim supports his complaint that the machine's defects are responsible for his accident. In either event, the medical report states that he received head trauma from contacting with the side discharge conveyor. Looking at figure 6, it is clear that the distances involved from the position of the platform at the front of the machine, to where

Figure 6

Mr. Bartow mounted the ladder built by Mr. Bassett, are not insignificant. We have estimated these distances in figures 7.

Method of Solution:

In order to establish which, if either, of Mr. Bartow's claims is accurate, we will consider the problem in terms of kinematics and projectile motion. Using this analysis, we will be able to determine whether Mr. Bartow *could have* fallen from either the platform or the ladder, and which of these locations was the more likely cause of the accident. Due to the low friction of the icy metal surfaces involved, the force of Mr. Bartow's step when he slipped caused him to leave the surface with projectile motion at some angle incident to the surface.

Known**:**

Mass of man: 81.65 kg (180lbs)

Height of man: 1.8288m (6ft)

Distance from ladder to conveyor (x-axis): 1.8288m (6ft)

Distance from platform to conveyor (x-axis): 4.2672m (14ft)

Distance of conveyor above ground (y-axis): 2.4384m (8ft)

Distance of top rung of ladder above ground (y-axis): 2.8956m (9.5ft)

Distance of conveyor above ground (y-axis): 3.9624m (13ft)

Assumptions:

Coefficient of Friction of icy metal surface is near enough to zero so as to be considered negligible

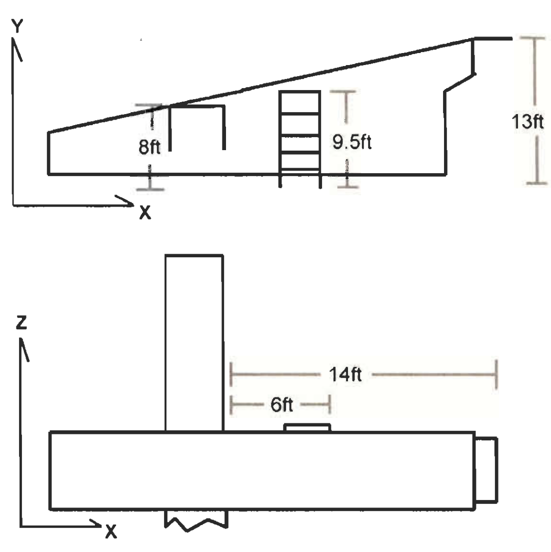
Force of Mr. Bartow's step was transferred to the metal surface at an angle approximately 45 degrees

Other than the side discharge conveyor, which Mr. Bartow's head seems to have struck, there are no other obstructions in his path of falling

<u>Derivation</u>

Using the laws of kinematics and projectile motion, we can proceed with solving the problem. The time required for a 180lb man to travel the lateral distance from either the platform or the ladder to hit his head on the conveyor can be found from Newton's First Law. The time required for a man to fall from the height of either the ladder or the platform to the ground below is given by the equation of projectile motion.

Figure 7 – Dimensions of Extec machine



Variables

$m_{man} = 81.65kg$

$g_c = 9.8 m/s^2$

$\theta = 45^\circ$

$x = 2.4384m$

$y_{platform} = 3.9624m$

$y_{ladder} = 2.8956m$

$y_0 = 2.4384m$

$V_{0y} = 0$

Equations of Lateral Motion

$$m_{man} g_c \cos\theta = m_{man} a$$

$$\iint g_c \cos\theta \delta t_x^{\,2} = \iint \delta x^2$$

$$\tfrac{1}{2} g_c \cos\theta t_x^{\,2} = \tfrac{1}{2} x^2$$

$$t_x = \sqrt{\frac{x^2}{g_c \cos\theta}}$$

Equations of Projectile Motion

$$y = y_0 + V_{0y} t + \tfrac{1}{2} g_c t^2$$

$$y = y_0 + \tfrac{1}{2} g_c t^2$$

$$t^2 = \frac{y - y_0}{\tfrac{1}{2} g_c}$$

$$t = \sqrt{\frac{y - y_0}{\tfrac{1}{2} g_c}}$$

Elapsed time for distance traveled

Platform

$$t_x = .93s$$

$$t_y = .557s$$

Ladder

$$t_x = 0s$$

$$t_y = .3057s$$

Our calculations reveal that a man of approximately 6 feet in height could easily hit his head on the side discharge conveyor if falling from the top rung of the ladder. Conversely, a man of the same size and weight falling from the forward platform would strike the ground below before he had traveled enough distance laterally (x-direction) to hit his head on the side conveyor.

From this, we must conclude that Mr. Bartow's original account of having fallen from the icy ladder is a more accurate depiction of how the accident occurred than his later description of falling from the platform while attempting the maintenance. As this ladder was of Mr. Bartow's own design and not constructed by Extec, Extec cannot be expected to be responsible for the ladder being unsafe.

4.5 Final Assessment

Under the principle of strict liability, the entity most able to have prevented this accident is Kenneth Bartow. In our analysis of the Extec machine, we do find that it is lacking in safety equipment that should be available, if not standard. However, we find Extec Screens and Crushers, LTD. to be free from liability in this case, as any design flaws in this machine did not contribute to Mr. Bartow's accident. Likewise, we find Extec of North America to be free from liability, although not adding additional safety measures when the machine was imported does leave them susceptible to future scrutiny. We find that Extec of America is 5% liable for neither employing any further safety measures on the machine, nor informing the purchaser or the operator of the inherent dangers of the some routine operations. Lastly, we find Kenneth R. Bartow to be 95% liable for this accident. In our opinion, Mr. Bartow did not fall from the platform, as he has indicated, but rather fell from the ladder of his own design and willful use. Mr. Bartow's charges are based on his own pain and suffering, as well as his inability to properly provide for and care for his family. With these concerns in mind, Mr. Bartow should have been responsible for his own safety, up to the point of refusing to work under circumstances that were not conducive to preventing this accident.

5. Bruce Perkins vs. Eric Rodgers

5.1 Background

On September 3rd 1999, on Route 101A/Nashua St, in Nashua, NH, a motor vehicle accident occurred between a 1999 Mercury Sable sedan, and a 1996 Harley Davidson motorcycle. The rider of the motorcycle, Mr. Bruce Perkins, was injured as a result of the collision between the two vehicles. He is the plaintiff against the driver of the sedan, Mr. Eric Rodgers. There was one witness to the accident, Mr. Stephen Neil.

On the evening of September 3rd 1999, the weather was hot and humid. The accident occurred at roughly 7:00pm, as dusk was setting in. The posted speed limit on the road was 25MPH. The motorcycle Mr. Perkins was riding struck Mr. Rodgers automobile on the left (driver) side rear quarter panel. All parties agree, and skid marks corroborate, that the collision occurred as the motorcycle skidded into the sedan. Mr. Perkins's injuries include crushed and torn ligaments in left foot, swollen, bruised, and torn knee, a gash in his head that needed 8 staples and 4 stitches, various parts of his body scraped, and feelings of pain from neck down through his shoulders, lower back and into his legs.

5.2 General Accident Description

Mr. Rodgers was attempting to make a left turn across traffic from a parking lot on the southbound side of the road. According to the statements made during his deposition, he looked to the left, then the right, and then left again before pulling out onto Rt101A. He also states that the motorcycle Mr. Perkins was riding was only a blur in his peripheral vision just before the collision occurred. In spite of his confidence in his mental and physical capacity, Mr. Rodgers also claims to have drunk 4-5 beers while eating over the course of 2 hours. The accident occurred as he was pulling out of the parking lot of the restaurant where he was eating/drinking.

Mr. Perkins states that as he was riding down Rt101A, at approximately 40MPH, with his headlights on, he saw Mr. Rodgers's sedan getting ready to pull out. Mr. Rodgers appeared to be inching the car forward, so Mr. Perkins moved his motorcycle over toward the center of the road in case Mr. Rodgers edged out any further. Mr. Perkins states that just as he was reaching the car's position, Mr. Rodgers pulled out into the lane, and then suddenly stopped. Mr. Perkins was attempting to go around the front of Mr. Rodgers's car near the center of the road when Mr. Rodgers pulled the car further forward. Mr. Perkins attempted to stop, locked up the motorcycle's brakes, skidded, and hit the sedan on the left rear quarter panel.

Mr. Perkins was also drinking on the day of the accident. He told the police officer that arrived at the scene that he had imbibed two beers, although he refused to take a Breathalyzer. Both the officer and a witness, Mr. Neil, stated that Mr. Perkins smelled like alcohol.

The witness to the accident, Mr. Steven Neil, described the accident in a fashion similar to that of Mr. Perkins and Mr. Rodgers. Mr. Neil was traveling down Rt101A when Mr. Perkins entered the roadway behind him. He recalls that the motorcycle's headlamps were on. He also believes that the motorcycle was traveling at a relatively high speed. He saw Mr. Rodgers's sedan as he was attempting to enter the roadway. He exercised caution in passing Mr. Rodgers, as he knew there were two telephone (or other civil use) poles that could obstruct the vision of a car pulling out of that parking lot. After he passed Mr. Rodgers, the accident occurred. Mr. Neil stopped and went back to assist.

He saw skid marks on the left side of the lane near double yellow lines. Mr. Neil also saw Mr. Perkins crawl to side of road after accident. The driver of the vehicle did not appear to be injured. He did detect that Mr. Perkins smelled of alcohol, although he did not detect a similar odor from Mr. Rodgers.

5.3 Investigation

Reconstructing the events of this accident and determining who was at fault required analysis of the accident scene and consideration of the actions of each driver.

The road that the accident occurred on is relatively straight and presents no abnormalities or complexities from the driver's point of view. Mr. Perkins was afforded a relatively clear view of vehicles attempting to enter the roadway from either side of the road, to head in either direction.

The parking lot that Mr. Rodgers was attempting to pull out from had what we consider to be a vision obstruction in the form of two public works poles in the left hand field of vision (*figure 8*). However, these are not extraordinary circumstances, as any experienced driver negotiates vision obstructions such as these on a daily basis.

Figure 8

A consideration of the actions of both Mr. Perkins and Mr. Rodgers will also be helpful in determining the liability in this case. Mr. Perkins openly admits that he was not certain of the speed limit on Route 101A, but that he was traveling at roughly 40MPH. This speed is higher than the 35MPH speed limit he believed to be in effect, and higher still than the 25MPH limit that is actually in place on that road. The minimum speed that Mr. Perkins was traveling at can be calculated based data available from the accident scene.

Mr. Perkins was traveling southbound on Route 101A at a speed in excess of the legal limit. As Mr. Rodgers nosed his car out of the parking lot he was pulling out from, he was leaving private property and returning to public roadways. As such, he was burdened with the responsibility of safely joining the motorists already using the public roads. In this situation, Mr. Perkins clearly had the right of way, as he was already traveling on the road Mr. Rodgers was attempting to enter.

However, three other elements are introduced into this analysis. First, Mr. Perkins was exceeding the speed limit. In addition to being illegal, this in itself can endanger other motorists. Although an argument could be made that Mr. Rodgers was unable to accurately estimate Mr. Perkins's speed due to this fact, both Mr. Rodgers conceded that his problem was obstructed vision, not poor estimation. Second, Mr. Rodgers did have an obstruction in the path of his vision. However, not only should an experienced driver have had other occasions where visibility was less than optimal, but Mr. Rodgers should have erred on the side of caution. Finally, there is the issue of intoxication, impaired judgment, and operating a motor vehicle while under the influence of alcohol. Both Mr. Perkins and Mr. Rodgers admit to having had alcoholic beverages prior to the time of accident. Although the exact blood alcohol content of both men is unknown, assumptions here will not greatly affect the overall outcome of the analysis. If Mr. Perkins judgment was impaired, he might not have been looking for dangers in the roadway, or have been able to effectively use the brakes of his motorcycle when necessary. Conversely, even cold sober, Mr. Perkins still had right of way and still had another vehicle pull out into his path. Mr. Rodgers's state of intoxication may have caused him to make a poor decision about pulling out of the parking lot, and subsequently about attempting to maneuver while perpendicularly across the southbound lane. However, even cold sober, Mr. Perkins claims that his decision to pull out was based on his belief that the roadway was clear, and as such he still failed to yield right of way to the vehicle already in the roadway.

5.4 Analysis

Having already considered several aspects of the traffic statutes, we will now try to verify or disprove Mr. Perkins's claim about the speed at which his motorcycle was traveling.

Method of Solution:

In order to establish an accurate estimate of Mr. Perkins's speed, we opted to analyze the kinematics of his deceleration had the accident been narrowly avoided. In order to do this, we constructed a free body diagram (*figure 9*) with the assumption that the car driven by Mr. Rodgers was stationary, that Mr. Perkins locked the brakes on his motorcycle as soon as he applied them, and that the motorcycle stops just short of contacting the car.

Known:

Mass of motorcycle and rider: 850lbs[1]

Mass of car and driver: 3400lbs[2]

Length of skid marks: 31.54 meters

Assumptions:

Velocity of car was near enough to zero so as to be considered negligible

Coefficient of Friction of locked (skidding) motorcycle tires: .7

Collision has low coefficient of restitution, so as to be considered be negligible

Derivation

Using the laws of kinematics and energy conservation, we can proceed with solving the problem. The kinetic energy of the motorcycle prior to braking is a function of its velocity, which we cannot be sure of, as it is only hearsay from Mr. Perkins. However, we can equate this unknown kinetic energy of the motorcycle to the balance of its energy at a complete stop (assuming narrow avoidance of the accident). When the motorcycle's brakes became locked, all of its deceleration came as a result of the sliding friction of the tires on the road surface. The motorcycle lost energy through friction over the distance between the initial lockup and the car's position. This distance is marked by the black skid marks on the road surface. If the motorcycle has stopped before colliding with the car, the resultant force on the car would be zero, thereby not generating any angular velocity of the car.

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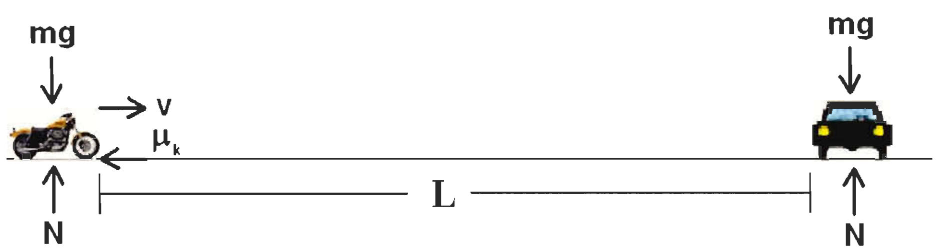
[1]approximated from Harley Davidson published specifications

Figure 9: Free Body Diagram of pre-accident conditions



Variables

V_{M_i} = Unknown

$V_{M_f} = 0\,m/s$

$M_M = kg$

$M_C = kg$

$\mu_K = .7$

$L_{sm} = 31.54m$

$\omega = 0$

$g_c = 9.8\,m/s^2$

Equations

$$KE = \tfrac{1}{2}M(V)^2$$

$$KE_{Rotational} = \tfrac{1}{2}I\omega^2$$

$$Friction = \mu_k M_M g_c L$$

Derivation

$$\tfrac{1}{2}M_M(V_{M_i})^2 = \tfrac{1}{2}M_M(V_{M_f})^2 + \mu_k M_M g_c L + \tfrac{1}{2}I_{car}\omega^2$$

$$\tfrac{1}{2}M_C(V_{M_f})^2 = 0$$

$$\tfrac{1}{2}I\omega^2 = 0$$

$$(V_{M_i})^2 = \frac{\mu_k M_M g_c L}{\tfrac{1}{2}M_M}$$

$$V_{M_i} = \sqrt{\frac{\mu_k M_M g_c L}{\tfrac{1}{2}M_M}}$$

$$V_{M_i} = \sqrt{2\mu_k M_M g_c L}$$

Speed of Motorcycle

$$V_{M_i} = 20.80\,m/s = 74.88\,k/h$$

$$;= 68.3\,ft/s = 46.56\,m/h$$

[2] approximated from Ford Motor Company published specifications

Assuming that the deceleration caused by the friction of the locked tires of the motorcycle ridden by Mr. Perkins had been able to stop the motorcycle before hitting the car, then Mr. Perkins's minimum speed would have been 45.56 MPH. At that speed, Mr. Perkins was exceeding the speed limit by at least 21.56 MPH. However, knowing that the deceleration was *not* sufficient to prevent the collision, we must conclude that Mr. Perkins was traveling at a speed even more in excess of the posted limit than we were able to determine.

5.5 Final Assessment

In this case, it seems that no one is completely free of fault. Both parties had imbibed alcoholic beverages, although the effect of the alcohol on the ability of either party to operate a motor vehicle is unknown. Although Mr. Perkins was already traveling in the roadway and should have been given the right of way by any vehicle attempting to enter the roadway, he was speeding by his own admission.

Under the principle of strict liability, we find that Mr. Eric Rodgers would have been best able to prevent this accident from occurring. Had Mr. Rodgers exercised further caution, and not challenged Mr. Perkins's right of way, then the accident would have been avoided. We find Mr. Rodgers 65% liable for this accident.

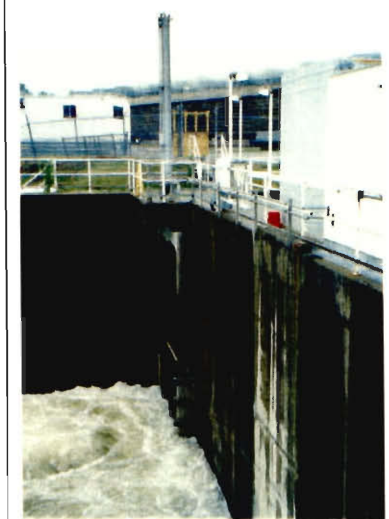
Mr. Perkins, although possessing right of way in this traffic scenario, was exceeding the speed limit by a wide margin, and was possibly under the influence of alcohol. It is possible that the removal of one or both of these factors may have prevented the accident. Regardless, the collision occurred because Mr. Rodgers did not yield right of way to Mr. Perkins, and now Mr. Perkins must suffer several physical injuries as a consequence. We find Mr. Perkins 35% liable for this accident.

6. Vermont Yankee Nuclear Power Corporation vs. Cianbro Corporation and Rodney Hunt Corporation

6.1 Background

Vermont Yankee Nuclear Power Corporation has a nuclear power plant located in Vernon, Vermont. This plant uses a water-cooling apparatus as part of its normal operation. The water-cooling system employs the use of two cast iron sluice gates (*figure 10*). The gates originally used in this application were manufactured by a company called Armco, and were in service from the plant's opening in 1972 until their removal in 1997 due to operational issues.

Figure 10



When the Armco gates needed to be replaced, Vermont Yankee contracted with Cianbro Corporation for the design, manufacture, and installation of new gates to be installed on the existing wall thimbles. Cianbro in turn outsourced the design and manufacture of the gates to Rodney Hunt Corporation. After Cianbro completed the installation of the Rodney Hunt gates, initial dry and wet tests were conducted. The gates became operational at Vermont Yankee on May 28th, 1998. On April 5th, 1999 a Rodney Hunt technician performing a routine inspection found both gates had suffered total failures. The gates were only operated 42 times over the 11 months they were operational, so the failure was considered to have occurred well within the boundaries of the normal use and life expectancy. Because of the nature of nuclear power generation, any inspection, maintenance, or failure occurring outside of scheduled plant "outages" will result in the lose of operating profits.

Vermont Yankee sought damages for the following charges:

1. Negligence, Design of Sluice Gates, Cianbro Corporation
2. Negligence, Design of Sluice Gates, Rodney Hunt Corporation
3. Negligence, Manufacture of Sluice Gates, Cianbro Corporation
4. Negligence, Manufacture of Sluice Gates, Rodney Hunt Corporation
5. Negligence, Installation of Sluice Gates, Cianbro Corporation
6. Breach of Express Warranty, Cianbro Corporation
7. Breach of Implied Warranty, Rodney Hunt Corporation

Further, Vermont Yankee sought 1.8 million dollars for the following damages:

1. Removal of damaged gates and purchase and installation of replacement gates
2. Cofferdam Installation and other mitigative measures
3. Lost generation and other incremental costs and damages
4. Interest and cost of capital
5. Miscellaneous expenses and costs directly related to gate failures

6.2 General Failure Description

The original sluice gates used at the Vermont Yankee facility were mostly cast iron, with wearing surfaces that were not replaceable. The gates were originally operated by an electric system, but over time the system proved to be inadequate. In 1989, Rodney

Hunt Corporation replaced the electric system with a hydraulically operated one. Although this cured the lack of power, Vermont Yankee experienced an increasing number of problems with the operation of the gates through the early and mid 1990's. The Armco gates were experiencing binding within the travel guides, cracking of cast pieces, and general sealing problems causing high leakage rates.

The type of Rodney Hunt gate that replaced the Armco gates were stainless steel with bronze tongue covers wearing against bronze guide liners. After their installation in 1998, the gates underwent both dry and wet testing. Unbeknownst to many parties, the tests were not a complete success, as the initial wet test showed the gates to require more power than expected to be completely raised and lowered. Over time, this difficulty necessitated modifications to the hydraulic system, as well as a change in Vermont Yankee's official operating procedure. One such change was that the gates were not to be operated simultaneously, as designed, but instead one at a time, to prevent the hydraulic system from tripping a pressure bypass value. These difficulties were not reported to either Rodney Hunt or Cianbro.

Within 11 months, the Rodney Hunt gates were declared inoperable, causing an unexpected outage of service at Vermont Yankee.

6.3 Investigation

The Rodney Hunt gates installed at Vermont Yankee in 1998 exhibited total catastrophic failure when inspected in 1999. It is clear that one initial failure in caused a cascading effect on other components of the gates. The North Gate's tongue liners were ejected and many of the bolts were missing or loose bolts and damaged wedges. The upper and lower guide connections had become separated due to missing bolts. This caused the gate to experience excessive amounts of friction when operated perpetuating the damage being done to the gate. The South Gate was found to be totally inoperable as it was missing tongue liners and had loose, missing, or sheared bolts. Several of the alignment wedges were missing or damaged. The South Gate was completely jammed and the guides had been displaced causing the gate to come out of its tracks. Both gates exhibited high leakage rates. In both gates, the screws holding the tongue liners in place failed first (*figure 11*), resulting in other failures. The tongue liners were ejected next and excessive gate movement within the guides ensued.

Figure 11

In the original contract between employer Vermont Yankee and contractor Cianbro, the contractor had an option in how to complete the contract; one option was to refurbish and repair the existing gates; the other was to replace the gates entirely. Since Cianbro had chosen to replace the gates entirely, it assumed responsibility for the design, manufacture and installation of the (2) 11'x13' sluice gates. When Cianbro then contracted Rodney Hunt Corporation for the design and manufacture of the two sluice gates, Cianbro retained responsibility for the installation of the gates.

At the Vermont Yankee facility, wall thimbles for the mounting of the sluice gates already existed in the concrete discharge structure, left over from the Armco gates. Cianbro was contractually aware that the existing wall thimbles may have been inadequate, and/or in need of repair. However, Cianbro's contract with Vermont Yankee specified that the contractor was responsible to check the wall thimble for corrosion, not flatness. The Rodney Hunt installation manual specified that the wall thimble must be checked for irregularities prior to installation, and contained procedures for doing so, but this was not the responsibility of Rodney Hunt. When the Rodney Hunt gates were removed in April of 1999, the wall thimbles on the discharge structure were found to be distorted, which is likely the main reason for the rapid failure of the gates. However, it us unknown whether this was a result of the gates' initial mode of failure, or whether it was the cause of that failure.

In a field such as fluid dynamics and water control systems, there are of course various different engineering standards which commercial products are required to adhere to. The original Armco gates used at the Vermont Yankee facility were compliant to a set of specifications known as the "EBASCO SPECIFICATION for Intake and Discharge Control Gates". The use of this standard was originally sketched out for the Vermont Yankee facility in 1968, several years before the plant became operational. The exact details of this standard include comments about the type of structures to be used, factor of safety, materials use, operation, and the catch-all phrase "….in accordance with the best modern practice…". These specifications specifically relate to the different requirements of a gate that experiences both seating and unseating head conditions.

By the time the original Armco gates needed to be replaced, the Ebasco specification was nearly 30 years old, and other, more modern standards had taken its place. Yet the contract between Vermont Yankee and Cianbro stipulated that the new gates meet the Ebasco specifications, as did the contract between Cianbro and Rodney Hunt. However, beginning in the late 1980's, Vermont Yankee received permission from the state of Vermont to begin using a hybridized flow condition with their cooling towers. This hybridized flow was such that turbulence could be created by the meeting of opposing water flows. The Ebasco standard may do quite well at specifying gates to operate with both seating and unseating head conditions, but they say nothing with regard to such a hybridized flow condition as was now being used by Vermont Yankee. It is possible that the turbulent flow created by this condition was also a contributing factor to the failure of the gates. In the contract between Rodney Hunt and Cianbro, it was stated that any required field dimensioning of existing conditions was the responsibility of the installing company, not the design/manufacturing company.

Among the more current standards for water flow management is the American Water Works Association C501 standard for sluice gates. This standard requires a factor of safety of 5, while Rodney Hunt Corporation's internal standard is for a factor of safety of 6. After the failure of the Rodney Hunt gates, Vermont Yankee, with influence from specific internal staff, sough to purchase gates that conformed to this standard, and using rubber J-seals. Rodney Hunt was equipped to and had been manufacturing gates of this type, but the contract with Cianbro specified the Ebasco standard. For this reason, it seems unfair for Vermont Yankee to have denied Rodney Hunt the opportunity to supply a replacement gate of similar design.

Further examination of the failure of the gates revealed some interested events that occurred at Rodney Hunt during the manufacturing phase. The ¼"-20 Philips head screws that fastened the moveable gate tongue cover to the tongue were originally specified to be a 304 austenitic stainless steel self-tapping screw. However, in post failure testing, the screws were actually revealed to be a 410 martensitic stainless steel. During the manufacturing of the gates, the 304SS screws had become unavailable. A 416SS screw was substituted on the specifications, but before the holes were tapped, a Rodney Hunt engineer recognized that the 416SS screws would not be right for the application, and the 410SS screws were substituted in their place. At each step of the way, Rodney Hunt documented these changes, and the final technical drawings submitted to Cianbro and Vermont Yankee reflected this documentation.

The 410SS screws are in fact stronger than the originally specified 304SS screws, however they are brittle due to additional heat treatment. During the post failure analysis, this additional heat treatment brought up the possibility of three uncommon modes of failure: hydrogen embrittlement, stress corrosion cracking, and hydrogen cracking. Also subject to this scrutiny were the dowel pins. These pins were all broken and missing when the gates were found to be in disrepair. The dowel pins were tubular 420 martensitic stainless steel, which is also susceptible to hydrogen embrittlement, stress corrosion cracking, and hydrogen cracking.

6.4 Analysis

Although the material used for the screws and dowel pins represents a poor selection based on the aqueous environment they were to operate in, and the high probability of the occurrence of hydrogen embrittlement, stress corrosion cracking, and/or hydrogen cracking, these modes of failure take long periods of time. It is our opinion that these forms of material failure could not have developed inside of one year, to the point of resulting in the catastrophic failure of the screws and the gates.

Analyzing the mode of failure of the screws revealed fatigue that ran rapidly across much of the cross section of the screw, and then more slowly over the remaining cross section until shear failure occurred. The presence of such a fatigue pattern suggests that the screws were originally over-torqued. This, however, was an impossibility as the self-tapping screws used, when driven into cast iron and over-torqued, will strip the threads out of the cast iron long before reaching damaging stress levels.

Thus, we return to the possibility that the failure of the gates was not due to a poor materials selection, but rather a result of inadequate design for the environmental and use parameters. To determine if this is the cause of the failure, we will analyze the forces on the gate, and on the screws used to secure the tongue liners to the gate itself (*figure 12*)

Figure 12

Each of the Rodney Hunt gates measured 11'x13'. This is a non-standard size gate for Rodney Hunt, so other details of the gates dimensions are not readily available. Referencing the schematic (*figure 13*) and table (*figure 14*) below, we can see the dimensions Rodney Hunt specifies for sluice gates up to 10' x 10'. We used this information to extrapolate other information about the dimensions of the gate, as needed.

Figure 13

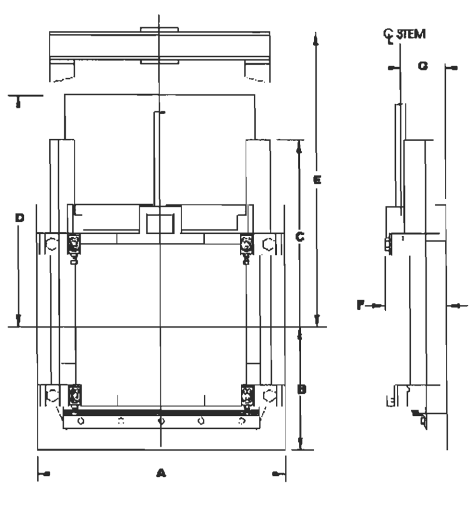


Figure 14

SIZE WIDTH X HEIGHT INCHES	DIMENSIONS. INCHES A	B	C	D	E	F	G
72 x 48	83.50	29.75	49.00	81.50	94.00	12.25	7.12
72 x 60	83.50	35.75	61.00	99.50	114.00	12.25	7.12
72 x 72	83.50	41.75	75.00	117.50	133.00	13.00	7.12
72 x 84	83.50	47.75	85.00	135.50	158.00	13.00	7.12
72 x 96	83.50	53.75	99.00	153.50	176.00	13.00	7.12
84 x 60	95.50	35.75	61.00	99.50	114.00	12.25	7.12
84 x 72	95.50	41.75	75.00	117.50	133.00	13.00	7.12
84 x 84	95.50	47.75	85.00	135.50	158.00	13.00	7.12
84 x 96	95.50	53.75	99.00	153.50	176.00	13.00	7.12
84 x 108	95.50	59.75	109.00	171.50	194.00	13.00	7.12
96 x 72	107.50	41.75	75.00	117.50	133.00	13.00	7.12
96 x 84	107.50	47.75	85.00	135.50	158.00	13.00	7.12
96 x 96	107.50	53.75	99.00	153.50	176.00	13.00	7.12
96 x 120	107.50	65.75	121.00	189.50	212.00	13.50	7.12
108 x 84	119.50	47.75	85.00	135.50	158.00	13.00	7.12
108 x 96	119.50	53.75	99.00	153.50	176.00	13.00	7.12
108 x 108	119.50	59.75	109.00	171.50	194.00	13.00	7.12
108 x 120	119.50	65.75	121.00	189.50	212.00	13.50	7.12
120 x 96	131.50	53.75	99.00	153.50	176.00	13.50	7.12
120 x 108	131.50	59.75	109.00	171.50	194.00	13.50	7.12
120 x 120	131.50	65.75	121.00	189.50	212.00	13.50	7.12
120 x 132	131.50	71.75	133.00	207.50	230.00	13.50	7.12
120 x 144	131.50	77.75	145.00	225.50	248.00	13.50	7.12

Method of Solution:

In order to determine whether or not the Rodney Hunt gates and the materials used in it were acceptable for the demands of the Vermont Yankee application, we will analyze fluid mechanics of the pressure exerted on the face of the gate by the water, assuming hydrostatic conditions. Finding the pressure distribution on the plate will allows us to calculate the total force exerted on the face of the gate by the water. This in term can be used to consider the force exerted on the screws used to secure the tongue guide to the gate.

Known:

Area of one gate face: 13.28 m^2 (143 ft^2)

Specific weight of the fluid: 9790 N/m^3 (62.4 lbf/ft^3)

Depth change from top to bottom of gate: 3.353 m (11 ft)

Number of screws: 54

Density of stainless steel: 7860 kg/m^3

Assumptions:

The gate is raised at constant velocity; a=0

The fluid is water at 20 degrees Celsius

The top of the gate is some unknown distance below the surface of the water

The depths is less than 1000 meters

Coefficient of friction for bronze-on-bronze: .22[3]

The gate is 19" (.4826m) thick

[3] This value is not agreed upon by all parties

The gate has a "mass multiplier", to correct for areas within the overall volume that have no material in them, of .6

Derivation

The force of a hydrostatic fluid on a flat, vertical plate is determined by the pressure distribution of the fluid on the plate (*figure 15*). The pressure on the plate increases linearly with depth. This assumption about the form of the pressure distribution is valid up to depths of 1000 meters. The pressure distribution is a function of the fluid depth and the specific weight of the fluid. Once the pressure distribution is found, the force on the gate can be resolved into point forces acting one-thirds above the lowest depth the face of the gate attains. These point forces can be considered in the friction analysis of the gate through its up- and down-stroke (*figure 16*), to determine if the screws were capable of handling the load they were subjected to.

Figure 15

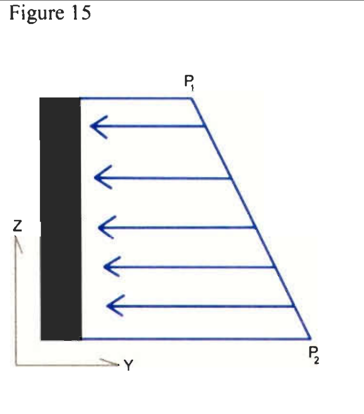
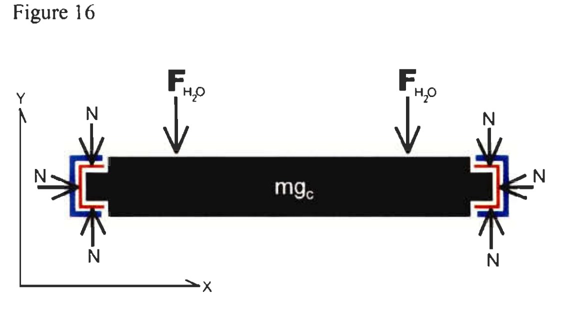


Figure 16



Variables

$$A = 13.28 m^2$$
$$\gamma = 9790 \, N/m^3$$
$$\Delta Z = 3.53 m$$
$$\rho_{SS} = 7860 \, kg/m^3$$
$$\mu_k = .22$$
$$M_m = .6$$
$$V = 6.40 m^3$$
$$g_c = 9.8 \, m/s^2$$

Force/Mass Equations

$$F_{frixction} = \mu_k (m_{gate} g_c) + F_{H_2O}$$
$$m_{gate} = M_m V \rho$$
$$F_{weight} = m_{gate} g_c$$

Results

$$\Delta P = 32825 Pa$$
$$F_{H_2O} = 435.2 kN$$
$$m_{gate} = 30182.4 kg$$
$$F_{friction} = 160.98 kN$$
$$F_{weight} = 295.79 kN$$
$$F_{total} = 456.76 kN; = 102684 lbf$$
$$F/_{screw} = 8.459 kN; = 1901.56 lbf$$

Hydrostatic Force Equations

$$F_{H_2O} = \Delta P A$$
$$\Delta P = \gamma \Delta Z$$

Total Force on Screws

$$F_{total} = F_{friction} + F_{weight}$$
$$F_{total} = \mu_k (mg_c + F_{H_2O}) + mg_c$$
$$F/_{screw} = \frac{F_{total}}{54}$$

The gate would experience a maximum force of 435.92kN, *if* the river was stagnant and not moving. However, this analysis does not reveal the amount of force the gate actually experienced in practice because the hybridized flow condition created a turbulent flow leading up to the gate. The gate would have experienced forces far in excess of anything it was designed for as it was designed, as requested, to the Ebasco standard, which does not deal with turbulent flow conditions. Rodney Hunt does manufacture gates for such flow conditions that employ baffles and other features to curtail a turbulent flow, thus reducing the force and the stresses on the gate.

The above calculations reveal that the force of $1901.56\,lbf$ applied to each screw is less than it's maximum capacity; the screws were rated to handle $3000\,lbf$ each, although testing revealed that $6000\,lbf$ before failure was a more accurate value.

6.5 Final Assessment

In considering this case, it was of key importance to identify miscommunications between the three parties, and use these to identify where errors were made. Rodney Hunt Corporation made several questionable decisions regarding the design and manufacture of the gates, specifically with regard to the bronze-on-bronze friction surfaces of the tongue guides, and the process of selecting the correct screws for attaching the tongue liners. However, these decisions were documented and communicated to both Cianbro and Vermont Yankee, and our calculations reveal that Rodney Hunt's engineering and materials selection was sound. We find Rodney Hunt Corporation to be free from liability in this case.

Cianbro Corporation was possibly somewhat negligent with regard to the quality of their workmanship when installing that gates, as there is no record that the flatness of the wall thimble was confirmed. However, since Cianbro was not contractually obligated to perform this check, they did in fact uphold their end of the contract. We find Cianbro Corporation to be free from liability for the failure of the gates.

Finally, under the principle of strict liability, we find that Vermont Yankee Nuclear Power Corporation was most able to have prevented this failure and subsequent losses. During initial testing, Vermont Yankee engineers reported difficulties in raising and lowering the gates. At this time, a decision could have been made to investigate further the source of the problem. Instead, the operation procedures were changed in an attempt to "band-aid" the problem. Furthermore, Vermont Yankee was negligent in specifying the use of a 30-year old standard for the design, manufacture, and operation of these gates, and then not adhering to the guidelines listed within that standard. If Vermont Yankee had better researched and communicated it's needs for these sluice gates, then the problem could have been avoided. It is only Vermont Yankee's negligence and poor communication with its contractee and sub-contractee that caused this failure, and the subsequent losses accrued through unscheduled plant outage. We find Vermont Yankee Nuclear Power Corporation to be 100% liable for this failure.

7. Conclusion

This Interactive Qualifying Project on Products Liability began with research into the litigation process, and a review of the principles behind product liability. This included identifying potential liability issues in product design as well as assigning responsibility in the event of a lawsuit surrounding a product flaw or failure. During this research, we gained insight into the steps an engineer can take to ensure the safe use and operation of a product before it even leaves the planning stages.

The knowledge we gained from this research was applied to three different cases where some issue of product liability or accident reconstruction would determine the outcome of the suit. Acting as experts, our task was to sort through conflicting stories, collecting facts and making reasonable engineering assumptions. In each case, the result of our Final Assessment was not apparent when we first began our analysis. However, we did our best to discern the truth in each case, and then used the principles of Strict Liability to determine who was at fault for the Plaintiff's claimed loss.

As we learned, this Project required not just an interest in engineering and law, but also an interest in success; the modern engineer must face the very real possibility that he or she will be involved in legal proceedings over the safety of a product at one time or another in his or her career. The best way to prepare for such an occurrence is to educate yourself about the procedures involved. In our professional lives, we will use this experience to maintain a keen awareness of the safety issues surrounding our products. This Interactive Qualifying Project on Products Liability provided our team with experience we simply could not have gotten inside the classroom.

8. Bibliography

Art of Advocacy Skills in Action Series. Matthew Bender and Company, Inc. New York.

Lux, William J. An Engineer in the Courtoom. Warrensdale, PA: Society of Automotive Engineers, 1995.

Phillips, Jerry J. Products Liability in a Nutshell. St Paul, MN: West Group, 1998