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TWENTY TWENTY HINDSIGHT

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An engineer works within constraints and protocols that he does not control when he designs a product. He is forced to compromise between choices not necessarily his own nor to his liking. He calls his choices engineering tradeoffs, but make no mistake for every such trade off something is left off. Given up, while something else is gained. When safety is compromised for marketing the price tag may be underestimated… someone will have to eventually pay the Piper.

Engineers have the terrible burden of having to have a perfect crystal ball to predict their product's performance within its design lifetime. Further the engineer can not simply dictate that his product will be used precisely within the guidelines and rules promulgated within the approved user manual of instructions. Such is not the real world. A bottle of cyanide pills emblazoned with a plain English Warning and a skull and cross bones does no good for a 3 year old Hispanic child.

It is the engineer's burden to determine the company- approved usage of the new product. It is an engineer's duty to determine through a crystal ball what usage a consumer may be reasonably expected to put a new product too. The law has suggested that the manufacturer have another duty.. To foresee what misuse a product may undergo while in the hands of an expected or reasonably foreseeable user. That means that an engineer who is generally a conservative and rational person must design for people who are not. In fact engineers must design to protect the undereducated, non conservative risk takers.

Various studies have shown that a vast majority of instruction books are only read after a problem has cropped up. To prove the point, watch how many Christmas toys get built incorrectly by average fathers who will not use an instruction manual before a screw driver...You as designers may be at fault legally, because you did not foresee this eventuality and design around it. You must kit proof your design against ever present "MURPHY"

You as engineers have tools and disciplines that you can use to design more perfect and safe systems. If your design group does not have the budget to conduct a full blown system safety analysis you are left to improvisation, experience and your personal crystal ball.

Lets review some basic concepts that have been codified by the military in System Safety circles.

They believe that through usage of system safety engineering discipline a designer of a product should.

1. Identify all HAZARDS and RISKS, hazards within the product design and risks within usage of the product.
2. Predict how often a hazard or risk will manifest itself and create a failure mode.

3. Predict how serious the hazard or risk will be under all expected possible operating conditions.

Category one hazard- will result in loss of the sytem and loss of life or serious injury
Category two hazard- will result in harm to system and loss of mission capability.
Category three hazard- will require routine maintenance to fix.

Other studies such as Cause and Effect Studies, Failure Mode Studies, Failure mode and Effect studies, Lessons Learned Studies and Field HOW MAL returns, and Sneak Circuits Analysis all provide the engineer the ability to design a more defect free product.

Further, the engineer is taught that it is far better to design a defect free widget than to fix a defect later. In order of preference it is better to:

A. Design a defect free product.
B. find and correct a defect in the factory
C. retrofit a defect in the field
D. Warn about a defect that can't be fixed.

The design engineer has the burden to accomplish the design goals that his company has established, and the engineer has a moral responsibility and a burden to do his job correctly so as to eliminate hazard and risk within the portion of the widget he is working upon. It is not enough to think that someone else will do a job correctly. [MORE LATER]

THE LAW

Let me digress and talk about the wonderful position a hated trial lawyer assumes when he works an accident case against the manufacturer of a allegedly defective widget.

As a trial Lawyer I have a lot going for me by default. I represent sympathy and retribution, I represent a poor widow or a dreadfully injured party. Helping the weak and downtrodden has automatic jury appeal.

As a trial lawyer representing a client against a faceless megalith corporation, I am David against the Goliath of engineering disregard. The jury understands without being told that the big company can and should pay for the harm it does before it banks corporate profits.

I am armed with twenty hindsight, I was not hired to design a better widget, I was hired to tell the jury what was wrong with that old widget. I have proof that something was wrong simply by looking into the smoking hole. A smoking hole pre supposes a defect of some kind. I get to grade the papers, I do not have to take the test. " I come to bury the widget, not praise it"

As a trial lawyer, I am going to try and persuade the jury made up of twelve non engineers that there was a defect within the product or that some act of negligence done by the defendant company caused the harm that befell my client. I will try to paint a picture in the juries mind 's eye that will indelibly mark your product defective as the result of bad engineering. Do not allow that bad engineering to be yours.

The law gives me two favorite ways to win for my client, while making your product liable for the accident.

The first is through application of NEGLIGENCE LAW, The second is through Application of STRICT PRODUCT LIABILITY IN TORT law.

Application of either, provides plaintiff with an avenue to play Break the Defendant's bank, which of course is the underlying reason to bring a lawsuit anyway. Plaintiff's attorneys can not raise LAZARUS from the dead, all they can do is find money damages for a lavish funeral post accident life.

Negligence law examines the **conduct** of a person or company. Conduct below the standard expected of a person or company in the same or similar business may expose that person to liability. A cause of action in negligence will exist once it is shown that:

1. The defendant owed a duty and standard of Care to the plaintiff
2. That the defendant breached that standard of Care.
3. That the breach of duty was the proximate cause of the accident.
4. That the accident harmed the plaintiff.

A product may be negligently designed, negligently manufactured or negligently marketed. Negligence may occur in the failure to warn or train about a new product and its usage.

Intervening changes or field modifications to a widget may or may not absolve the original manufacturer of liability. Like wise, post delivery maintenance and misuse of the product may or may not absolve the manufacturer of liability. Here the test may be whether the changes or modifications were allowed or outlawed by the manufacturer, and whether the changes became the actual proximate cause of the harm. Unauthorized maintenance or misuse or the product may constitute a separate proximate cause. The manufacturer may still be liable if he could reasonably foresee or expect such unauthorized maintenance or misuse.

The law of NEGLIGENCE requires the plaintiff to pinpoint the specific acts of negligence and pinpoint who was at fault. The correct defendant is the defendant who

breached a duty owed the plaintiff. Thus the plaintiff must track down and identify the appropriate defendant and must specify what duty was breached. Proof by circumstantial evidence is allowed in some limited instances.[Example. a new car engine fails internally. It has never been worked on since leaving the factory. On tear down it is shown that nuts were left off. Here we can say that negligence occurred at the factory] The the plaintiff must still show how this breach proximately caused the accident and how the accident harmed the plaintiff.

STRICT PROCUCT LIABILITY in TORT (S.P.L.I.T.)

Strict Product Liability Law is much more favorable to a plaintiff and more detrimental to the defense and to the engineer. In SPLIT there is no need to prove that a person or company a breached any duty of care. In S.P.L.I.T. one simply looks at a product, or a portion of an overall product and examines it to see if the product is defective.

Defectiveness depends solely upon a determination of whether or not the product creates an unreasonable risk of harm or represents an unreasonable hazard to the user. The designer's or the manufacturer's conduct is not in question. Thus a product may be found defective under a S.P.L.I.T. definition without any breach of engineering conduct. The design may be approved, the manufacture conducted to specification, and the marketing correct and unpuffed and the product may still be defective.

For a plaintiff to prevail in a SPLIT case, he must
1. Show that the product was defective.
2. Show that the defect caused or contributed to an accident.
3. Show that the plaintiff was harmed as a result of that accident.

A product may be found defective in its design, in its manufacture, or in its marketing. If a product is defective in design then every such widget will be defective. A product may be defective in manufacture. This means that the widget, and perhaps others, were not produced in accordance with specifications and control drawings. Such a defect often occurs when Q.C. fails or a production line process goes out of tolerance. A Marketing defect occurs when a defect or hazard is identified and insufficient warnings are issued. It may also be a marketing defect when a training manual or course is incorrect or incomplete.

Defectiveness may be a very small portion of a very big product. The defect Complained about by plaintiff, for the sake of liability may be very small, when considered against the overall product performance. As an example the FORD PINTO rear end fire cases did not focus on all aspects of PINTO design, or it's overall performance. What was being scrutinized was the design and placement of the rear gas filler cap, filler tube, and fuel tank connections. Such a design was defective because of what would be expected to occur in low speed rear impacts.

The test of defectiveness has expanded over the last thirty years, and it is a little more difficult for a trial lawyer to call a product defective and make the allegation stick. Today most trial lawyers analyze a product design from the following viewpoint.

1. At the time of the defective design, was an alternative design technically feasible?
2. If an alternative design was technically feasible, would it have been economically viable?
3. If such an alternative design were incorporated, would the widget have been safer?
4. If such an alternative design could have been incorporated, would the product's usefulness continue unabated. (utility)

If a plaintiff attorney can answer yes to each of these questions, he can prevail in any and all U.S. jurisdictions. The product was indeed defective in design. Warning and manufacturing defects are generally not amenable to the same test of defectiveness. The insurance industry and defense lawyers shudder over the fact that each state has differing tests for defectiveness, and so they have a difficult time predicting litigation outcome.

THE REAL WORLD

One of my vices is I am an sport fisherman. I spend large amounts of time and money going where the fish are. In a legal case against a Product the liability fish are always located in the corporate areas of engineering design, safety, system safety, quality control and reliability. It is in these areas that the company tries to identify and eliminate hazard. It is within these disciplines that the company tracks the product in field usage. It is within these confines where a a trial lawyer will seek out documentation and testimony to prove his allegations of defect or negligent design.

When a product causes an accident, the trial lawyer will eventually find out what happened. This will occur through strong investigation and usage of expert witnesses acting as investigative consultants. Once the attorney learns what happened and why he has the burden to prove up and document his case with credible and probative evidence.

It is then that the attorney will go to his tackle box of legal discovery, and begin his technical fishing. It is an axiom that you catch more fish in a good fishing hole than in a bad one. In Product Liability cases, good attorneys go to the spawning grounds of the defect. That is the design engineer, System Safety, Safety, Quality assurance, and Reliability programs. That is where the fish are.

My tackle box is well equipped for Legal discovery, and there no hiding from the process. The step by step analysis goes like this.

I want to know what it was you knew and when you knew it. What did you consider in the design of your widget? I want to know who ordered the design of your product and what exactly were the conceptual goals as you began the process of designing and eliminating other choices. Did you apply System Safety Analysis? I want to see the Fault trees, the hazard studies, the failure modes, the lessons learned, the field usage history,

the warranty returns, the upgraded analysis to insure field usage compares favorably to predictions. What did you consider in all aspects of your design? Were alternatives considered? Were choices made where safety was the victim of budgetary economics?

What testing was accomplished? What results were documented in preparation testing before first article testing was accomplished. Who created the criteria for first article testing? Who designed testing. Was testing best case, worst case or other case? Did you follow the product in the field?

I will come at you from position of power. When I fish in Safety I can not lose. If you have no safety program and resulting documentation -you lose. If you have a weak safety program - I will find it out and pinpoint the weakness. If you have a superior safety program - I will opine that something must have been flawed since the accident occurred..

Between the system safety programs, quality assurance programs, vulnerability studies and maintainability and reliability studies there will be no hiding place.

EXAMPLES

I.

In one case we found a Fault tree concerning CAT.I failure of a main attitude instrument called the gyro horizon. The failure mode and effect went like this.
A: Failure - day light - good weather, Instrument not required.
B. Failure - night – bad weather, Stand by indicator, condition controlled.
The problem was that some years later the Accident board found the stand by instrument unreliable and defective and said replacement required.
This entry was not reflected in an updated failure modes and effects study.

DOCUMENTS: Fault Tree and USAF accident report
Late date fault tree/update

II.

In a case where the First Article testing of a submersible fuel pump required dry running for several hours without overheating the thermocouples were placed on the case. The pump passed original testing. A test technician was concerned and he placed a thermocouple on the upper bearing and ran the same test. It overheated beyond ignition temperatures. This data went no where.

EVIDENCE: First article tests, Dry run tests, Recent USAF test data, deposition testimony of R and D test technician.

III

We have been made aware of automobile cases involving fire potential, where the manufacturer has been made aware of a fire hazard, and has chosen to not fix, because the cost of the fix was predicted to be greater than the insurance costs of resulting lawsuits.

EVIDENCE: Test data from crash testing and famous memo on cost to fix –cost of litigation.

IV

A Flight control system of a major military aircraft may not transition completely from hydraulically powered flight to cable operated manual reversion. This failure to transition can cause loss of aircraft and possible loss of life. During the lawsuit, the manufacturer was sanctioned for destroying several hundred boxes of design related historical data. Ironically the manufacturer was sanctioned, lost the case, and may have destroyed documents that would have aided in it's defense.

Evidence: System Safety Group Minutes, Field experience reports. Fault tree and system safety studies.

VI

A Major manufacturer sells its ejection seats to the Air Force while the Navy has determined the same type seat should be replaced by a high tech seat that provides stability during phases of man seat separation. Test film shows precisely how unstable the seat actually is. Luckily new high tech seats are ordered, and the unstable seat is replaced before too many necks are snapped during miss positioned opening shock. It is noteworthy that the defective seat had the best over all save rate in the world. It was only defective during high speed ejections where man seat separation occurred very quickly.

Evidence: Test film, Rocket sled testing, Dayton T. Brown windblast tests.

DON'T DESTROY SAFETY DOCUMENTS – USE THEM

From what has been stated concerning the plaintiff's ability to discover damning safety and design documents, one might think it would be better to discard all such studies and thereby deprive the plaintiff of the evidence to prove up his case. Such would be a penny wise and pound foolish move.

For me, a plaintiff's lawyer, to be successful with this line of investigation, I must find a defect. I must then take your documents and educate a jury as to the content. The jury must understand the defect and must be convinced from your documents and studies. Your documents prove my case.

For years, you have had these documents. You were the creator, the investigator, the designer, the librarian. You had access to the same truth I now show the jury. If I can convince a jury, you should have been convinced years ago. Too often the truth has been collected, and the inertia of success does not allow the recognition that a fix for safety is required.

The point is that System Safety Works, if you use it. It indeed predicts the severity and probability of hazard. It suggests what will occur when a mode fails. The very same truth that I will show the jury has been available to you the manufacturer for years. It is what you do or didn't do that determines whether the defect reaches and stays with the public. Use the programs you have in place- make a safe product. Put a hated lawyer out of work.

SAFETY – The Name of the Place where Liability Hangs Out !

If one looks deeply enough, almost every accident is a result of human failure - not always in the form of operator error. It is the design engineers, the safety specialists and quality control specialists that are supposed to insure that systems are designed and manufactured safely, that operations are conducted properly, and that devices are manufactured consistently to specification.

Safety, quality and reliability does not result from luck. The contrary is true. Safety, quality and reliability results from adherence and application of proven techniques.

When investigating an accident from a legal standpoint, it is always important to find out what the manufacturer knew and when he knew it. Most often such data exists in the System Safety Office records.

The System Safety Program

System Safety concerns itself with the attainment of the optimum degree of safety consistent with the mission requirements..

System safety is a very distinct discipline that exists to help designers design hazard out of new products and system safety exists to help understand and correct potential hazards in products as they reach production and field maturity.

In every entity utilizing a System Safety Group or Division, there will be specific programs set up to track the product's field history. It is not unusual in the case of aircraft for the manufacturer to be constantly in touch with the maintenance history of it's product through numerous means to include:

o it's own technical field representatives.
o Customer complaints through marketing.
o accident and incident reports, obtained from government sources.
o Malfunction and Defect reports.
o Service Difficulty Reports,

o How-Mal Computer read outs.
O System Safety field feedback.

An attorney auditing a system safety program may be overwhelmed in paper, and in engineering studies and data. The job is to analyze whether the initial studies have been correctly completed. The next step is to see whether the data available to the system safety group has actually been utilized to enhance safety or whether such data only constitutes a repository of intelligence. Many times the data exists to fulfill a contractual requirement, and is not used appropriately to increase safety.

Requisite with a system safety program is the ever present requirement that the system safety group continue to monitor its product in real world field usage to see if the predictions made concerning risk are controlled or worse than envisioned. It is this vigilant monitoring of performance versus prediction that is the final proof of the pudding.

Quality Assurance Programs

Quality assurance tends to restrict itself to the production process from the inspection and control over incoming raw materials through the distribution of the completed product. Quality assurance attempts to warrant that the production process is maintained within acceptable limitations in order to insure a appropriate end product in compliance with specification and print.

What quality assurance program is about is to create a system of controls over a total manufacturing and assembly process in order to insure that only acceptable end products (those built in accordance with all specifications) are delivered to the user. The science is to prevent rejects from occurring by implementation of known quality assurance methods.
The art is to adopt cost effective procedures from the arsenal Quality Control techniques

Many companies have separate Research and Development Labs, Testing Labs and Quality Assurance Divisions. It is usually a combination of these groups that set up initial testing to verify that a newly developed product meets all program requirements or specifications. Quality Assurances role in this testing phase is primarily to insure that the First article testing is accomplished on a representative sample in accordance with testing rules. They insure that the test article is an exemplar of what is to later be produced. Up until final verification, validation or qualification testing: Ergo testing done during research and development many variables are allowed. During qualification the product is supposed to be the end product and q.c. usually verifies this aspect.

Another recent development has become standard in quality assurance circles. Major manufacturers are taking better control of quality by forcing subcontractors to employ Quality assurance techniques approved by the prime while manufacturing sub components for the prime. Thus as an example a Car Manufacturer may require it's generator supplier to utilize their quality control methods while designing, testing and manufacturing generators. Often such a major manufacturer may either initiate such QC programs, or have actual

presence within a sub manufacturer’s factory. The basic premise of both System Safety and Quality Assurance is control from initiation to finished product operation.

Some major companies have expanded their quality assurance programs to even test incoming raw materials at subcontractor sources for specification compliance and contaminants. Companies devoid of such programs are suspect of being derelict in their duty.

Wherever there is control, there necessarily follows a paperwork trail of accomplishment and failure. This trail is usually discoverable to a legal investigator.

Reliability

Product reliability attempts to predict and eradicate failures in performance of a manufactured end product. The sound programs of system safety and quality control will be integrated with reliability programs, because the disciplines used to predict are similar in nature, and the end goal is similar. To produce a product according to specification that will perform in accordance with the standards and goals set for that product is the goal of a reliability program.

Fitting reliability programs into the hierarchy is keyed to obtaining the most benefit for management. It is a tool that helps predict impending failure before it appears. Note that System Safety identifies hazard, categorizes the severity of hazard and predicts the probability of failure : It does not attempt to quantify when such occurrence is likely to occur. Reliability attempts to minimize the probability of malfunction or failure. What the designer wants to achieve is failure free performance within a known duration of time.

Some failures are predictable in the usage of a new product. These are failures that show up early in product life. These may be called " Burn In " failures. They are as a result of production oversight and production defect. They usually manifest themselves early in product life. The next set of failures tends to happen randomly over the life of the product due to some defects that manifest themselves. The last set of failures occurs as the product wears out or is fatigued.

A product is not unlike a child. In early life it is the children’s diseases and birth defects that kills, n mid life it is random acts and accidents, and as old age creeps in so does the inevitable old age diseases.

The object of a reliability engineer is to know and analyze the expected usage of the product in it's expected habitat and to predict the extremes of it's performance expectations under the varied usage the product is expected to receive. How will it perform and when will it break.

The real point here is for the engineer to know when the part will in all probability fail. The idea of course is that the part may be exchanged before such a failure occurs if the part is

critical to safety. Already we see a relationship between safety and reliability. If the part is c5ritiacal to safety it ought to be reliable as well.

Notice that , System Safety, and reliability and the QA disciplines require the engineer to predict the usage of the product in every imaginable usage. Now the concept of what is reasonably foreseeable is no longer simply a company Guru with a Crystal Ball. All major manufacturers are fully familiar with these concepts and they have participated in such disciplines and studies from the onset of the first development of their product. What an attorney/ investigator need do is mine this wealth of data.

In the current negligence law we must find that a manufacturer breached a duty of care to the plaintiff. The standard of care a manufacturer is capable of designing in to a product is defined within the disciplines of System Safety, Quality Assurance and Reliability.

In the law we need to show that the every reasonably foreseeable usage possibility has been considered and designed to protect against..

REMEMBER - The law asks:

At the time of the defective design, was an alternative design technically feasible?

If an alternative design was technically feasible would it have been economically viable?

If such an alternative design were incorporated would the widget have been safer?

If such an alternative design could have been incorporated would the product's usefulness continue unabated. (utility)

The answers to each and every one of these questions can be discovered by asking the correct questions of the designer, The Systems Safety Group, and Quality Assurance and Reliability and maintainability groups. If your job was done correctly my job will end. Remember, as a lawyer, I grade your papers. If they are done correctly:

1. The public will be served by a safe product,
2. Your company would profit and have good reputation,
3. My client would still be healthy,
4. I could go fishing in another pond filled with water - not engineering malfeasance.

BIOGRAPHICAL INFORMATION.

Myron Papadakis is a mechanical engineer (Nebraska 63). He was a U.S.Navy carrier and test pilot. He is currently an airline captain for Delta Airlines. He is a lawyer and has been an adjunct Professor of Law for 16 years. He taught Aviation Law and Advanced Product Liability Law. He is Fellow of the International Society of Air Safety Investigators.