Radiation and Litigation: Analyses of the ALARA principle and low dose radiation in the courts, and the future of radiation in court cases.

by

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ABSTRACT

Currently there are a growing number of radiation workers. In order to ensure the safety of the employees, regulations have been established by the federal government and state governments to limit the dose equivalent to radiation workers. The most well known strategy for reducing radiation doses in the work place is the ALARA principle which stands for "as low as reasonably achievable". Within the phrase, "reasonably achievable" there is an implied element of subjectivity. Because "reasonably achievable" can vary in meaning for different people, this paper will analyze the ALARA principle in detail. Also, the manner in which inconclusive data on low dose radiation are treated in the court rooms will be evaluated.

A secondary part of the paper will deal with what happens when accidents occur to radiation workers. Specifically, this paper will deal with the accidents at Kerr-McGee, Three Mile Island and SONGS. The thesis will delve into the litigation that followed the radiation accidents and analyses of the rulings, and will look at where current radiation litigation is heading.

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I. Introduction to Radiation

To discuss the legal issues involved with workplaces that involve radiation, we must first have a sound grasp of certain concepts. Radiation is the concept which will be discussed at length and therefore needs the most elaboration.

Radiation is defined by the EPA (Environmental Protection Agency) as energy that travels in the form of waves or high speed particles [1] (for additional information see Appendix II).

Radiation can be broken up into two categories, ionizing radiation and non-ionizing radiation. Ionizing radiation has the energy required to remove electrons from atoms and create ions. In order to ionize atoms, radiation has to carry more than 10 eV [2]. Ionizing radiation is regulated by the government because it has the ability to damage DNA [1]. When the reference to radiation is made from now on, there will be the assumption that the radiation is ionizing.

A current problem with radiation is the topic of low dose. High dose radiation is known to cause adverse health effects (see Appendix II). However, the data linking low dose radiation to increased adverse health effects are currently inconclusive [3]. The scientific community has not been able to create disprove or prove that low doses of radiation cause adverse health effects. The cut off set for low dose radiation that is estimated by the Science and Technology and Review (published by Lawrence Livermore National Laboratories) is any absorbed dose under .1 Gy [3]. Any further mention of low dose radiation will have the implication that the absorbed dose is below .1 Gy.

When accidents occur in the radiation workplace, it is common for the accidental radiation doses that follow the accident to fall into the low dose category. The workplace accidents involving radiation covered in this paper all fall into the low dose radiation range. A judicial quandary arises when lawsuits are filed after a radiation accident where low doses were experienced, because of the inconclusive data on adverse health effects.

The current energy policy of President Bush calls for a growth of the nuclear energy industry. President Bush is asking for the implementation of new nuclear reactors to meet the growing demands of energy in the US [4]. With the implementation of next generation nuclear power plants the number of radiation workers could increase significantly. With the number of radiation workers increasing so could the number of accidents involving radiation and lawsuits that arise from the accidents. This paper will address the issues involving radiation in the courts, specifically the implementation of the ALARA principle (see part II.D) and low dose effects data.

II. Current Radiation Standards

II.A. *International Governing Bodies on Radiation Protection*

The international community has agencies that suggest certain regulations of radiation protection. These international regulations are not the law in the United States, but they do serve to influence the US national agencies that monitor and set radiation protection regulations.

One such international agency that sets radiation protection policies is the ICRP (International Committee on Radiation Protection). This organization was founded in 1928 by the professional association of radiologist physicians [5]. An example of the recommendation they make can be found in the ICRP Report #60 which was published in 1990. The ICRP recommends that an embryo/fetus should only receive a dose equivalent of .002 Sv during the gestation period [6], which would be more than twice as strict as the US NRC (Nuclear Regulatory Commission) regulation of .005 Sv [7].

The IRPA (International Radiation Protection Association) was created in 1964. There are currently 49 countries in the IRPA which includes the US. Not all recommendations by these international agencies are about specific dose rates. The 11^{th} Congress of the IRPA met in 2004 and emphasized the need for radiation workers to take radiation safety into their hands [8]. The IRPA concluded that the radiation worker needs to be better informed about radiation risks if he or she is to further take radiation safety into his own hands.

II.B. *National Governing Bodies on Radiation Protection*

The United States NRC (Nuclear Regulatory Commission) is in charge of regulating Atomic Energy Act materials which include: source material (thorium and uranium), special nuclear material (enriched uranium and plutonium), and other byproduct materials. The NRC is also in charge of regulating dose limits to radiation workers and members of the public. They are in charge of regulating how to monitor and label radioactive material, and the posting of radiation areas. Lastly the NRC has the power to regulate the reporting of theft or loss of radioactive material [7]. Table 2-1 shows the occupational dose limit for radiation workers (adults) set by the NRC.

Annual Dose Equivalent Limit (Sv)	
.05	Total effective dose equivalent.
.5	Sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye.
.15	Lens dose equivalent.
.5	Shallow dose equivalent to the skin of the whole body or to the skin of any extremity.

Table 2-1: Annual dose equivalent limit for adults [7].

The occupational dose limit for minors is 10 % of the annual dose limit for adults in Table 2-1. The dose limit allowed for an embryo/fetus during the whole pregnancy is .005 Sv [7]. The NRC regulation differs from the ICRP suggestion of less than .002 Sv of dose equivalent to the fetus.

The Atomic Act of 1954 gives the NRC the power to enforce and create the regulations to promote radiation protection. The Atomic Act of 1954 also grants the NRC permission to make an agreement with the states to regulate the above mentioned radioactive materials [7].

Another important federal agency in regulating radiation safety is the EPA (Environmental Protection Agency). Under the Code of Federal Regulations Title 40 the EPA is in charge of limiting radiation doses to the public. The EPA is also in charge of regulating of low level radioactive waste that has not been released [9]. An example of the EPA regulating dose limits to the public can be found in EPA's Yucca Mountain fact sheet. Yucca Mountain would be the US first nuclear waste repository. There are currently problems building the Yucca Mountain Repository because the Nevada residents do not want radioactive waste in their state. The EPA has proposed that for the first 10,000 years of the repository the site can not emit a dose equivalent of more than 15 mrem (.15 mSv) . The EPA has also set the standard for 10,000 years to 1,000,000 years of no more than 300 mrem (.03 Sv) [10].

Lastly the US Department of Transportation has the power to regulate radiation safety protection. Under the Code of Federal Regulations Title 49 the US Department of Transportation has the power to regulate the transportation of low-level radioactive waste. The US Department of Transportation decides what containers must be used for the waste, what type of labels must be used, and what papers need to be accompanied with each shipment [9].

Table 2-2 shows a general annual radiation dose limit for both the general public and radiation workers.

Annual Radiation Dose Limits	**Agency**
Radiation worker: .05 Sv	NRC, occupationally exposed
General Public: .001 Sv	NRC, member of the public
General Public: .00025 Sv	NRC, D&D all pathways
General Public: .0001 Sv	EPA, air pathway
General Public: .00004 Sv	EPA, drinking water pathway

Table 2-2: Comparison of annual dose limits regulated by NRC and EPA [11].

II.C. *State Regulation on Radiation Protection*

The states that choose to regulate their own Atomic Energy Act radioactive materials are called agreement states. Currently there are 34 agreement states in the United States. They have agreed to regulate radiation safety protection in accordance with the Atomic Energy Act of 1954 and have been granted permission to regulate their own state by the NRC [12]. In addition to being allowed to regulate Atomic Energy Act radioactive materials, the states can usually regulate the non Atomic Energy Act radioactive materials. These other radioactive materials include radium, radon, and radioactive material produced in particle accelerators like Co-57 [7].

Massachusetts is one of the above mentioned agreement states. Under the Massachusetts' Department of Public Health is their Radiation Control Program. The mission of the Radiation Control Program is to protect the public from all sources of radiation [13].

The Massachusetts 105 CMR (Code of Massachusetts Regulation Title 105) lists the standards for protection against radiation for its state. The occupational dose limits are the same as the ones set forth by the NRC, for reference look at table 2-1. The restriction for minors and the fetus/embryo is also the same for both the NRC and the Massachusetts Department of Health [14].

Though the standards that the state of Massachusetts has chosen are mostly the same as the NRC radiation protection standards, the state of Massachusetts retains the right to regulate its own radiation safety protection programs. Any infractions or accidents regarding radiation safety that occur in the state of Massachusetts fall under the jurisdiction of the state of Massachusetts.

Universities and workplaces have their own set of rules that complies with federal and state regulations regarding radiation safety. For instance, at MIT

(Massachusetts Institute of Technology), the MIT RPO's (Radiation Protection Office) mission is to protect the institute population and members of the public from radiation sources from MIT. The MIT RPO has a detailed manual on radiation safety. An example of the MIT RPO's detailed manual is their procedure for the labeling of radioactive materials, which labels materials with either, "CAUTION RADIOACTIVE MATERIAL" or "Radioactive Material ", depending on how radioactive the materials are [15].

III.D. *ALARA*

The ALARA principle in radiation safety stands for "as low as reasonably achievable". Within the ALARA philosophy is the implication that radiation doses be kept as low as possible [16].

The CDC (Center for Disease and Control) Radiation Safety Manual lists the common practices of the ALARA philosophy. The CDC splits up ALARA work practices into two categories; increasing external radiation protection and increasing internal radiation protection.

ALARA practices to minimize external radiation exposure include maximizing the distance from the radiation source, minimizing the time of exposure, and using a shield against the radiation source. Gamma and x-ray radiation dose varies inversely with distance, therefore tripling the distance from the source means a 1/9 reduction in dose. As for minimizing time in front of the source to reduce the dose, the radiation worker should do his or her work as quickly as possible while still maintaining his or her efficiency. The radiation worker should also use proper shielding when working with radioactive materials. If working with high energy penetrating radiation like neutrons, x-rays, and gammas lead shielding is appropriate. When the radiation worker is around a beta emitting source, 3/8" acrylic shielding is appropriate. [16].

ALARA practices to minimize internal radiation exposure include reducing inhalation, reducing puncture accidents, reducing ingestion, and reducing absorption. Examples of each precaution include using a chemical fume hood, disposing promptly of syringes, never bringing food or drink into a restricted area, and wearing protective eye goggles and gloves, respectively. [16]

The radiation worker is in charge of maintaining his exposure as low as reasonably achievable through the above mentioned practices. In addition the CDC Radiation Safety Manual recommends that employers provide appropriate equipment in a laboratory. Examples of recommended equipment includes fume hood, shielding, gloves, goggles, appropriate dosimetry, plastic bags for radioactive waste disposal, and appropriate signs and labels for places and containers holding radioactive substances.[16]

Under the CDC Radiation Safety Manual there are also guidelines to achieve as low as reasonably achievable doses during a pregnancy. The recommendations includes notifying a supervisor when the pregnancy is known, wearing extra shielding, and more frequent dosimetry checks [16].

The current ALARA philosophy includes many recommendations. The recommendations are useful in reducing the dose exposure of workers, but part of the problem is that they are not mandatory. The only hard numbers that a worker can follow are the annual dose limits established by the NRC, EPA, and the states.

ALARA philosophy strives for the best possible solution, which is the lowest radiation exposure possible for the radiation workers while being able to work efficiently. However, the word "reasonably" implies subjectivity. By analyzing some of the ALARA recommendations one can see where the subjectivity arises from. An example of this subjectivity occurs when the radiation worker is told to stand as far away from the source as possible to reduce the dose exposure. The worker is supposed to balance the efficiency of being up close to the source and the safety of being far away. There is no concrete distance that balances the efficiency and safety. Consequently each radiation worker and employer will have their own distance that they believe is safe enough. Because of these varying interpretations of what is safe enough, when an accident occurs, the employer will have difficulty proving that the worker was not at a safe enough distance. Assigning the blame to the employer will also be difficult to prove if litigation ensues. For the employer to be found responsible for the accident the radiation worker must prove that the radiation worker was following ALARA procedures. In the case of what distance to stand from the source, the radiation worker must prove he was standing at a safe enough distance.

There are, however, some ALARA principles which have concrete solutions regarding what the radiation worker should practice. For example, the wearing of appropriate clothing, including gloves and goggles is not necessarily subjective. Clearly wearing the gloves and goggles is better for attaining ALARA results. There is no subjectivity about compliance to ALARA principles if the radiation worker always wears gloves and goggles. The problem of subjectivity only occurs when the worker decides that he does not need to wear gloves and goggles because the risk is not high enough to outweigh the inconvenience of wearing gloves and goggles. Then if an accident occurs while the radiation worker made a conscious choice not to wear goggles and gloves, the employer can argue in a court of law that the radiation worker should have been wearing the goggles and gloves if the worker wanted to follow ALARA procedures.

When litigation caused by a radiation accident occurs, there is a certain gray area. The gray area is in regards to the responsibility of the accident between the employers and employees because of subjectivity of the ALARA philosophy.

III. Court Cases Involving Radiation

III.A. *Silkwood v. Kerr-McGee Corporation*

Silkwood v. Kerr-McGee Corporation was an important court case because it marked one of the first times a case involving radiation had been ruled against the employer. The court ruling also showed the impact of the ALARA principle as it applied to a radiation accident in a nuclear plant.

On November 5, 1974 a radiation worker named Karen Silkwood found that she had been exposed to plutonium 239. Ms. Silkwood had been working at a Kerr-McGee nuclear fuel plant. The day of her exposure to higher than normal radiation she had been working on polishing and grinding plutonium pellets that would be used as fuel rods [17].

Ms. Silkwood died in a car accident before she could file a lawsuit against Kerr-McGee, but her father filed a law suit on her behalf. The result of the trial was $10.5 million in punitive damages and personal injury for the plaintiff. The decision was reversed in the 10th Federal Court of Appeals and instead Ms. Silkwood's estate was given $5,000 to compensate for the personal property Ms. Silkwood lost during the decontamination of her apartment. In 1986, after a Supreme Court ruling in Silkwood's favor, when the case was headed to a retrial in the civil courts, both litigants settled out of court with a payout of about $1.3 million [17].

The Kerr-McGee plant was near Crescent, Oklahoma. When Bill Silkwood, Karen Silkwood's father, filed the lawsuit, he based the lawsuit on Oklahoma law that was designed to recover for the damages to Ms. Silkwood person and property. As to the question of Ms. Silkwood's accidental contamination of plutonium-239, Kerr-McGee alleged that Ms. Silkwood purposely took plutonium out of the plant in an effort to embarrass the company. The jury, however, did not side with Kerr-McGee on that issue. The cause of Ms. Silkwood's contamination was ruled to likely be through ingestion. An autopsy revealed 8.8 nanocuries in her body due to plutonium; at the time the permissible amount allowed by the NRC for a radiation worker was 40 nanocuries. No specific cause (i.e. torn gloves) was found as to how Ms. Silkwood was contaminated. Evidence throughout the course of the trial showed that Kerr-McGee was not always compliant with NRC regulations, particularly with the amount of unaccounted plutonium. An NRC official testified that the Kerr-McGee plant was not conforming to ALARA principles [18].

The court was interested in finding out the issues of strict liability and negligence. Regarding punitive damages the court instructed the jury to award damages when:

A) the jury feels the defendant has been guilty of oppression, fraud, or malice, actual or presumed.
B) there is evidence of recklessness and wanton disregard of another's rights [18].

The final outcome of the first trial in Oklahoma was in favor of Ms. Silkwood's estate. She won $505,000 in actual damages and $10 million in punitive damages [18].

In the first trial of Silkwood v. Kerr-McGee Corporation the employer was found liable in a civil suit. This was actually one of the first cases where the suit resulting from a radiation accident was successful. The jury felt that the Kerr-McGee Corporation was "strictly liable and negligent" when they ruled against them. Because the actually cause of how Ms. Silkwood was contaminated was never fully known, the focus instead shifted to the reputation of the employer and the employee. The jury had to decide who was following as low as reasonably achievable procedures. If the employee, Ms. Silkwood, was not following the ALARA principles the jury would have most likely ruled against her. The only way Mr. Silkwood could have won the suit was to prove that Ms. Silkwood followed ALARA principles, while Kerr-McGee did not. There was no evidence that Ms. Silkwood did not follow ALARA procedures.

If the story would have been that Kerr-McGee and Ms. Silkwood both had a spotless record in terms of following ALARA procedures, then the jury would have considered Ms. Silkwood's contamination an accident in which the blame could not be assigned more to one side. Furthermore, had it been the case that both the employer and the employee followed ALARA procedures and the accident still occurred the accident would have been seen as unavoidable and again the jury would not have ruled against the employer.

The decision of the first court was overturned in a Federal Court of Appeals. The Kerr-McGee plant was regulated by the US NRC standards which fall under federal regulations. Mr. Silkwood filed the lawsuit under Oklahoma Workers Compensation Law. The Federal Court of Appeals ruled that federal law pre-empted the state law and thus no personal injury nor punitive damages could be awarded. The federal law in question that pre-empts the state law is the Atomic Energy Act. The Atomic Energy Act has provision that the United States should promote nuclear energy as a viable alternative energy source. If state law punitive damages were to be awarded in this court case, investors would be scared of putting in money into nuclear energy. Consequently if fewer investments are coming into the nuclear energy sector, then the Atomic Energy Act is not being fulfilled because nuclear energy growth is not being promoted [17].

In 1984 the Supreme Court ruled in the case of Silkwood v. Kerr-McGee Corporation (464 U.S. 238) in favor of Ms. Silkwood. The majority opinion expressed by the honorable Justin White ruled that the award for punitive damages could not be pre-empted by federal law. The majority opinion stated that the intent of the Congress with the Atomic Energy Act to promote nuclear power was not being frustrated. In addition, the power of the NRC to levy fines for not following regulations was not being undermined, because paying both federal fines and state punitive damages was entirely possible [18].

The dissent which included the honorable Chief Justice Marshall concluded that the issue was whether a jury could impose a fine on a nuclear plant. The minority dissent felt that juries were being given too much power to regulate the complicated issues in a nuclear power plant. The honorable Justice Powell, part of the minority dissent, called the case:

"... a disquieting example of how the jury system can function as an unauthorized regulatory medium [18]."

The minority dissent felt that when the original trial jury was given the task of finding strict liability and negligence, they failed. The jury was suppose to be guided by whether they felt the defendant, Kerr-McGee, had been guilty of "oppression", "fraud", or "malice", actual or presumed. The minority dissent felt that those were strong challenges for the jury to find in the defendant. The minority dissent did not agree with the lay jury in its decision to find Kerr-McGee liable [18].

The minority dissent was trying to point out that the lay jury was unauthorized to levy fines in the nuclear power plant field. This shows the difficulty in regulating radiation safety. The as low as reasonably achievable principle makes litigating of radiation accidents complicated. The concept of complying with the ALARA principle can be subjective even when being interpreted by people well educated in radiation safety. Therefore when the general population is called upon to be on the jury for a radiation accident trial, the person will have an even harder time understanding if the employer or employee were practicing the ALARA principle. For example part of the ALARA principle is to minimize the time the radiation worker is in front of a radioactive source. In order for the radiation worker to attain as low as reasonably achievable dose exposure, the worker must balance the speed at which he or she works and the quality of his or her work. The member of the jury will have difficulties figuring out what was an unsafe length of time that the radiation worker was in front of a radiation source. The member of the jury will also have a hard time figuring out what is acceptable quality work. The member of the jury will have to base his or her decision on what ALARA means on experts. For these reasons, the member of the jury will not come up with an individual assessment of whether the employers and employees were following ALARA procedures, which is what he was designed to do in the court of law.

The ruling in the Federal Court of Appeals in the Silkwood case showed the courts' willingness to follow the strict interpretation of the law. By strict interpretation of the law, this paper assumes no regard for ethical values. These ignored ethical values include the current societal views on what is wrong and right; and more importantly the judge's personal beliefs of right and wrong. The courts decision was based purely on reading into the laws existed. The Federal Court of Appeals was the court that ruled in favor of Kerr-McGee on the basis that federal law pre-empted state law, and therefore Mr. Silkwood would not receive punitive damages for his daughter, Ms. Silkwood.

Another argument could be made that the Federal Court of Appeals and the Supreme Court minority dissent paid attention to economic factors in their rulings. The economic factor that guided them was the Atomic Energy Act provision that called for the growth of nuclear energy. The courts believed that this was a part of the Atomic Energy Act that should be followed closely. Because of their pre-disposed support of nuclear energy, the judges were going to use the current laws to help them back up their pro-nuclear energy stance. As a result of favoring the growth of nuclear energy these judges ruled in favor of the nuclear power plant, which was Kerr-McGee in this case.

Lastly, there was an element of ethics that was used to come up with a decision in the first trial and in the Supreme Court majority opinion of Silkwood v. Kerr-McGee. The jurors in the first trial were asked to prove whether the Kerr-McGee

Corporation was strictly liable or negligent. A major part of the jury's assessment of Kerr-McGee liability was their strict compliance with the ALARA principle. However, as explained above, sometimes figuring out if ALARA compliance is being followed is difficult among those educated in radiation safety. Figuring out ALARA compliance is even more difficult for those members of the general public serving in the jury. As a result, the jury members will tend to vote on their moral judgments and use various laws to compliment their moral judgments. Sometimes they might see the plaintiff as a greedy person. Or in the case of the Kerr McGee Corporation, the jurors might see the defendant as a greedy corporation. And the winner will be the side that labels the other side as the greediest.

The Supreme Court majority opinion also had the element of a ruling based on the moral values of the judge; however, the difference between the juror and the Supreme Court judges was the reasoning behind the rulings. Because a Supreme Court judge knows the law better than anyone, a Supreme Court judge has the ability to back up any decision. For example, a Supreme Court judge can have a pro big business moral code and as a result every case that comes across him involving big business he will rule in favor of it; he will know how to sufficiently argue for it.

III.B. *Class Action Lawsuit against Metropolitan Edison Company*

The class action law suit against Metropolitan Edison Company was significant in that radiation litigation moved to a new ground. District court judge Rambo wanted hard facts. She was not interested in accepted testimony of inconclusive low dose data nor was she interested in assigning blame based on the subjectivity of the ALARA principle.

In 1979 the Three Mile Island nuclear reactor in Pennsylvania suffered a partial meltdown. Three Mile Island was owned by MEC (Metropolitan Edison Company). Following the accident more than 2000 lawsuits were filed against the Metropolitan Edison Company to claim punitive damages [19].

The lawsuits were not resolved until 1996, when Judge Sylvia Rambo dismissed a class action lawsuit filed against the Metropolitan Edison Company. The honorable judge Rambo did not find conclusive evidence that the radiation from the partial meltdown at TMI (Three Mile Island) caused the adverse health effects the plaintiffs were proclaiming which included cancer [19].

In order for the plaintiffs to win the trial, they needed to prove that they were exposed to radiation due to the TMI meltdown. Secondly, the plaintiffs needed to prove that the radiation exposure due to TMI was harmful. The plaintiffs were able to prove the first part of their case. MEC's own study found that on average a 1.4 mrem (1.4×10^{-5} sievert) dose equivalent was received by those around the Three Mile Island area [19].

However, the court ruled for the defendants. The court ruled that radiation doses that are below the legal limit (.05 Sv for radiation workers and .001 Sv for the public) cannot be blamed for the adverse health effects that the plaintiffs were afflicted by. The plaintiffs had to prove that the defendant's calculations for the dose equivalent of 1.4×10^{-5} sievert was incorrect [19]. The court was looking for plaintiffs to establish a case that they actually received a dose equivalent that correlated to an absorbed dose of greater than .1 Gy.

In this case the question of low dose radiation came into effect. The lack of conclusive data that low doses of radiation cause adverse health effects doomed the plaintiffs. In order for Judge Rambo to believe that the radiation that leaked from TMI caused cancer in the plaintiffs, she needed to see that the absorbed dose experienced by those around TMI was greater than .1 Gy. The courts also disallowed the assigning of blame for the accident based on the ALARA principle. The courts wanted to know if the accident caused radiation to leak out of the plant, and into radiation worker and members of the public. The courts also wanted to know if radiation that was leaked the cause of the adverse health effects people suffered.

Radiation litigation moved in a new direction in this court case. In this court case the ALARA principle and its inherent subjectivity was thrown out. An accident was presumed to have happened by the court. The court did not care if the lowest reasonably achievable dose was acquired. The accident was assumed to be the employers fault. The court knew that the radiation dose that leaked out was in low dose range. The courts were also not interested in the inconclusive data of low dose radiation. Judge Rambo wanted hard numbers for the plaintiffs to win their punitive damages. Judge Rambo wanted the plaintiffs to prove that they received an absorbed dose of more than .1 Gy. Absorbed doses of .1 Gy and greater are in the high dose range, where conclusive data show that there are adverse health effects.

III.C. *Joe Kennedy v. Southern California Edison; Combustion Energy Incorporated*

Joe Kennedy v. SCE/CEI was an important court case involving a radiation accident because it shaped the current course of radiation litigation. The current course of radiation litigation is a battlefield for public relations of nuclear energy.

Joe Kennedy filed a wrongful death suit in 1996 on behalf of his wife, Ellen Kennedy who died of cancer at the age of 43. Mr. Kennedy worked in the SONGS (San Onofre Nuclear Generating Station) which is owned by SCE (Southern California Edison) as a machinist during 1984 through 1987. During 1984 – 1987, faulty fuel rods produced contamination. Mr. Kennedy brought home the contamination and exposed his wife to radiation levels above the federal dose limit. Calculations of his wife's contamination were estimated at less than one microrem (1×10^{-8} Sv), which is a dose equivalent that falls into the low dose radiation range. The estimated dose equivalent for Mrs. Kennedy was 1/1000 of the dose a person receives in one day from background radiation. Mr. Kennedy claimed that the radiation he brought home from work caused the cancer that killed his wife, Ellen. Mr. Kennedy sued both the owner of the SONGS, which was SCE and the makers of the faulty fuel rods, Combustion Energy Incorporated [20].

The first trial resulted in favor of the defendants SCE and CEI (Combustion Energy Incorporated). California law states that no expert can identify which ray of radiation initiated the cancer. The plaintiffs struggled to prove that it was the contamination the Mr. Kennedy brought home that caused his wife to develop terminal cancer [20].

In 2000, the 9th Federal Court of Appeal reversed the previous ruling of the district court. The honorable circuit judge Hawkins ruled that the previous court improperly informed the jury on causation of cancer due to radiation. The burden of proof was unjust for Mr. Kennedy to win the suit. Furthermore, the honorable Hawkins dismissed the claims that CEI could not be found liable under California's product liability laws. Mr. Kennedy now had the right to sue the makers of the faulty fuel rods which was CEI [20].

More suits were filed against SCE as a result of the faulty fuel rods during 1984-1987. Howarth and Smith the law firm that handled Mr. Kennedy's lawsuit also handled six other lawsuits related to the faulty fuel rods at SONGS. The NRC fined SONGS $100,000 for not complying with radiation safety guidelines due to the faulty fuel rods [21]. One of the other suits, Gregory McLandrich vs. SCE, attracted the attention of the attorney general, John Ashcroft. Ashcroft submitted a brief in favor of SCE asking for stricter guidelines in identifying proof of guilt in nuclear safety accidents [21].

In the court case Joe Kennedy v. SCE/CEI, the employer was clearly at fault for not following ALARA procedures. The employer did not provide its radiation workers with a safe work environment. At first the leaks in the equipment were not the fault of the Southern California Edison, but the company assumed responsibility when it bought the faulty rods and placed them in the SONGS where radiation workers were contaminated for more than 3 years. SONGS should have monitored the faulty fuel rods more frequently from the beginning and done something about the leaks as soon as the problem occurred.

In Kennedy v. SCE/CEI, radiation litigation moved on to a new phase beyond just proving who is responsible for the accident, the employer or employee. Now the burden of proof was not whether the employer was at fault for the accidental radiation exposure, but whether the increased dose due to the accident caused adverse effects. The plaintiff had to prove that the increase in radiation exposure due to the employer's fault actually caused adverse affects.

The first ruling in Kennedy vs. SCE/CEI, which was in favor of the defendants, showed the difficulty in linking low radiation doses to an increase in cancer. The radiation that the workers absorbed, including Mrs. Kennedy, was below the federal limit. In addition, the radiation that the workers absorbed was also below .1 Gy. The low dose radiation region is below .1 Gy according to the Science and Technology Review from Lawrence Livermore National Laboratories [2]. As to how harmful the low dose radiation is, the current low dose radiation data are inconclusive. Added to the uncertainty of the low dose radiation, was the fact the jury members were not properly instructed on the causation of cancer due to radiation and instead were told by the defendants that "no expert can sort out what radiation ray initiated the cancer". The members of the jury were left to wonder that normal radiation (i.e. cosmic rays) could have triggered the cancer in Mrs. Kennedy. In the previous case of Silkwood v. Kerr-McGee Corporation, the jury based their decision on moral grounds. In this case, the jury ruled by strictly interpreting the California law that stated that no expert can pin point the ray of radiation that induces cancer.

Despite the setback in the district court, the ruling of the 9th Federal Court of Appeals was a victory for the plaintiffs. Mr. Kennedy got the right to a retrial and the right to sue CEI for faulty fuel rods.

One of the interesting facts about the civil suits versus SCE was the Bush administration siding with SCE. A new battleground in the radiation litigation courts was being formed between the pro-nuclear energy and anti-nuclear energy forces. The public is already wary of the word "nuclear" that any more law suits in favor of radiation workers would further brand the nuclear industry as unsafe. The Bush administration which has been a proponent of nuclear energy from the start of his campaign [3], knows that part winning strategy for increasing nuclear energy is winning battles in the court rooms.

The fact that the Bush administration has to work hard to restore public confidence in nuclear energy exposes the US public's caution to approach anything nuclear. Like the Bush administration, the anti-nuclear energy groups also seek to take advantage of the court room rulings. For the anti-nuclear energy groups an award for damages to a radiation worker involved in a radiation accident is huge win.

The court room is the interpreter of the law. The judges and juries have the last say in declaring who has been responsible for accidents. Court room litigation cases have now become a battlefield in determining whether nuclear energy is safe. The NRC found SCE to be responsible for the accident involving the fuel rods at SONGS, but until a court of law makes them pay damages the public will not see SONGS as responsible.

IV. Conclusion.

Radiation law suits are complex because of the ALARA principle, the nature of low dose radiation, and the battleground they represent. The ALARA principle was found to be subjective in many practices. An example of this subjectivity is when a radiation worker is figuring out the exact distance to work from a source by balancing safety and efficiency. Another example occurs when the radiation is trying to minimize the time spent in front of the source; in this case the worker has to balance safety and quality. The ALARA principle works efficiently in the real world, but when accidents occur, proving that workers or employers were not complying by it is difficult. The ALARA principle becomes difficult for members of the public serving as jury members to gauge in lawsuits involving radiation because of the complexity of radiation safety.

When the blame of the accident is established, because of the failure on one side (either employee or employer) to follow the ALARA principles, the next question the courts want answered is whether the increase in radiation exposure was a major factor in the adverse health effects. When the increase in radiation absorbed dose that the radiation worker experiences falls under the low dose radiation (<.1 Gy), the link between the increased radiation and increased adverse effects is not supported well by current data. As a result the lawsuit becomes difficult to rule on. Currently the precedent has been set, in 1996, by the TMI case that low dose radiation can not be blamed for the causation of adverse health effects.

Lastly due to the negative opinion of nuclear energy, current pro nuclear energy factions like the Bush administration have started identifying radiation lawsuits as battlegrounds for winning the public relations war.

Appendix I: Acronyms to Know

AEA *Atomic Energy Act (1954)*

ALARA *As Low as Reasonably Achievable*

CDC *Center for Disease and Control*

CEI *Combustion Energy Incorporated*

CFR *Code of Federal Regulations*

CMR *Code of Massachusetts Regulation*

DOE *Department of Energy*

EPA *Environmental Protection Agency*

ICRP *International Committee on Radiation Protection*

IRPA *International Radiation Protection Association*

NRC *Nuclear Regulatory Commission*

OAS *Organization of Agreement States*

SONGS *San Onofre Nuclear Generating Station*

SCE *Southern California Edison*

TMI *Three Mile Island*

Appendix II: Radiation in Depth

Appendix II.A. *Ionizing Radiation vs. Non-Ionizing Radiation*

Radiation is energy that travels in the form of waves or high speed particles [1].

Radiation can be ionizing or non-ionizing. Ionizing radiation has enough energy (more than 10 eV) to remove electrons from atoms and create ions. Ionizing radiation is known to have the ability to harm DNA [1].

Non-ionizing radiation does not have enough energy to remove electrons [1]. Figure 2-1 shows the split in the electromagnetic wave spectrum of non-ionizing and ionizing radiation. The range of non-ionizing radiation goes from visible light to past radio waves [1]. When the US government refers to radiation safety they are not talking about non-ionizing radiation.

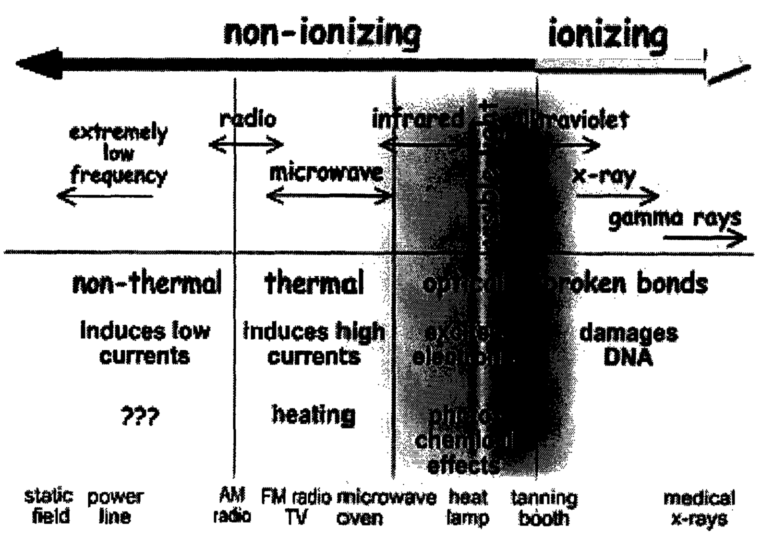

Fig. A2-1 shows the electromagnetic wave spectrum split between non-ionizing radiation and ionizing radiation. [1]

Appendix II.B. *Ionized Radiation in Depth: Charged Particulate Radiation vs. Uncharged Radiation*

Ionizing radiation can be categorized into two subsets, charged particulate radiation and uncharged radiation. Charged particulate radiation includes fast electrons and heavy charged particles. Fast electrons most commonly come from beta decay. Heavy charged particles, like the alpha particle come from alpha decay [2].

Uncharged radiation comes from electromagnetic radiation and neutrons. Electromagnetic radiation can be in the form of gamma rays which can be yielded from beta decay when the excited nucleus is transitioning to a lower-lying nuclear level [2].

Other sources of electromagnetic radiation includes photons with .511 MeV that are produced during positron emission (or $\beta+$) when the original positron emitted and the electron annihilate each other. Another common form of electromagnetic radiation is from bremsstrahlung which occurs when fast electrons interact with matter. Characteristic x-rays are also electromagnetic radiation that comes from the electrons transitioning between the lower atomic energy levels. The other form of uncharged radiation besides electromagnetic radiation is the neutron. neutrons can also be a form of radiation which can come from spontaneous fission or radioisotope sources [2].

Appendix II.C. *Normal Doses of Radiation in the US.*

A significant factor in legal issues involving the radiation safety is the average amount of dose equivalent a person in the US gets. By establishing what is normal, the courts can see how much excess radiation a person has received through accidents involved in working around radiation.

The general US population is exposed to natural and man-made sources of radiation annually. Table A2-1 shows what percentage of the total dose equivalent from natural and man made sources of radiation the average US person receives. The average US person receives a total of 3.6 mSv/year (see Appendix III for explanation of dose measurements) with the majority of the dose coming from Radon. Man-made sources, which include medical x-rays, nuclear medicine, consumer products, and other, contribute about 18% of the US population's radiation dose [22].

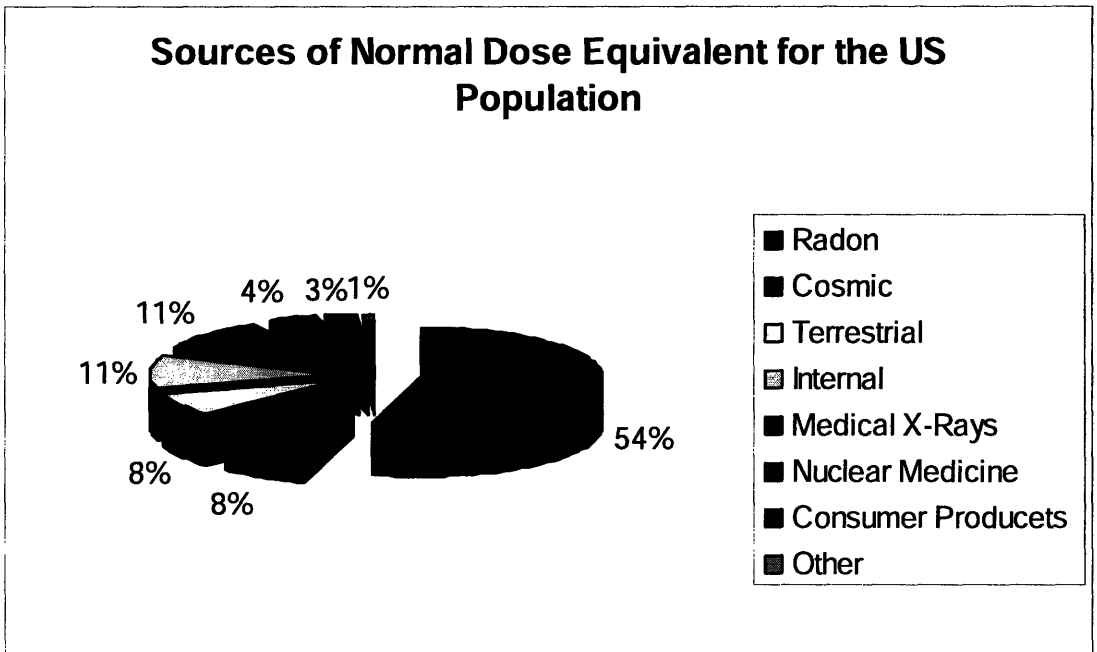

Table A2-1: Breakdown of the normal dose equivalent for US residents due to natural and man-made sources [22].

Appendix II.D. *Exposure to Low Doses of Radiation.*

Currently there is a debate about whether low doses of radiation exposure beyond the normal average are harmful. There is no doubt that at the high ends of radiation absorbed doses, like 7 Gy (minimum absolutely lethal dose), there are harmful effects [23]. Table A2-2 shows known effects for high doses of radiation.

Exposure (Sv)	Health Effect	Time to Onset
> .05	Radiation burns as exposure increases.	---
.05-.1	Changes in blood chemistry.	---
.5	Nausea.	Hours.
.55	Fatigue.	---
.7	Vomiting.	---
.75	Hair loss.	2-3 Weeks.
.9	Diarrhea.	---
1	Hemorrhage.	---
4	Death from fatal doses.	< 2 Months.
10	Destruction of internal lining. Internal bleeding. Death.	--- --- 1-2 Weeks.
20	Damage to central nervous system. Loss of consciousness. Death.	--- Minutes. Hours to day.

Table A2-2: Effects of high doses of radiation [1].

The problem exists when high end dose effects are extrapolated to the low dose radiation effects. There has not been enough data to conclusively demonstrate low dose radiation effects as either harmful, neutral, or positive relative to the high dose data.

For the reason that low dose radiation is inconclusive as to its effects, a victim of a radiation accident will have difficulty proving that he was harmed if the levels of exposure to radiation were low.

As Figure A2-2 shows there is conclusive evidence beyond a certain exposure. The current cut off point for what is considered low dose radiation dose is estimated to be below .1 Gy [3]. Figure A2-2 also shows the three theories of what the graph of radiation dose vs. risk could look like. The three theories on low dose radiation exposure being: more harmful relative to the high dose data, just as harmful (straight line), or less harmful.

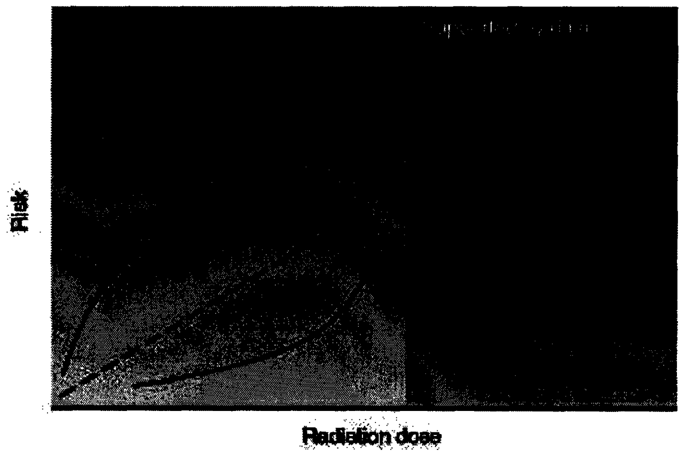

Figure A2-2: Graph showing the inconclusiveness of low dose radiation exposure vs. risk [3].

Appendix III: Measurements of Radiation and Useful Definitions

Electron Volt: (ev) an unit of energy, the energy carried by one electron that is accelerated through 1 volt of electric potential difference [24].

*all definitions below are from US NRC Code of Federal Regulations Title 10 Part 20

Activity: The rate of disintegration or decay of radioactive material.

Becquerel: (Bq) is the SI unit of measuring disintegration per second, 1 Bq = 1disintegration/second, (1 Curie = 3.7×10^{10} Bq).

Absorbed Dose: the energy imparted by ionizing radiation per unit mass of irradiated material.

Gray: (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (1 Gy = 100 rads).

Equivalent Dose: (H_T) is equal to product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Sievert: is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

Quality Factory: (*Q*) means the modifying factor that is used to derive dose equivalent from absorbed dose. Table 6-1A shows the Q value for various types of radiation. Table 6-1B shows the Q values for varying energy values of neutrons.

Type of radiation	**Quality factor**
X-ray, gamma, or beta radiation.	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge.	20
Neutrons of unknown energy	10
High energy protons.	10

Table 6-1A: Quality factor value for various forms of radiation [25].

Neutron energy (MeV)	Quality factor
2.5 x 10-8	2
1 x 10-8	2
1 x 10-7	2
1 x 10-6	2
1 x 10-5	2
1 x 10-4	2
1 x 10-3	2
1 x 10-2	2.5
1 x 10-1	7.5
5 x 10-1	11
1	11
2.5	9
5	8
7	7
10	6.5
14	7.5
20	8
40	7
60	5.5
100	4
200	3.5
300	3.5
400	3.5

Table 6.1B: Quality factors for neutrons of various energies [25].

Effective Dose Equivalent: (H_E) is the sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$).

Organ Dose Weighing Factors: W_T, for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. Table 6-2 shows the W_T values for various organs.

Organ or Tissue	**W_T**
Gonads	.25
Breast	.15
Red bone marrow	.12
Lung	.12
Thyroid	.03
Bone Surfaces	.03
Remainder	.30
Whole body	1.00

Table 6-2: Organ Dose Weighing Factors [25]

Whole Body: means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Stochastic Effects: means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

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