REGULATORY ANALYSIS OF
REVISIONS TO 10 CFR 20

Unified Skin Dose Limit

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1. Statement of the Problem

Since 1985, many nuclear power plants have detected contamination of individuals and their clothing by small, usually microscopic, highly radioactive beta or beta-gamma emitting particles with relatively high specific activity (James, 1988; Kelly and Gustafson, 1994). These particles, known as "discrete radioactive particles" (DRPs) and sometimes as "hot particles," most commonly contain ^{60}Co from corrosion products or fission products from leaking fuel. A unique aspect of DRPs on or near the skin is that very small amounts of tissue can be exposed to very large, highly nonuniform doses. These intense local irradiations may produce deterministic effects such as reddening, ulceration, or necrosis of small areas of skin, but the stochastic risk of inducing skin cancer due to a DRP exposure is negligible. The skin cancer risk from a DRP dose at the proposed limit of 50 rem averaged over 10 cm^2 is estimated to be 4 orders of magnitude lower than the cancer risk associated with a whole-body dose of 5 rems.

In addition to power reactors, DRPs have been occasionally encountered at facilities that manufacture radioactive sources for calibration, medical devices, industrial gauges, and similar devices that contain radioactive materials. Highly localized skin contaminations are also encountered at facilities that manufacture or use high specific activity liquids, such as nuclear medicine, radio-pharmacies, and radio-pharmaceuticals manufacturers. Although not technically "DRPs", such localized contaminations share many of the key characteristics exhibited by DRPs, mainly highly localized intense radiation fields from small to nearly microscopic sources on the skin.

2. Background

Prior to the revision of 10 CFR 20, the NRC issued Information Notice (IN) No. 90-48, "Enforcement Policy for Hot Particle Exposures" (NRC, 1990) containing a Commission approved policy statement. This statement indicated that enforcement discretion would be used in cases involving occupational doses to the skin from exposure to DRPs that exceed the skin dose limit in 10 CFR 20. IN 90-48 further stated that the provisions of this enforcement policy would be followed by the NRC staff until a new limit applicable to DRP exposure cases was established by revising 10 CFR 20.

IN 90-48 explained that, for DRP exposures to the skin, the staff would use a beta emission criterion of 75 uCi-hr (approximately 300-500 rad) for a DRP on the skin and a skin dose criterion of 0.5 Sv (50 rem) for a DRP off the skin averaged over one cm^2 for determining appropriate discretionary enforcement actions and appropriate severity levels. IN 90-48 stated that the enforcement policy did not change the limits of 10 CFR 20, the methods for determining compliance with those limits, or the notification and reporting requirements of 10 CFR Parts 19 and 20. Thus, exposures above 0.5 Sv (50 rem) were still reportable.

In 1991, the NRC revised Part 20 and its occupational dose limit for the skin of the whole body or to any extremity to 0.5 Sv (50 rem) averaged over one cm^2 per year to prevent deterministic effects (May 21, 1991; 56 FR 23360). This dose limit for the skin is contained in 10 CFR 20.1201 (2) (ii) (CFR, 2000) and is intended to prevent damage to relatively large areas of the skin that could compromise skin function or appearance. The *Federal Register* notice for the final rule stated that there would be a rulemaking to set limits for skin irradiated by DRPs. This proposed rule responds to that commitment.

In 1989 the National Council on Radiation Protection and Measurements (NCRP) issued report No. 106, Limit for Exposure to "Hot Particles" (NCRP, 1989) on the Skin, in which it recommended *"(1) A limit for exposure to hot particles be based on ensuring that acute deep ulceration of the skin be prevented and that this be accomplished by a limit based on the time integral of the beta particles emitted due to the activity of the particle in contact with the skin, and (2) Exposure to the skin from a "point" particle or a particle of unknown size but less than 1 mm in diameter be limited to 10^{10} beta particles emitted from the radionuclides contained in the particle. For the case where 1 beta particle is emitted per disintegration, this limit may be expressed as 10 GBq-s or 75 uCi-hr. For a particle for which the self absorption can be measured or calculated, the limit can be increased by the ratio of the beta particles emitted by the radionuclides divided by the beta particles emitted from the surface of the particle. Alternatively, the limit can be expressed as 10^{10} beta particles emitted from the surface of the particle."*

These recommendations were based on consideration of both stochastic (cancer) and deep ulceration (nonstochastic) risk estimates. At the proposed limit, the skin cancer mortality risk estimates were considered insignificant (about a factor of 2.3×10^{-6} lower than the deep ulceration risk) and orders of magnitude below the observed risks of mortality from accidents in safe industries. It was also recognized by the NCRP that when small areas of skin involved in DRP irradiation are irradiated sufficiently to cause erythema and lesions which give the appearance of dry desquamation, such effects are temporary, are confined to an area of a few square millimeters and were not considered to be severe nonstochastic effects. Ulceration, dermal thinning and pigment changes in such small areas were also not considered to be severe nonstochastic effects.

The NCRP recommendations were for particles on the skin. However, the Council indicated that the circumstances in which skin is irradiated by DRPs not directly on the skin required further study. They also indicated that "*Additional research is occurring presently and should be continued on both the biological effects of hot particles and the dosimetry of hot particles. Results from this ongoing work may well eventually provide sufficient new information to further support these recommendations or to require their review at a later time*."

Therefore, before rulemaking could proceed, the staff determined that additional research to study the effects of DRPs both on and off the skin was needed to provide adequate information to form the technical basis necessary for rulemaking. The NRC contracted with Brookhaven National Laboratory (BNL) for this research. The research was completed in June l997 and published as NUREG/CR-6531, "Effects of Radioactive Hot Particle on Pig Skin" (Kaurin, et. al., 1997). This work was reviewed and commented on by numerous members of the NCRP, the International Commission on Radiological Protection and representatives of the nuclear power industry. The results of this work and other recent studies were considered by the NCRP Scientific Committee 86 which published Report 130, Biological Effects and Exposure Limits for "Hot Particles", in 1999 (NCRP, 1999).

NCRP Report 130 provided an extensive review and summary of the scientific literature on biological effects and dosimetry related to DRP exposures to skin and other organs. In this review the Council discusses the problems of dosimetry for particles on clothing. In the working environment a DRP on clothing may move relative to a specific skin site, and may be at a variable distance from the skin. Both of these factors will result in a more homogenous dose to a larger area of skin. The anticipated movement of a particle on clothing, relative to the skin would also make it difficult to identify the most highly exposed 1 cm^2 of skin and to quantify the exposure. Therefore, a limit was derived that would take account of a range of potential geometries specific to DRP exposure that will prevent deep ulceration. To achieve this goal, the Council recommended: "*The dose at a depth of 70 μm on skin (including ear), hair or clothing be limited to no more than 0.5 Gy averaged over the most highly exposed 10 cm^2 of skin.*"

When applied to DRPs, this limit is mathematically equivalent to the 10^{10} beta particles or 75 uCi-hr [2,775 kBq-hr] limit recommended by NCRP in Report 106, which is the current enforcement discretion limit, and to a limit of 500 rad (5 Gy) averaged over 1 cm^2. The limit is below the dose at which the probability for acute lesions is 50 percent for all the particle energies studied and reviewed by the NCRP. At this limit, the risk of a stochastic effect (skin cancer mortality) was estimated as 1.1×10^{-7}. It was recognized by the NCRP that small transient effects may occur, "*However, if a biological effect were to result from a hot-particle exposure near or exceeding the recommended limit, the result is an easily treated medical condition still involving extremely small risk. Such occurrences would be indicative of the need for improvement in radiation protection practices, but should not be compared in seriousness to exceeding whole body exposure limits.*"

In March of 2001 the NCRP issued Statement No. 9 which addresses "Extension of the Skin Dose Limit for Hot Particles to Other External Sources of Skin Irradiation." In this document, the NCRP points out that a single radioactive particle in random motion relative to the skin could produce a dose distribution nearly equivalent to that from either distributed contamination on the skin or an external beam that exposed the same area. The main difference is that the instantaneous dose rate to a small area of skin near the source would be higher for a moving DRP or a very small beam than for uniform contamination or a uniform beam delivering the same total dose over the same area. For this reason the NCRP indicated that "the absorbed dose in skin at a depth of 70 μm from any external source of irradiation be limited to 0.5 Gy (50 rad) averaged over the most highly exposed 10 cm^2 of skin."

To minimize the probability that exposures from DRPs would result in doses that exceed current NRC guidelines, licensees have reduced the number of potential sources of cobalt DRPs, and conduct rigorous DRP exposure control programs. These include more frequent surveys, e.g., once every two hours (which increase health physics technician exposures), and personnel monitoring checks (which increase the worker's whole-body dose) to avoid DRP exposures to the skin and to minimize the possibility of a reportable event. Considering the almost nonexistent deterministic effects that are being averted, any measurable whole-body doses attributable to monitoring workers for DRP contamination would not be considered as low as reasonably achievable (ALARA) and should be avoided.

In addition, personnel contaminated by DRPs or high specific activity drops of liquid could in many cases exceed the current regulatory skin dose limit of 50 rem/yr averaged over 1 cm^2 before decontamination is completed successfully. Such personnel would be required by current NRC regulations to stop all work that may lead to any additional occupational exposure for the remainder of the calendar year. Such an action is unnecessary in view of the minimal risk from such contaminations, and may have severe consequences on the person's employment position, including in some cases loss of a job.

3. Objectives of this Rulemaking

The statement of consideration published with the revised 10 CFR Part 20 (56 FR 23360, 1991) stated that the DRP issue would be resolved by rulemaking. The objective of this rulemaking is to provide a risk-based skin dose limit for all sources of shallow dose equivalent including DRPs and small area contaminations that: (a) trades a higher risk of occurrence of deterministic effects to the skin for a reduction in the risk of whole-body stochastic effects, (b) reduces the unnecessary burden on licensees for reporting exposures which have insignificant health implications, (c) aids in avoiding unnecessary whole-body exposures and possible additional non-radiological health risks such as heat stress to workers, and (d) provides a common limit for shallow dose equivalent from all external sources of exposure to the skin.

4. Alternatives

Two alternatives are considered:

Alternative 1 - Make no change to Part 20.

This is the no-action option (the status quo). It is the alternative that is used for comparing costs and benefits with the recommended alternative two below.

Alternative 2 - Propose a shallow dose equivalent limit in Part 20.1201 for skin of 50 rem (0.5 Sv) averaged over the 10 square centimeters of skin receiving the highest exposure.

To determine the preferred alternative, the costs and benefits of each are evaluated and differences in net costs/yr and total costs discounted over a period of 20 years are estimated. An estimated 104 nuclear power units and a few materials licensees would be affected by the proposed changes. Information derived from two EPRI Reports (James, 1988; and Kelly & Gustafson, 1994), one joint EPRI/NEI report (ERS, 1997), NRC documents (Karagiannis and Hagemeyer, 2000; NRC, 1997); inspection reports in the NMED Database (NMED, 2001), and through personal contacts with several plants and knowledgeable individuals were used in arriving at the estimates below.

James (1988) surveyed sixty-one plants for incidence of DRPs. Nineteen of these reported finding fuel DRPs. Twenty-nine plants reported finding only activation DRPs. Kelly and Gustafson (1994) surveyed all nuclear utilities and nuclear power plants operating in 1991. Ninety-nine percent of the operating power reactors (71 sites/109 reactor units) responded to the survey. This is an exceptionally high participation rate and is indicative of the importance that utilities placed on collecting and documenting the industry's experience with DRPs. Of the 15,068 DRPs discovered during the period covered by this report only 0.2% involved both a skin contamination and a DRP of activity $>$ 1 uCi. Since 1991 plants have improved operations significantly. As a result only two or three plants are currently experiencing significant DRP problems.

5. Consequences

1) Routine area surveys of the workplace are conducted for DRPs and contamination during operations and shutdowns at nuclear power plants as part of a DRP and contamination-control program. The number of such surveys needed should not change under the new rule. These surveys are made to prevent spread or release of contamination and even particles well below the activity value of concern for the dose limit will continue to be searched for.

2) Following the discovery of DRPs during maintenance operations at a nuclear power plant, follow-up surveys are routinely employed to ensure that particles have been adequately controlled to prevent their spread to other locations, and to prevent workers from exceeding administrative and regulatory dose guidelines. The frequency, number and extent of these surveys are a function of particle activity, and plant and regulatory action levels.

With the proposed dose limit one could average the dose over an area of 10 cm^2 rather than the currently used 1 cm^2, leaving the skin dose limit of 50 rem/yr (0.5 Sv/yr) unchanged. For DRPs on the skin, this is mathematically equivalent to raising the current dose limit by a factor of 10, from 50 rem (0.5 Sv) averaged over the most highly exposed 1 cm^2 area of skin to 500 rem (5 Sv) averaged over the most highly exposed 1 cm^2 area of skin. The new dose limit would in effect be 50 rem (0.5 Sv) averaged over the most highly exposed 10 cm^2 of skin. This will make it reasonable to use longer working periods or "stay times" in those jobs likely to experience DRP or contamination problems, and yet not exceed the dose limit. These stay times are typically set at 2-3 hours under the current policy. Assuming the stay times are extended at least a factor of three, they will typically be more than six hours, which would essentially remove the need for a worker to leave a job to check for DRPs or contamination. Or, the number of times a surveyor will need to enter the area to check workers for DRPs will be fewer, and may be zero for most jobs. Thus, whole-body dose, added labor time, and costs should all be reduced significantly under the new regulation.

3) Protection from DRPs and contamination tends to increase the need for an extra layer of protective clothing. Any reduction of needs for protective clothing will also reduce the very important, related non-radiological hazards such as heat stress risks, and will increase the efficiency of workers. In addition, clothing is more often discarded as waste rather than washed if DRPs or contamination are present. However, under the new regulation, we expect costs for clothing, laundering and surveying to be reduced significantly since these costs are dictated primarily by contamination control needs. These will be less critical when dose from contamination can be averaged over 10 cm^2.

4) Nuclear Power Plant Jobs Likely to be Affected by DRPs:

a) During refueling operations at nuclear power plants, the reactor cavity is decontaminated. This operation is normally on the critical path and, for plants experiencing DRP problems, to avoid exceeding DRP administrative action levels, workers leave the work area to check for DRPs or contamination, This leads to additional external whole-body dose, labor costs and power costs. The frequency of these special checks is expected to decrease by about a factor of about three for the few plants that experience this problem under the new regulation. This will result in significant savings of whole-body dose and labor costs.

b) In nuclear power plants, work on the Residual Heat Removal (RHR) heat exchanger and valves is likely to result in DRP releases if the plant has had significant fuel failures, or problems with activated cobalt particles. Workers must leave the job periodically to check for DRPs or contamination in order to avoid exceeding the administrative action levels and limits. The new regulation is expected to require fewer such extra entries with resulting savings in both whole-body dose and labor costs.

c) In PWR plants, steam generator maintenance is sometimes a critical path job and is a significant source of DRPs and contamination for plants which have experienced significant fuel failures or activated cobalt particles. The extra time and whole-body dose caused by needed checks for DRPs or contamination under the existing policy will be reduced under the new regulation. The reduction in extra entries is expected to yield significant dose and cost savings.

d) In PWR plants, maintenance of excore detectors is a potential source of DRPs and contamination. Workers are often required to leave the job to check for DRPs on their clothing thus causing extra whole-body dose, and labor costs. Since this job is often on the critical path, large additional costs can result from the extended outages. The need for these checks is expected to be less under the new regulation.

e) Refueling operations are generally on the critical path and are occasionally a source of DRP exposures. Delays due to the need for periodic checks for DRPs and contamination can lead to significant whole-body dose, labor and power costs. These extra costs are expected to be reduced under the new regulation.

f) Decontamination of the upper internal lift rigs is another potential source of DRPs and contamination. Workers must periodically leave the job to check for DRPs or contamination, leading to additional whole-body dose and labor costs. Fewer such entries are expected under the new regulation.

g) Decontamination of refueling equipment is an important source of DRPs and contamination for plants with significant fuel failures or activated cobalt problems. Workers must leave the job to check for contamination, thereby increasing their whole-body dose and time on the job. Under the new regulation fewer reentries will be needed, thus saving dose and labor costs.

5) DRP and contamination control training is needed to ensure workers are familiar with the characteristics, controls and measurement requirements. Under the new regulation the time spent on training is not expected to change significantly.

6) Administrative activities related to DRP activities and personal contamination incidents will be reduced due to fewer required reports and less probability of over-exposures.

7) To assess doses to workers exposed near the dose or administrative limit, or to evaluate the characteristics of DRPs, lab analyses are often required. Although only a few percent of exposures need these analyses, even fewer will be needed under the new regulation since shallow dose equivalent will be averaged over 10 cm^2 rather than over 1 cm^2 as required in the current regulation. For spots of highly concentrated activity or DRPs, this is an effective increase of about a factor of ten in dose permitted to the most highly exposed 1 cm^2 of skin. This will make it much less likely that a person will approach the limit and hence need a careful assessment.

8) First year NRC costs to implement the new regulation will be modest.

9) Licensees will incur minimal costs to change procedures, train workers, and implement the new regulations.

6. Value Impact Analysis

The value (benefit) and impact (cost) of the proposed changes are estimated in this section. These values represent the best estimated changes from the current baseline. From reportable events (NMED, 2001) and existing reports (Karagiannis & Hagemeyer, 2000), it is known that existing DRP rules as implemented are effective in protecting the licensee's employees from exposure to localized skin exposures. For example, during the period 1990-1999 only 11 skin and extremity exposures were reported in the NRC's Radiation Exposure Information and Reporting System (Karagiannis & Hagemeyer, 2000) that exceeded 500 rem averaged over 1 cm^2, and another 30 exceeded 50 rem averaged over 1 cm^2. However, these improvements have been made at considerable cost in dose and monetary units. After an extensive survey of 105 nuclear power plants Kelly and Gustfason (1994) indicated overall cost impacts of from $200,000 to $2,000,000 annually per site. The impacts most commonly cited as resulting from DRPs were:

- "*Increased whole body exposures due to increased stay time (i.e. increased radiological controls resulting in slower work progress).*

- *Increased time and manpower to do a job, thereby increasing costs.*

- *Heat stress due to additional heavy clothing requirements.*

- *Other physiological and psychological stresses on workers."*

The survey also concluded: "As an overall average among the responding sites, DRPs contributed to a 28% overall loss in productivity (28% increase in labor requirements). However, two sites reported an actual comparison, based on identical work, with and without DRP controls. Based on those scenarios alone, the sites experienced an estimated loss of 33%-55% in worker productivity due to DRP control measures."

"Fifty-four percent of the respondents indicated that the implementation of DRP control measures increases the whole body exposure of the individual radiation worker in specific DRP zones. Moreover, 38% indicated that there is an increase in total person-rem due to increased stay times in radiation fields in general."

"Additional DRP control measures can result in a physiological impact; existing utility documentation suggests that this is due primarily to heat stress as a result of the additional PCs (e.g.; double coveralls) and increased respiratory protection practices. Therefore, the magnitude of the impact is directly proportional to the DRP control measures implemented."

"Twenty-four percent of the respondents noted that critical path was affected (i.e.; longer outages). This was due to (and accompanied by) decreased worker efficiency."

"Two thirds of the respondents reported no impact from the implementation of IE Notice 90-48. The Notice reduced enforcement actions but not the requirement for treating exposures in excess of 10CFR20 exposure limits as overexposure. Thus, utilities either determined that the Notice did not provide significant enough relief to warrant change, or the current procedures were more conservative and, thus, more preferable. However, 28% reported some procedural changes incidental to the Notice."

These proposed changes in the application of the skin dose limits (i.e. averaging dose over 10 cm^2 instead of averaging over 1 cm^2) are a redefinition of acceptable DRP protection guidelines. They are an attempt to bring into better balance the risks due to whole-body exposures that cause stochastic risks, and localized skin exposures that lead to an increased possibility of skin effects. The deterministic risks in both alternatives are sufficiently small that there is no attempt to quantify added value or impact on employee health. The values and impacts of the changes are all related to potential whole-body dose saving or added cost in operating an effective radiation control program at licensee sites. In making the estimates, the following general assumptions were made

- The changes affect 104 power reactor licensees.

- Although some non-power-reactor licensees would be affected, their operations are not likely to be affected significantly by the changes. The costs and benefits to these licensees are small compared to those for the power plants and, therefore, are only considered qualitatively, and in section 7 on sensitivity analyses.

- Estimated labor cost is $150/hr for a power reactor licensee including all overhead and fringe benefit costs (NRC, 1997).

- NRC labor cost is estimated at $70/hr (NRC, 1997).

- Approximately 200,000 power reactor workers/yr are currently monitored for radiation exposure. About half the monitored workers are exposed and receive a measurable dose. Of those exposed to a measurable dose, all are potentially exposed to DRPs.

- The average plant has a remaining lifetime of 20 years.

- The impact and value of future doses and costs were discounted at 7%/yr using discrete (annual) discounting (NRC, 1997).

- The monetary value of dose avoided at nuclear power plants is estimated at approximately $10,000/person-rem collective dose based on recent nuclear power plant experience. Based on an October 2000 survey (Miller, 2001), valuations of dose avoided employed at U. S. nuclear power plants ranged from $5,000 /person-rem to $33,000/person-rem with a median value of $10,000/person-rem and an average of $12,682/person-rem. For these evaluations a value of $10,000/person-rem was employed. This value is significantly higher than the health effects value of $2,000/person-rem recommended in NUREG/BR-0184 (NRC, 1997). The difference is caused by high doses to maintenance workers. To avoid these worker doses approaching or exceeding dose limits, plants often hire extra workers for some high-dose jobs.

- Replacement power costs are $15,000/hr when critical path time is extended. This value depends on assumptions concerning plant capacity factors and was the approximate value that could be justified in 1993 (NRC, 1997).

These assumptions are made based on NRC data and on information obtained from industry experts on radiation protection, licensees, reports of the Electric Power Research Institute in Palo Alto, California and the Nuclear Energy Institute in Washington, D.C. The estimates and specific assumptions and rationale used are presented below item by item following the same sequential order as the discussion in Section 4. A summary of the overall values and impacts for nuclear power plants is presented at the end of this section. Alternate assumptions were used to test the sensitivity of results to the above values. Results from these analyses are summarized in Section 7 below.

6.1 Routine Surveys

Concerns over potential DRP or contamination exposures and spread of particles or contamination to clean areas leads to a need for additional routine area surveys beyond that which is necessary to prevent spread of DRP contamination. For this report it is assumed that approximately 4.9 hours/yr are spent doing surveys specifically for DRPs, or as supplements to normal contamination surveys because of the concerns for DRPs. On average these surveys are assumed to occur in radiation fields delivering 0.1 mSv/hr (10 mrem/hr) to the surveyors. It is assumed that all 104 nuclear power plant licensees do and will continue to do these surveys. The number of area surveys needed to prevent spread of contamination is assumed to remain constant under the new rule. The number of extra area surveys performed to prevent DRP contamination of workers will be reduced somewhat. Key specific assumptions in the analysis of this attribute are:

- 104 licensees at risk
- 4.9 hours survey time required/yr
- 10 mrem/hr average dose rate
- 100 percent of licensees need to do routine surveys each year
- 20 percent fewer routine surveys will be needed under new rule

With these assumptions the total current industry costs/yr would be

[(4.9 hr x 10 mrem/hr x $10/mrem) + (4.9 hr x $150/hr)]/licensee x (104) licensees = $127,400

Under the new rule, costs/yr are estimated at 80 percent of those for the current rule or

0.8 x $127,400 = $101,920

The net savings per year for all licensees combined under the new rule would be

$127,400 - $101,920 = $25,480

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $270,088 under the new rule. Annual dose savings of about 0.01 Sv (1 rem) are estimated.

6.2 Follow-up Surveys

This change will reduce the number of follow-up surveys required to meet plant and regulatory guidelines on exposure to DRPs. Plants currently employ follow-up surveys whenever they discover DRPs during routine or job-specific surveys. It is assumed that, on average, each year 1 percent of plants at risk (approximately 1) discover a significant number of particles that require follow-up surveys that are in addition to those surveys normally required for contamination control. It is assumed that the threshold activity for these additional surveys will increase a factor of two to ten, due to the larger area permitted for dose averaging, following implementation of the proposed regulation. Based on published distributions of activities typically found in particles at nuclear power plants, it is assumed that the higher dose reporting level will lead to the need for 34 percent fewer follow-up surveys. It is further assumed that these surveys currently require approximately 7 hours for technicians working in fields having average dose rates of about 0.1 mSv/hr (10 mrem/hr). Key specific assumptions in the analysis of this attribute are:

- 104 licensees at risk
- 7 hours survey time required/yr
- 10 mrem/hr average dose rate
- 1 percent of licensees need to do additional follow-up surveys each year
- 34 percent fewer follow-up surveys are needed under the proposed rule

With these assumptions the total current industry costs/yr would be

[(7 hr x10 mrem/hr x $10/mrem) + (7 hr x $150/hr)]/licensee x (0.01 x 104) licensees = $1,820.

Under the new rule, costs/yr are estimated at 66 percent of those for the current rule or

0.66 x $1,820 = $1,201

The net savings per year for all licensees combined under the new rule would be

$1,820 - $1,201 = $619.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings during 20 years would be $6,559 under the new rule. Annual dose savings of about 0.25 mSv (25 mrem) are estimated.

6.3 Nuclear Power Plant Jobs Likely to be Affected by DRPs

The occurrences of DRP problems at nuclear power plants are related to work that breaches the primary system. Areas where DRPs and radioactive material contamination are found include fuel transfer pools, cask wash-down pits, steam generator cavities, fuel pits, reactor water clean-up rooms, and in laundry rooms. Jobs in which DRPs or contamination are likely to be found include work on control rod drives, the residual heat removal heat exchanger, cutting thermal shields, work on incore instrumentation spent fuel cleanup schedules, irradiated waste handling (fuel channel) and consolidation (shielding, compacting) projects. Several of these jobs are considered below:

a) Reactor Cavity Decontamination

Following each refueling, the reactor cavity is decontaminated. This operation is labor intensive, involves moderate dose rates (typically about 10 mrem/hr) and is normally on the critical path which leads to significant costs if operations are delayed. To ensure that workers do not exceed skin dose reporting thresholds, either workers must leave the work area to periodically check for DRPs or contamination, and/or additional health physics technicians must be assigned to monitor the workers clothing and work areas. If a plant is experiencing problems with DRPs, these activities can cause an additional collective whole-body dose of from a few mSv (few hundred mrem) to several cSv (several rem). These activities can also lead to extended outages with large costs for replacement power. In this analysis, it was assumed that 2 percent of the plants at risk experience such problems in a typical year, causing workers (including health physics technicians) to receive an average of 0.01 Sv (1 rem)/yr collective whole-body dose. Additional labor time for entries and exits for contamination checks is estimated at 50 hours for operations personnel and 50 hours for health physics personnel. An additional 2 hours time is needed for job planning due to DRP and contamination concerns. The extra surveys and reentries cause a 15 hour longer outage, and replacement power costs of $15,000/hr are assumed.

Key specific assumptions in analysis of this attribute are:

- 104 licensees at risk
- 102 hours total labor time required/yr
- 100 hours spent in 10 mrem/hr average dose rate fields
- 2 percent of licensees experience this degree of need/yr
- Outage is extended by 15 hours
- 50 percent less costs will be incurred under the new rule
- Replacement power costs $15,000/hr

With these assumptions the total industry costs/yr for this attribute would be

[(100 hr x 10 mrem/hr x $10/mrem) + (102 hr x $150/hr) + (15 hr x $15,000/hr)]/licensee x (0.02 x 104) licensees = $520,624

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.50 x $520,624 = $260,312.

The net savings per year for all licensees combined under the new rule would be

$520,624 - $260,312 = $260,312.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $2,759,307 under the new rule. Annual dose savings of about 10.4 mSv (1.04 rem) are estimated.

b) Residual Heat Removal

During maintenance on the residual heat removal system and valves, DRPs and contamination may be released. This problem has caused doses of about 1,000 mrem/outage at some PWR plants. For purposes of this analysis, it was assumed that 1 percent of plants may experience this type of problem in a typical year, leading to an average additional dose of about 6.5 mSv (650 mrem). This dose would be received during an additional 60 hours of maintenance worker time spent on the job due to DRP and contamination surveys and reentries, plus 5 hours health physics time for these surveys. It was assumed that no critical path time would be incurred, and that 50 percent less effort would be expended under the new rule.
Key specific assumptions in analysis of this attribute are:

- 69 licensees at risk
- 65 hours labor time required/yr
- 10 mrem/hr average dose rate
- 1 percent of licensees experience this degree of need/yr

- Outage is not extended
- 50 percent less costs will be incurred under the new rule

With these assumptions the total industry costs/yr for this attribute would be

[(65 hr x 10 mrem/hr x $10/mrem) + (65 hr x $150/hr)]/licensee x (0.01 x 69) licensees = $11,213.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.50 x $11,213 = $5,606

The net savings per year for all licensees combined under the new rule would be

$11,213 - $5,606 = $5,606.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $59,426 under the new rule. Annual dose savings of about 2.24 mSv (224 mrem) are estimated.

c) Steam Generator Maintenance

Steam generator maintenance is a major reoccurring job at nuclear power plants. These jobs have major potential for DRP and contamination exposures. The dose impact for steam generator activities involving DRPs is commonly due to elevated radiation fields adjacent to the steam generator platforms or nearby DRP survey areas. Some plants establish low dose personnel DRP survey areas away from the steam generator platforms, thereby requiring workers to move between the work platforms and the shielded survey area each time a DRP personnel survey is required. If significant quantities or activities of DRPs are encountered, these worker movements may occur on an hourly or even quarter-hour schedule. Typically workers receive from 100 to several hundred mrem extra exposure due to needed surveys and worker exits and reentries for DRP checks. Of the 69 PWR plants at risk, it was assumed that 1 percent have significant risk of DRP and contamination exposures It is estimated that special surveys and worker exits and reentries for contamination checks require 50 hours worker time and 6 hours health physics technician time, in average dose rates of 0.1 mSv/hr (10 mrem/hr). Of the plants experiencing problems, half are assumed to be on critical path and result in approximately a 5 hr extension of the outage, at a cost for power of $15,000/hr.

Key specific assumptions in analysis of this attribute are:

- 69 licensees at risk
- 56 hours labor plus health physics time required/yr
- 10 mrem/hr average dose rate
- 1 percent of licensees experience this degree of need/yr
- Outage is extended by 5 hours for half of the plants affected
- 50 percent less costs will be incurred under the new rule
- Replacement power costs $15,000/hr

With these assumptions the total industry costs/yr for this attribute would be

[(56 hr x 10 mrem/ hr x $10/mrem) + (56 hr x $150/hr) + (0.5 x 5 hr x $15,000/hr)]/licensee x (0.01 x 69) licensees = $35,535

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.50 x $35,535 = $17,768.

The net savings per year for all licensees combined under the new rule would be

$35,535 - $17,768 = $17,768.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $188,336 under the new rule. Annual dose savings of about 1.93 mSv (193 mrem) are estimated.

d) Excore Detector Maintenance

Maintenance of excore detectors in PWR plants can lead to significant exposures to DRP and need for special contamination control procedures. This job typically requires an additional whole-body exposure of about 1.9 mSv (190 mrem) due to an estimated 17 hours maintenance crew time and an estimated 2 hours health physics technician time for contamination checks and surveys in fields averaging 10 mrem/hr. These operations are typically on critical path and cause an estimated outage extension of about 5.75 hours at a cost of $15,000/hr.

Key specific assumptions in the analysis of this attribute are:

- 69 licensees at risk
- 19 hours labor plus health physics time required/yr
- 10 mrem/hr average dose rate
- 1 percent of licensees experience this degree of need/yr
- Outage is extended by 5.75 hours for the affected plants
- 50 percent less costs will be incurred under the new rule
- Replacement power costs $15,000/hr

With these assumptions the total industry costs/yr for this attribute would be

[(190 mrem x $10/mrem) + (19 hr x $150/hr) + (5.75 hr x $15,000/hr)]/licensee x (0.01 x 69) licensees = $62,790.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0. 5 x $62,790 = $31,395.

The net savings per year for all licensees combined under the new rule would be

$62,790 - $31,395 = $31,395.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $332,787 under the new rule. Annual dose savings of about 0.66 mSv (66 mrem) are estimated.

e) Refueling Operations

Several steps in the refueling of a reactor can lead to release of DRPs and contamination. This item covers disassembly, cleaning and reassembly of the reactor vessel head, fuel leak testing through "sipping", and fuel shuffling and replacement. Since refueling is normally on the critical path, an average outage delay of 34 hours was assumed for plants experiencing DRP problems. The refueling operations were assumed to occur in average fields of 10 mrem/hr, and incur 32 Sv (3,200 mrem) collective dose during 300 person-hours of operator hours work and 20 hours of health physics technician hours work. Under the new rule, it was assumed that costs would be reduced by 50 percent due to fewer reentries and special surveys for DRPs and contamination.

Key specific assumptions in the analysis of this attribute are:

- 104 licensees at risk
- 320 hours labor time required/yr
- 10 mrem/hr average dose rate
- 1 percent of licensees experience this degree of need/yr
- Outage is extended by 34 hours for these plants
- 50 percent less costs will be incurred under the new rule
- Replacement power costs $15,000/hr

With these assumptions the total industry costs/yr for this attribute would be

[(320 hr x 10 mrem/hr x $10/mrem) + (320 hr x $150/hr) + (34 hr x $15,000/hr)]/licensee x (0.01 x 104) licensees = $613,600.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.50 x $613,600 = $306,800.

The net savings per year for all licensees combined under the new rule would be

$613,300 - $306,800 = $306,800.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $3,252,080 under the new rule. Annual dose savings of about 16.6 mSv (1,660 mrem) are estimated.

f) Upper Internal Lift Rig Decontamination

In plants experiencing DRP problems, decontamination of the upper internal lift rig after each refueling operation typically causes about 0.67 mSv (67 mrem) extra dose due to about 6.7 hours of operations personnel and health physics technician time spent doing special surveys and checks for DRPs and contamination in areas with average dose rates of 10 mrem/hr. It is estimated that about 1 percent of plants at risk will experience DRP problems each year. For these plants it is estimated that a 50 percent reduction in the work requirements would be made for this job under the new rule. No reduction in work requirements or dose are assumed for the plants not experiencing DRP problems.

Key specific assumptions in the analysis of this attribute are:

- 104 licensees at risk
- 6.7 hours labor time required/yr
- 10 mrem/hr average dose rate
- 1 percent of licensees experience this degree of need/yr
- Outage is not extended
- 50 percent less costs will be incurred under the new rule

With these assumptions the total industry costs/yr for this attribute would be

[(6.7 hr x 10 mrem/hr x $10/mrem) + (6.7 hr x $150/hr)]/licensee x (0.01 x 104) licensees = $1,742.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.50 x $1,742 = $871.

The net savings per year for all licensees combined under the new rule would be

$1,742 - $871 = $871.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $9,233 under the new rule. Annual dose savings of about 0.35 mSv (35 mrem) are estimated.

g) Decontamination of Refueling Equipment

Post-outage decontamination of refueling equipment requires special zoning of the work area and frequent surveys by health physics technicians to ensure that DRPs and contamination are not released from the equipment and spread to other areas of the plant. It is estimated that plants at risk expend about 4 hours controlling the DRP problem and about 1 percent experience serious problems entailing about 80 hours of extra effort on the part of health physics technicians and decontamination workers. These jobs are not on the critical path. It is estimated that 50 percent less effort will be needed under the new rule due to the larger area over which dose may be averaged under the new rule.

Key specific assumptions in the analysis of this attribute are therefore:

- 104 licensees at risk
- 4 hours health physics and worker time is required/yr at half of the plants at risk, and 80 hours are required at 1 percent of the plants

- Costs will be reduced by 50 percent under the new rule

With these assumptions the total industry costs for this attribute would be

(4 hr x $150/hr)/licensee x (0.5 x 104) licensees/yr + (80 hr x $150/hr)/licensee x (0.01 x 104) licensee/yr = $31,200/yr + $12,480 = $43,680/yr.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.50 x $43,680 = $21,840/yr.

The net savings per year for all licensees combined under the new rule would be

$43,680 - $21,840 = $21,840.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $231,504 under the new rule. No dose savings are expected.

6.4 Protective Clothing Costs at Nuclear Power Plants

Based on an EPRI study of average industry costs for replacement, disposal, and extra monitoring of protective clothing at three nuclear power units experiencing DRP problems, it is estimated that typical additional costs are currently about $30,000/yr at such plants. It is further assumed that on average only 1 percent of U.S. plants are likely to need this level of control and cost each year. Under the new rule it is assumed fewer plants will need to incur these costs, and fewer costs will be incurred at those plants experiencing problems. It is assumed that net costs will be reduced by 34 percent under the new rule.

Key specific assumptions in the analysis of this attribute are:

- 104 licensees at risk
- 1 percent of licensees experience this degree of need/yr

- 34 percent less costs will be incurred under the new rule

With these assumptions the current total industry costs for this attribute are

0.01 x 104 plants x $30,000/plant-yr = $31,200/yr.

Under the new rule, costs are estimated at 66 percent of those for the current rule or

0.66 x $31,200 = $20,592/yr.

The net savings per year for all licensees combined under the new rule would be

$31,200-$20,592 = $10,608.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $112,445 under the new rule.

6.5 DRP and Contamination Control Administrative Activities

Routine administrative activities will be reduced under the proposed rule due to fewer incidents needing to be investigated and reported on. Since very few incidents led to over exposures in the past, administrative efforts will more likely relate to the reduced number of incidents that will require reporting. Based on the change of a factor of ten in the area over which dose may be averaged, it is estimated that the number of reportable incidents should decrease by about 50 percent under the new rule. Other administrative costs related to initial implementation of this change are covered under item 18 below. In any year it is estimate that 5 percent of all plants at risk will need to perform administrative activities related to routine reporting of incidents and related follow-on actions. These activities will require an average of 50 hours of plant health physics and administrative time.

Key specific assumptions in the analysis of this attribute are therefore:

- 104 licensees at risk
- 50 hours administrative time required/yr for plants experiencing this need
- 5 percent of licensees experience this degree of need/yr
- Costs will be reduced by 50 percent under the new rule

With these assumptions the total current industry costs for this attribute would be

(50 hr x $150/hr)/licensee x (0.05 x 104) licensees/yr = $39,000/yr.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.5 x $39,000 = $19,500/yr.

The net savings per year for all licensees combined under the new rule would be
$39,000 - $19,500= $19,500.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $206,700 under the new rule.

6.6 Lab Analyses of DRPs at Nuclear Power Plants

The number of DRPs needing analysis varies widely with the degree of problems experienced. Typically, only a few particles per year will need analysis, however, for some plants, many dozens may need analysis. It is estimated that 1 percent of plants will fall in the latter category and cause health physics technicians and analysts to spend about 12 hours per year on this effort. It is further estimated that the required efforts will be reduced by 10 percent under the new rule.

Key specific assumptions in the analysis of this attribute are therefore:

- 104 licensees at risk
- 12-hours health physics and analysts time are required/yr at affected plants

- 1 percent of plants at risk experience this degree of need/yr
- Costs will be reduced by 10 percent under the new rule

With these assumptions the current total industry costs for this attribute would be

(12 hr x $150/hr)/licensee x (0.01 x 104) licensees/yr = $1,872.

Under the new rule, costs are estimated at 90 percent of those for the current rule or

0.9 x $1,872 = $1,685/yr.

The net savings per year for all licensees combined under the new rule would be

$1,872 - $1,685 = $187.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings during a 20-year period would be $1,984 under the new rule.

6.7 NRC Surveillance Costs

Average NRC surveillance and related training and reporting time currently spent on DRP and contamination control issues for all nuclear plants at risk is estimated at four hours per year per plant. Under the new rule, it is estimated that costs will be reduced by 50 percent due to fewer reports of exceeding the reporting requirement and somewhat less time spent on inspections and training related to these issues.

Key specific assumptions in the analysis of this attribute are therefore:

- 104 licensees at risk
- An average of 4-hour NRC staff time is required/yr/plant
- Costs will be reduced by 50 percent under the new rule

With these assumptions the total costs for this attribute would be

(4 hr x $70/hr)/licensee x 104 licensees/yr = $29,120/yr.

Under the new rule, costs are estimated at 50 percent of those for the current rule or

0.5 x $29,120 = $14,560/yr.

The net savings per year for all nuclear power plant licensees combined under the new rule would be

$29,120 - $14,560 = $14,560.

Assuming an average plant lifetime of 20 years, and employing a 7 percent discount rate for future doses and costs, the total discounted savings over 20 years would be $154,336 under the new rule.

6.8 NRC Costs to Implement

Costs to implement the new rule would include those related to dissemination of information to licensees, and training NRC inspectors. These are estimated at about $10,000 expended primarily in the first year. For convenience of comparison with other costs, using a 7 percent discount rate, this present value cost is expressed as an equivalent discounted annual cost of $944./yr.

6.9 Plant Costs to Implement

To implement the new rule, all plants will need to evaluate and revise policies and procedures, and train staff and workers. With the additional emphasis on reducing whole-body doses, avoiding use of unnecessary protective and respiratory equipment and minimizing risks from non-radiological factors such as heat stress, significant new training will be required. It is estimated that these activities will require an average of 80 staff and worker hours/plant to implement during the first year yielding present value costs of

104 plants x 80 hr/plant x \$150/hr = \$1,248,000.

Allocating this cost over 20 years and using a 7 percent discount rate for future costs yields \$117,736/yr cost attributed to the new rule.

6.10 Total of Values and Impacts for Nuclear Power Plants

Table 1 shows a summary of the above value/impact analyses. Total savings/yr estimated for the above jobs and functions affected by DRPs equals to \$588,376/yr. Total discounted savings estimated over 20 years for these jobs equals \$6,236,785. These savings include an estimated collective dose saving per year of about 0.0427 person-Sv (4.27 person-rem). These values reflect only a portion of all jobs likely to be affected if a DRP problem is encountered at any given plant. Other DRP-related activities that have been identified and may result in additional dose and cost savings include: containment cavity drain line (filter suction) work, containment sump cleanout and inspection, dryer/separator pit work for boiling water reactors, spent fuel shuffle, transfer canal maintenance and decontamination in PWRs, spent fuel cask handling, loading, decontamination, cask washdown (decontamination) pit sump cleanout and inspection, control rod drive rebuilding, refuel floor area control activities, reactor head stand control zone work, reactor coolant pump platform work, reactor coolant pump seal decontamination/rebuild room work, residual heat removal pump room work, and primary side valve repair. Thus, although all of the jobs analyzed above will not be affected by a problem at any one plant, other jobs not included in the above estimates would likely be affected. Therefore, the overall estimate for jobs affected by DRPs and contamination at nuclear power plants is thought to be realistic or probably conservative (on the low side).

7. Value/Impacts on Other Licensees

Of the licensees who report to the NRC, about 92 percent of the reported workers with measurable doses were monitored by nuclear power facilities in 1999, where they received approximately 84 percent of the total collective dose (Karagiannis & Hagemeyer, 2000). Other NRC licensees received the remaining 16 percent of collective dose. In addition, approximately twice as many facilities are licensed to Agreement States as the number licensed by the NRC

(Karagiannis & Hagemeyer, 2000). Data from facilities licensed by agreement states are not included in the values above.

Little published information is available on the impacts of contamination and DRPs on non-nuclear-power and Agreement State licensees. To estimate likely impacts on these other licenses, it is assumed that the costs (except costs for replacement power) and impacts will be proportional to the respective collective doses. Omitting costs and savings of replacement power leaves annual cost savings of about $159,000 for nuclear power licensees. Assuming non-nuclear-power NRC licensees' savings are proportional to their collective doses relative to those for nuclear power plants, one can estimate these savings as 16 percent of $159,000 = $25,440/yr or $269,666 per 20 years. Also, Agreement State licensee benefits may contribute another estimated 32 percent of the non-power-replacement nuclear power plant savings, that is, $50,880/yr or $539,331 per 20 years. These values are also shown in Table 1. Including these estimates with those for nuclear power plants yields a total estimated benefit of $664,696/yr or $7,045,782 per 20 years with implementation of the new rule.

In addition, assuming the collective doses for other licensees are reduced in proportion to relative collective doses for nuclear power plants, the dose savings per year are estimated as 6.8 mSv/yr (0.68 rem/yr) for non-nuclear-power-plant NRC licensees, and 13.7 mSv/yr (1.37 rem/yr) for agreement state licensees. The actual values and impacts are likely to be less than these estimates, but not negative. The added flexibility afforded by the increase in area over which skin dose may be averaged (10 cm^2 under the new rule vs. 1 cm^2 under existing regulations) should permit more efficient work planning, less need for heavy gloves and in some cases extra protective clothing with resulting better utilization of the principal of ALARA and optimization of operations to reduce whole-body doses. In any case, the impacts on other licensees are expected to be smaller than those for nuclear-power-plant licensees, and possibly negligible.

8. Sensitivity Analyses

Values for some of the assumptions employed above are somewhat uncertain. To test the sensitivity of the results to assumptions made, values of the following were varied and values/impacts were recalculated and compared to the original (reference) results: (a) replacement power costs, (b) dollar value of dose reduction ($/person-rem), (c) plant labor costs, and (c) NCR labor costs. Results are shown on Table 2 .

Replacement power costs were originally assumed to be $15,000/hr of extended outage. Since this value was more appropriate in 1993, an increase of 20 percent to $18,000/hr was assumed for this sensitivity test. Increased savings over original values of about $119,181/yr or $1,263,314 over a 20 year period are estimated for the increased value of replacement power. This is an increase in savings of about 17.9 percent.

Values of dose avoided were tested at $2,000/person-rem saved and $16,000/person-rem saved. The $2,000/person-rem value corresponds to the value recommended in the Regulatory Analysis Technical Evaluation Handbook (NRC, 1997) for health effects. The $16,000/person-rem value is 26 percent higher than the average employed at nuclear power plants in 2000. The $2,000/person-rem assumption caused a decrease in monetary savings of about 7.6 percent/yr, whereas the increase to $16,000/person-rem caused an estimated increase in savings of 5.7 percent/yr over values obtained with the reference assumptions.

The value of $150/hr recommended in the Regulatory Analysis Technical Evaluation Handbook (NRC, 1997) for plant labor costs was increased to $200/hr to test for sensitivity to this parameter. The results were estimated to increase monetary savings by $52,208/yr or 7.9 percent over the values obtained with the reference assumptions.

Assumed NRC labor costs were increased from $70/hr to $100/hr to test for sensitivity to this parameter. The results were estimated to increase monetary savings by $9,236/yr or 1.4 percent over the values obtained with the reference assumptions.

9. Decision Rationale

Of the two options considered, option two is preferable because it satisfies the following decision criteria and Agency goals:

9.1 Goal – Maintain worker and plant safety:

- the trades off of increased deterministic skin effects for reduced whole-body stochastic risk is based on comparative risks

- Retains assurance that large DRP skin doses that might cause significant health effects would not occur in large numbers through the limit of 50 rem (0.5 Sv) averaged over the highest exposed 10 cm^2 of skin

- Would reflect recommendations of the NCRP

- Provides a simplified, more easily understood regulatory approach than the existing enforcement policy

- Reduces the need for extra layers of protective clothing, which add to heat-stress for the workers, reduces worker efficiency, and adds additional whole-body dose

9.2 Goal – Reduce unnecessary burden:

- Reduces the frequency of job-related personnel-monitoring checks and surveys for DRPs and contamination, thereby reducing unnecessary whole-body doses that are incurred in attempts to avoid skin exposures due to DRPs and contamination and current reporting requirements

- Reduces the reporting burden on licensees because the reporting level is raised from 50 rem (0.5 Sv) averaged over 1 cm^2 to 50 rem (0.5 Sv) averaged over 10 cm^2 and few exposures are expected to exceed that level

- Would reduce and simplify the record keeping burden since the same exposure limit (50 rem (0.5 Sv) averaged over the highest exposed 10 cm^2) would apply for discrete particle exposures, contamination exposures and exposures to skin of the whole body

- Would provide greater planning and operations flexibility such as deciding to use or not use protective clothing based on considerations of other risks and the ALARA principal, thereby improving the efficiency and cost-effectiveness of licensee radiation protection programs

- Would reduce the number of related investigations and reports

- Responds in a positive way to the industry's petition for regulatory relief.

9.3 Goal – Increase public confidence:

- Would reflect the most recent recommendations of the NCRP and thereby ensure appropriate radiation protection practices

- Removes the interim enforcement policy, which was a temporary solution while more scientific data was developed

9.4 Goal – Increase NRC efficiency and effectiveness:

- Permits comparing all reported skin doses to a single limit

- Would reduce the number of related investigations and reports

10. References

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Table 1. Summary of Value/Impact Analyses.

Item	Savings/yr with New Rule	Disc. Savings Summed Over 20 yrs	Total Dose Savings/yr (person-rem)*
1. Routine Surveys	$25,480	$270,088	1.02
2. Follow-up Surveys	$619	$6,559	0.02
3. Reactor Cavity Decon	$260,312	$2,759,307	1.04
4. RHR Heat Ex. & Valves	$5,606	$59,426	0.22
5. Steam Gen. Main.	$17,768	$188,336	0.19
6. Excore Detector	$31,395	$332,787	0.07
7. Refueling	$306,800	$3,252,080	1.66
8. Upper Int. Lift Rig Decon	$871	$9,233	0.03
9. Decon of Refuel Equip	$21,840	$231,504	0.00
10. Prot. Clothing Costs	$10,608	$112,445	0.00
11. DRP Admin. Activities	$19,500	$206,700	0.00
12. Lab Analyses of DRPs	$187	$1,984	0.00
13. NRC Surveillance Costs	$14,560	$154,336	0.00
14. NRC Costs to Implement	($944)	($10,000)	0.00
15. Plant Costs to Implement	($117,736)	($1,248,000)	0.00
Nuclear Power Plant Totals:	$596,866	$6,326,785	4.27
Non-Power-Plant Licensees:	$25,440	$269,666	0.68
Agreement State Licensees:	$50,880	$539,331	1.37
Grand Totals:	$673,186	$7,135,782	6.31

*100 rem = 1 Sv

Table 2. Results of Sensitivity Analyses

Variable	Value	Benefit/yr	Benefit/20yr	Change/yr	Change/20yr	% change
(base case)		$664,696	$7,045,782	$0	$0	0.0
Power	$18,000/hr	$783,877	$8,309,096	$119,181	$1,263,314	17.9
$/person-rem*	$2,000	$614,189	$651,408	($50,507)	($535,374)	-7.6
$/person-rem*	$16,000	$702,577	$7,447,312	$37,881	$401,530	5.7
Plant Labor	$200/hr	$716,904	$7,599,182	$52,208	$553,400	7.9
NRC Labor	$100/hr	$673,932	$7,143,675	$9,236	$97,893	1.4

*$1,000/person-rem = $100,000/person-Sv