NRC PUBLIC DOCUMENT ROOM

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY & LICENSING BOARD

In the Matter of	)	Docket Nos. 50-250-SP
	)	50-251-SP
FLORIDA POWER & LIGHT COMPANY	)	
	)	(Proposed Amendments to Facility
(Turkey Point Nuclear Generating	)	Operating License to Permit
Units Nc . 3 and 4)	)	Steam Generator Repair)

LICENSEE'S RESPONSE TO
"SUPPLEMENTAL SUBMISSION
OF PETITIONER
MARK P. ONCAVAGE"

In large part the "Supplemental Submission of Petitioner Mark P. Oncavage" (Supplemental Submission) constitutes an effort "to satisfy the Board that the Petitioner has the ability to contribute to a hearing . . ." (p. 2, n. 1), i.e., "to assist in developing a sound record." 10 CFR § 2.714(a)(1)(iv) It also contends that "[a]llowing the Petitioner to intervene will not cause serious delay or broadening of the proceedings." (p. 8)

For the reasons set forth below, a hearing for the principal purposes suggested in the Supplemental Submission is most unlikely to develop "a sound record." The hearing will inevitably be lengthy. It would threaten substantially to delay issuance of the license amendment here involved and to deny FPL of the flexibility required for the scheduling of the steam generator repairs. In addition, Petitioner has never established good cause for the extreme lateness of the petition to intervene or for additional contentions as they continue to accumulate.

I

Development of a Sound Record

The substantive issues addressed in the Supplemental Submission can be classified into two main categories: "Occupational radiation exposure" (pp. 2-3); and releases of radioactivity, either through the earth from stored steam generator assemblies or through liquid pathways, apparently primarily from leakage into or out of the Turkey Point cooling canals or overflow from those canals. (pp. 2, 3-4) Both claims are expressed in extremely general terms and both ignore the substantial body of relevant publicly available information. Neither explains why earlier judgments based upon such information are erroneous or should be addressed again in the context of the instant proposed amendment; and neither seems to take serious issue with the underlying bases of, and the technical conclusions reached in, FPL's Steam Generator Repair Report (SGRR) and the NRC Staff's Safety Evaluation Report (SER).

A. Occupational radiation exposures.

The Supplemental Submission (p. 3) states that Professor Karl Z. Morgan "will address the occupational exposure problem created by the proposed repairs." It also refers to an article by Prof. Morgan in the April 5, 1979, issue of the periodical "New Scientist," pp. 19-21, entitled "How dangerous is low-level radiation" (copy attached). The Supplemental Submission goes on to state (Id.):

> The recently prepared Safety Evaluation Report (SER) on Turkey Point Plants 3 and 4 apparently believes the licensee's "estimated 1300 man-rem" exposure is within tolerable bounds. See SER pp. 2-9 through 2-11. Professor Morgan's recent New Scientist article recommends a 500 man-rem limit. His testimony will explain his conclusions and also analyze the validity of the licensee's methods for determining the exposure level.

It also states (p. 7) that "by presenting testimony from Dr. Morgan concerning occupational radiation exposure, we have raised a 'significant matter not considered by the staff.'"

It is not clear from the Supplemental Submission precisely what aspect of "the occupational exposure problem" the Petitioner intends to address. The various petitions for leave to intervene submitted by Petitioner prior to the prehearing conference of May 2, 1979, did not refer to occupational exposures at all. However, at the prehearing conference Petitioner moved[1/] to supersede the earlier contention with a new set of contentions. Only one of these, Contention 5, might be interpreted as referring to

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1/ That motion has not yet been acted on. See Transcript of May 2, 1979, Prehearing Conference (hereinafter "Tr. ___") at pp. 65, 87-90, 98, 108, 121. The new contentions are incorporated at the end of the transcript.

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occupational exposures insofar as it raises the question whether the proposed steam generator repairs "comply with 10 CFR Part 20, NEPA, or the FWPCA?" 2/

Although the Supplemental Submission cites the SER, it does not indicate that that report discusses occupational radiation exposure in considerable detail. (Section 2.6, pp. 2-4 through 2-11) The discussion analyzes the operation and breaks it down into various elements, such as post shutdown repair preparation, steam generator removal, etc. It considers the relevant literature, including the recent Battelle Pacific Northwest Laboratories' report, "Radiological-Assessment of Steam Generator Removal and Replacement." (NUREG/CR-0199) It describes the procedures which will be followed in connection with each type of activity and the measures which will be taken to reduce occupational exposures. It concludes that the specific limits on individual exposures prescribed by 10 CFR Part 20 will not be exceeded. It also finds acceptable FPL's efforts to comply with the direction contained in 10 CFR § 20.1(c) to make "every reasonable effort to maintain radiation exposures . . . as low as reasonably achievable" (ALARA).

2/ Contention 1 also raises the question of occupational exposures, but in the context of continued operation of the plant prior to shutdown for the steam generator repairs. See also Supplemental Submission, p. 2, n. 2. However, such operation does not require amendment of the Turkey Point operating licenses, and that issue is therefore outside the scope of this proceeding. See Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), ALAB-245, 8 AEC 873, 875 (1974).

The Supplemental Submission nowhere indicates whether it takes issue with any of the bases for the conclusions reached in the SER or even whether it actually does challenge those conclusions. Consequently it fails to frame any specific issue concerning compliance with 10 CFR Part 20. That failure makes it impossible to conclude that there is any likelihood that Petitioner will contribute to developing a sound record with respect to such an issue. However, to the extent discernible, Petitioner's concerns as to occupational radiation exposure seem to relate to something other than 10 CFR Part 20. Petitioner seems to be contending that "a 500 man-rem limit" of some kind should be imposed. Yet here too, Petitioner fails to frame an issue. The sole explanation of the limit sought is the reference to Professor Morgan's article, but the article refers only to a man-rem limit on normal operations. The suggestion is not made in a context which could refer to the repair operation here involved.[3/]

To date, the man-rem concept has been used only for the purpose of predicting or estimating collective radiological impacts upon some population group: e.g., employees of a

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3/ The article (p. 21) suggests that a

> limit of 500 man rem per 1000 megawatt (electrical) years might be set for presently operating plants and those under construction, and 200 man rem per 1000 megawatt (electrical) years for plants now on the design board.

plant or residents of a specific geographical area. It has been used by the NRC as a means of measuring environmental impacts and not as a limit upon an activity or operation. The NRC ordinarily protects against radiation by limiting the exposure of individuals in terms of rems. Thus limits on radiological exposures of persons within an "exclusion area" or a "low population zone" are imposed in 10 CFR Part 100 in terms of maximum individual exposures measured by rems. The limits on occupational exposures imposed by 10 CFR Part 20 also apply only to individuals in terms of rems. In addition, in 1976 10 CFR Part 50 Appendix I was amended to impose numerical limits on radiological releases to the general population from normal plant operations. However, this was done "only after a number of years of consideration and a lengthy rule making hearing . . . ." Florida Power & Light Company (St. Lucie Nuclear Power Project, Unit No. 2) 5 NRC 1038, 1063 (1977), aff'd ALAB-435, 6 NRC 541 (1977), aff'd Hodder v. NRC, (Nos. 76-1709, 78-1149) D.C. Cir. December 26, 1978[4/]

Although the Supplemental Submission fails so to indicate, the Licensing Board in the St. Lucie 2 proceeding heard a substantial amount of evidence on the question

4/ A petition for writ of certiorari is pending before the Supreme Court. Neither that petition nor any of the administrative or judicial appeals from the decision of the Licensing Board challenged that body's findings or conclusions with respect to occupational exposures.

whether a man-rem limit should be imposed on the normal operation of the plant there involved. The Licensing Board explained that, in part in response to testimony of Professor Morgan, it first imposed a 75 man-rem guideline dose limit for occupational exposures in a partial initial decision. In response to a motion for reconsideration, it cancelled that action but directed that further evidence on the matter be submitted. 5 NRC at 1060-1061 Thereafter, extensive hearings were conducted. 5 NRC at 1061-1064 As a result, the Licensing Board concluded:

> Based on consideration of the extensive record on this matter, the Board concludes that it is not feasible at this time to set an in-plant occupational guideline dose limit in man-rems/year as a condition of the construction permit for St. Lucie Unit No. 2 as an incentive to the Applicant to meet the Commission's criteria of keeping occupational doses as low as is reasonably achievable. The man-rem estimate is intended as a tool for comparison with other environmental impacts in the FES. Any particular value would not be specific to any plant or situation in any given year. . . .

5 NRC at 1064

If the Supplemental Submission intends to suggest that this Board should reconsider the question of imposing a man-rem limit on normal operation, as the Morgan article suggests, it wholly fails to indicate why the findings of the St. Lucie Licensing Board should be reexamined. If, on the other hand, the Supplemental Submission intends to suggest that a man-rem limit should only be imposed on the repair operation it fails to indicate why what has been found not to be feasible for normal operations is feasible for a repair project.

In sum, the regulations of the Commission do not now provide for the imposition of man-rem limits upon occupational activities.[5/] It cannot be determined that a significant contribution to the record with respect to such a radical change could be made by a petitioner who seems to be wholly unaware of both the basic pattern of existing regulation and the record with respect to recent consideration and rejection of a similar proposal.

B. Other radiation exposure.

Apparently in a hearing, Petitioner would also address radiation releases resulting from the storage of steam generators upon an "earthen floor" (pp. 2, 4) and from strong winds and tides surging over the cooling canal system and escape from the canals. (pp. 2, 3) Miscellaneous other matters might also be explored. (p. 6) However, beyond these generalities the bases for the concerns are not specified; and, again, the Supplemental Submission does not

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5/ To do so would, we submit, constitute a deviation from the regulations which this Board could not require in the absence of an exception granted by the Commission under 10 CFR § 2.758.

indicate that the relevant available material has been examined and with what part of that material, if any, issue is taken.

1. <u>Storage of the steam generator lower assemblies</u>.

The Supplemental Submission expresses a concern for "the long-term on-site storage of steam generator lower assemblies in an earthen floor facility" and "the integrity of the stored steam generator seals . . ." and the possibility of "leakage upon the earthen floor . . ." releasing radioactivity to the environment. (pp. 2, 4)

Nevertheless, except for the reference to the "earthen floor," the Supplemental Submission nowhere indicates why the planned storage scheme is inadequate. FPL's plans for steam generator storage are described in Sections 3.4 and 8 and Appendix D of the SGRR. The storage building performs the primary functions of shielding, weather protection and control of access to the steam generators. All openings to the interior of the steam generator will be welded shut in order to avoid releases of radioactivity within the storage building. (SGRR, Sections 3.4.2, 3.4.6, Appendix D, p. D-1-1) The continued integrity of these welds will be assured by a periodic monitoring program as described in Section 3.4.6 and Appendix D, p. D-2-1 of the SGRR. Thus, the steam generator itself will perform the function of radioactivity containment.

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The external surfaces of the steam generators will be decontaminated, if required, to acceptable levels. (SGRR, Appendix D, p. D-3-1) Finally, Section 3.4.7 of the SGRR reports that the majority of the radioactivity associated with the steam generator lower sections is found on the inside surfaces of the primary side of the steam generator in a "protective corrosive film of metal oxides which is very adherent and very refractory." Consequently, as stated in Section 3.4.6, "the radioactivity within the steam generators is immobile . . ." and the release of such radioactivity is "unlikely."

These plans for on-site steam generator storage were reviewed and evaluated by the NRC and the results reported in Section 2.6.6 of the SER, which concluded that the use of the on-site storage facility, including the earthen floor 6/ "is in accordance with ALARA philosophy." (p. 2-16)

Thus Petitioner has had available technical information which describes a number of measures which will be taken to avoid radioactive releases. The sealed steam generator will prevent leakage; the radioactivity will be "adherent," and "immobile"; its release is therefore "unlikely"; water accumulation is unlikely; and there will be an effective monitoring program. Petitioner fails either

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6/ With respect to that floor the SER states: "No water accumulation is expected since the roof is watertight and the generators will be drained prior to storage." § 2.6, p. 2-16 to refer to or to take serious issue with these measures. The judgment that he is likely to make a significant contribution to the record with respect to this matter cannot be made.

2. The cooling canals.

The Supplemental Submission expresses a concern about the "escape of radioactive material from . . . the cooling canals . . .", and refers to "strong winds and tides surging over the cooling canal system . . ." (p. 4) and the dangers caused by such tides and hurricanes (p. 3). Accordingly, the Supplemental Submission indicates that at a hearing evidence would be submitted concerning a liquid radioactive pathway emanating from the cooling canals.

The suggestion seems to ignore the basic fact that the present Turkey Point operating licenses limit all radiological releases, including any releases to the cooling canal system, in accordance with applicable NRC regulations. In other words, protection against such liquid releases is effected prior to discharges from the plant to the canals and the canals are no part of the protective system.7/

7/ The cooling canal system is a closed system in accordance with a 1971 Final Judgment of the United States District Court for the Southern District. It is readily apparent from a review of this judgment that that system was required to be closed because of the thermal effects on Biscayne Bay and Card Sound, and not because of any radiological considerations. See Final Judgment in United States of America v. Florida Power & Light Company, Civil Action No. 70-328-CA, S. D. Fla. September 10, 1971. The Final Judgment is reproduced as Appendix C of the 1972 Turkey Point Final Environmental Statement (FES).

Liquid radioactive releases from the plant, both during normal operation and the planned steam generator repair are controlled by Appendix A of the Turkey Point Operating Licenses (Technical Specifications, Section 3.9) as well as by written procedures. Both quantity and concentrations are controlled. The releases are required to and do meet the restrictions imposed by 10 CFR Part 20 and Part 50, Appendix I, and those requirements are met whether or not some of the contents of the canal somehow reach Card Sound or Biscayne Bay.[8/]

In short, the existing regulatory documents disclose that radioactive releases from the plant to the cooling canals are so limited and controlled that further discharges from the canals into another body of water is acceptable from a radiological point of view. For this reason the question whether there will be such discharges as a result of storms or hurricanes is irrelevant.

This conclusion becomes even more significant since it was made in relation to normal operation. The SGRR (Section 3.4.5.4) and the SER (Section 2.6.4) disclose that radioactive releases during the repair efforts will be significantly less than during normal operation. See Tables 5.2-3 and 5.2-7 of the SGRR. For the foregoing reasons, the meteorological issues sought to be explored

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8/ The Supplement to the Turkey Point Environmertal Report (November 8, 1971, Section 2.3.7) and the FES (pp. V-26 to V-27) make it clear that such radioactivity as might be found in the canals is acceptable.

would not make a substantial contribution to the record. 9/

3. Other concerns.

The Supplemental Submission states (p. 6)

> . . . we are concerned about various inconsistencies in the licensee's position which have occurred throughout their submissions. Without belaboring the point, we note that Section 3.4.5.1(d) of the Steam Generator Repair Report says "90 days of radioactive decay assumed prior to cutting operations." Section 5.2.2.1(e) of the Report states "15 days of radioisotopic decay were assumed prior to cutting the reactor pipes." Which statement is accurate?

However, a careful reading of the SGRR discloses that the 90 days referred to in Section 3.4.5.1(d) is an estimate of the man-rem exposures associated with cutting up the

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9/ Footnote 2 on page 3 of the Supplemental Submission implies that, in analyzing the steam generator repair and subsequent storage of used lower assemblies, the licensee assumed only a 10.1 foot storm tide and that failure to consider more severe flooding constitutes a deficiency. This implication is not correct.

For the reasons discussed in the text above, storm tide height is irrelevant insofar as radiological releases are concerned. Flooding will not result in unanalyzed, impermissible discharges to the environment, and neither the SGRR nor the SER refers to a "10.1 foot storm tide." Such flooding is only mentioned as part of an historical discussion of storms contained in Section 2.6.6 of the Turkey Point Final Safety Analysis Report (FSAR). The design of plant safety systems, however, is based on a predicted maximum flood stage, resulting for the maximum probable hurricane of 18.3 feet MLW. See Supplement 13 to the Preliminary Safety Analysis Report, December 11, 1967; FSAR, p. 2.6-13.

steam generator for disposal off-site. It refers to an operation related to one ultimate disposal option. The 15 days of decay referred to in Section 5.2.2.1(e) is associated with an entirely different operation--cutting the steam generators <u>from</u> the reactor coolant system. Thus, the different decay times are both correctly used to estimate exposures from different activities. There is no discrepancy; both statements are "accurate," and, we submit, this is not an issue concerning which the Petitioner is likely to assist in contributing to the record. Similarly, it cannot be assumed that he will make a contribution with respect to the "various inconsistencies" which he has failed to identify at all.

The foregoing review of the Supplemental Submission may be summarized as disclosing that Petitioner has enlisted two witnesses, Professors Morgan and Goldberg.[10/] However, the matters they will address are at best only generally related to proposed contentions.[11/] Moreover, despite the

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10/ Without explanation, no mention is made of Dr. Raymond McAllister who was characterized as a "firm" witness during the prehearing conference. (Tr. 67)

11/ In addition to the discussion above, see "NRC Staff Response to Board Order Relative to Petitioners Contentions," May 23, 1979, p. 3, where it is pointed out that most of the revised contentions submitted at the prehearing conference are inadmissible.

availability of both the SGRR and the SER, the Supplemental Submission hardly discusses those documents or the many specific matters they address. Other relevant publicly available material is also ignor d. Therefore nothing in the Supplemental Submission indicates that the Petitioner is likely to make a contribution to a hearing, should one be conducted.

II

Broadening the Issue and Delay

The foregoing discussion of the subjects Petitioner wishes to address makes it quite clear that grant of the petition for the purposes suggested in the Supplemental Submission would "broaden the issues" within the meaning of 10 CFR § 2.714(a)(1)(v). Assuming it could be done in accordance with 10 CFR § 2.758, consideration of the imposition of a "500 man-rem limit" would broaden the issues since such a limit is not part of the NRC's existing regulatory system. In addition, Petitioner appears to desire that meteorological issues be discussed in detail even though such discussion is not required for the reasons set forth above.

Grant of the petition will also substantially delay the proceeding. The first request for a hearing was submitted more than a year after the time to do so had expired and after an extensive review of the proposal by the NRC Staff was near completion. In its various pleadings, FPL has emphasized its need for flexibility in initiating the steam generator tube repairs and that the hearing requested by the Petitioner would create substantial delay and deprive it of needed flexibility in scheduling such repairs. 12/

Notwithstanding its statement to the contrary (p. 8), the Supplemental Submission confirms these concerns and indicates that grant of the petition to intervene will cause serious delay. Thus it states that Professor Morgan, Petitioner's radiological witness, "has international travel plans this summer." (p. 7, n. 4) Even if he did not, as is clear from the discussion above, imposition of a "500 man-rem limit" is not susceptible of expeditious treatment. We have noted that the suggestion represents a radical departure from existing regulatory practice. It, therefore, cannot be litigated in an abbreviated hearing. A similar proposal required the St. Lucie Unit No. 2 Licensing Board to consider an "extensive record on this matter . . . ." 5 NRC at 1064 Nor is it credible to assume that Petitioner, who "has not pursued the meteorological side of this case until counsel recommended it . . .," and

12/ See "Licensee's Response to Untimely Request for Hearing of Mark P. Oncavage," dated March 9, 1979; the attached affidavit of H. D. Mantz, dated March 8, 1979; and Tr. 77-78.

cannot now name witnesses (p. 3, n. 2) can prepare such a case without considerable additional delay. It is therefore clear that grant of the petition to intervene will both broaden the issues, unnecessarily, and delay the proceeding.

III

Remaining Factors

The remaining factors referred to in 10 CFR § 2.714... can be discussed briefly.

The second factor refers to the availability of other means of protecting the Petitioner's interests. If it is assumed, as the Supplemental Submission does (pp. 6-7), that the requested hearing is the only means by which the Petitioner's interests could be protected, then that factor must be decided in his favor--the only one which could be so decided. However, the factor must be appraised in the light of the contentions which have been made. As pointed out above, the principal contentions are either inadmissible or, at best, inappropriate for consideration in the requested hearing.[13/]

13/ The Supplemental Submission (pp. 6-8) seems to suggest that Petitioner has some kind of due process right to the requested hearing. This is simply incorrect. With irrelevant exceptions, publication in the Federal Register is notice "to all persons residing within the States of the Union . . . 44 U.S.C. § 1508. It is well established that all that due process requires is notice of the opportunity to be heard; publication in the Federal Register satisfies this requirement; and the denial of a nontimely intervention does not constitute denial of due process. North American Pharm., Inc. v. HEW, 491 F.2d 546 (8th Cir. 1973); Buckner Trucking, Inc. v. U.S., 351 F. Supp. 1210 (S.D. Tex 1973) In situations such as are here involved, administrative agencies, including the NRC, have broad discretion to deny a hearing. Dunlop v. Bachowski, 421 U.S. 560 (1975); People of Illinois v. NRC, 591 F.2d 12 (7th Cir. 1979).

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It is our view that the fourth factor, the extent to which the Petitioner will be represented by existing parties, is not relevant here. This factor presumably refers to a situation in which a hearing is being conducted and other parties "exist."

Finally, it must be reemphasized that Petitioner's request for a hearing was over one year late, and despite repeated opportunities, he has never been able to make any showing of good cause for his untimeliness. See, e.g., Licensee's Response to Untimely Request for Hearing of Mark P. Oncavage (Mar. 9, 1979); NRC Staff Response for Leave to Intervene Filed by Mark P. Oncavage (Mar. 1, 1979). Consequently, Petitioner does not satisfy the first factor included in 10 CFR § 2.714(a)(1). In such circumstances, he has a heavier burden with respect to the other factors than he might otherwise. USERDA (Clinch River Breeder Reactor Plant), ALAB-354, 4 NRC 383 (1976); Virginia Electric and Power Co. (North Anna Nuclear Power Station, Units 1 and 2), ALAB-289, 2 NRC 395, 398 (1975).

IV

Conclusion

Since February of this year, Petitioner has been afforded liberal opportunities to establish that the balance of factors set forth in 10 CFR § 2.714(a) favor grant of his extremely late petition to intervene. He has wholly failed to do so. In particular, the three most significant factors weigh heavily against him. He has not demonstrated good cause for his extreme lateness; he has not established that he is likely to assist in developing a sound record; and it is clear that grant of his petition will both broaden the issues and delay the proceeding. Therefore, we submit, the petition to intervene should be denied.

Respectfully submitted,

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Dated: June 20, 1979

Attachment

POOR ORIGINAL

How dangerous is low-level radiation?

The risks of developing cancer because of exposure to low doses of ionising radiation are much greater than once thought. But this need not restrict the future of the nuclear industry—the medical profession is responsible for 90 per cent of man-made radiation to which people are exposed.

Professor Karl Z. Morgan is Neely professor in the School of Nuclear Engineering at the Georgia Institute of Technology, Atlanta

In the first years of the "atomic age" many scientists accepted the theory that there is a safe level of exposure to ionising radiation, and that so long as a person does not exceed this threshold level no harm will result as any radiation damage will, on the average, be repaired as fast as it is produced. From 1960 to the present, an overwhelming amount of data has accumulated to show that there is no safe level of exposure and there is no dose of radiation so low that the risk of a malignancy is zero. Therefore, the question is not: "Is there a risk from low-level exposure?" or, "What is a safe level of exposure?" The question is: "How great is this risk?" or, "How great may a particular radiation risk be before it exceeds the expected benefits, such as those from medical radiography or nuclear power?"

At least for some types of radiation damage and for some kinds of radiation exposure (especially from X, gamma and beta radiations) there is some repair of the radiation damage going on in the body. The diehards for the threshold hypothesis, however, do not seem willing or able to accept the evidence that for man there is never a complete repair of the radiation damage. Even at very low exposure levels there are many thousands of interactions of the radiation with the cells of the human body. For example, the relatively small dose of one rad of X-rays of 1 million electron volts corresponds to 2·2 billion photons per square centimetre acting on the body. It is inconceivable that all the billions of irradiated and damaged cells would be repaired completely or replaced.

The most significant damage from low-level exposure to radiation results from the direct interaction of the stream of ions produced by radiation with the nucleus of one of the billions of irradiated cells. The cell may be killed, the radiation may produce no damage, or such damage as is caused may be repaired. But it is a fourth possibility that concerns us: that the cell nucleus may be damaged but the cell survives and multiplies producing, over a period of years, a clone of cells that is diagnosed as a malignancy.

It seems obvious that if the cell nucleus is damaged and some information is lost or if a similar series of events leads to the development of a malignancy, there can be no dose so low that the risk is zero. Thus the risk of induction of cancer from radiation increases more or less with the increase or accumulation of exposure. The risk is simply one of chance, just the same as the risk of an accident every time a trip is made in a taxi.

It is also evident that all persons do not run the same risk of developing a malignancy from a given radiation exposure and that the risk of some types of cancer is greater for certain people than it is for others. The final onset of a malignancy or other disease may require a series of events. For example, a given type of leukaemia may require as many as three successive events (like throwing three electrical switches connected in series). Some of these switches may be thrown by viruses, bacteria, chemicals, mechanical damage or radiation.

Studies by Irwin Bross, of the Roswell Park Memorial Institute in New York, support this hypothesis of a series of switches in disease processes and suggest that there may be interactions (synergisms) between the events in the series. Bross has shown, for example, that children under four with allergic diseases such as asthma or hives have a 300 to 400 per cent increased risk of dying of leukaemia compared with other children. Allergic diseases throw one switch. Children who were exposed to diagnostic X-rays in the womb have a 40 to 50 per cent increase in risk of dying from leukaemia. But children with two switches thrown (that is, *in-utero* exposure and later allergic disease) have a 5000 per cent increase in risk of dying from leukaemia.

Thus, because of genetic inheritance, various diseases, age, sex, eating and smoking habits and, perhaps many other individual characteristics, certain members of the general population have a higher risk of radiation-induced malignancies than others.

The cancer risk from exposure to ionising radiation is much greater than was thought to be the case some years ago. Following the deaths of the Japanese survivors of Hiroshima and Nagasaki from radiation sickness, many scientists believed that the only principal chronic risk from radiation exposure was an excess of cases of leukaemia, which reached a peak about six years after the bombing and then slowly declined. Unfortunately as the study of these survivors continued, other forms of cancer (bone, breast, lung, salivary gland, prostate, thyroid and so on) showed a significant increase. With the passage of time we will probably find that this exposure has resulted in an increase in many or most kinds of malignancies that are common among human populations.

Until 1960 almost everyone assumed that the genetic risk from low-level radiation exposure far exceeded the risks of chronic somatic damage such as cancer. But it has become increasingly clear that this assumption may be unwarranted. In 1971 the International Commission on Radiological Protection (ICRP) concluded that: "the ratio of somatic to genetic effects after a given exposure is 60 times greater than was thought 15 years ago". Most of us now recognise that the risk of inducing cancer at low doses of radiation is far greater than we once thought and may be as great or greater than genetic risk.

No safety factor

Much of what has been said about the risks of exposure to low levels of ionising radiation would have considerably less weight if it could be shown that the linear hypothesis (which predicts that dose and effect are directly related) provides a very large safety margin at low doses and dose rates. Unfortunately, in most cases of human exposure there is no evidence of a safety factor at low doses, if we assume that the linear relationship between radiation and cancer at high doses also applies at low doses.

We have a large amount of data—much of them human—showing a statistically significant increase in malignancies as a consequence of exposure to low doses of ionising radiation and indicating that the number of malignancies increases progressively as the dose accumulates. These doses in some cases are considerably lower than the present levels of maximum annual exposure permitted for the radiation worker. Indeed in some cases the data show that the linear hypothesis actually underestimates the risk.

Table 1 indicates the magnitude of the cancer risk and shows that this risk falls linearly with decreasing dose down to a very low value. These low doses (0·1 to 6·5 rad)

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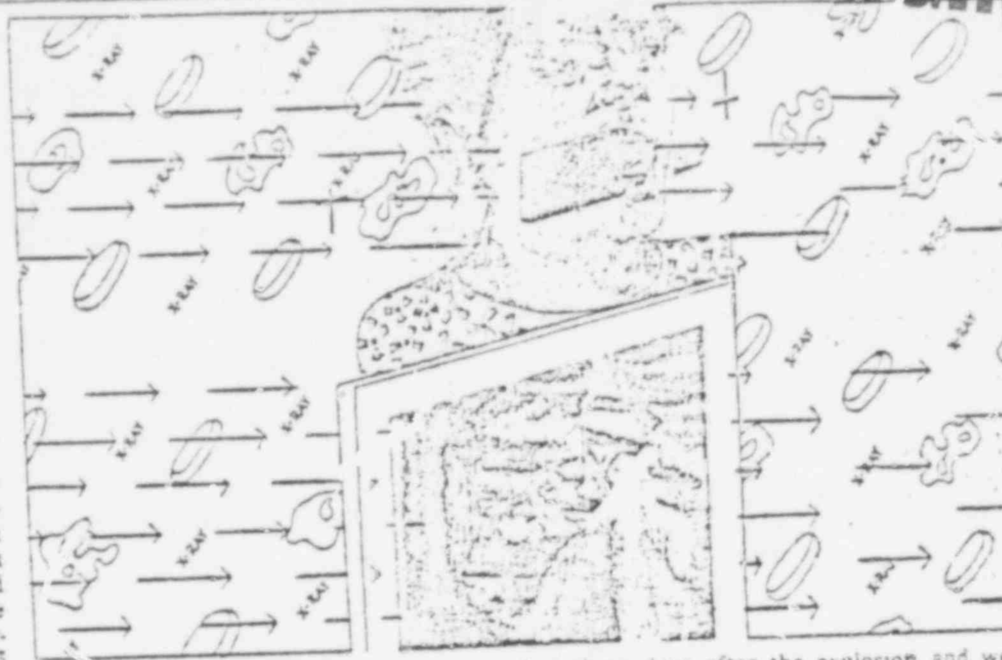

are not doses below which the linear hypothesis breaks down, but the lowest points on the human exposure curves for the two malignancies considered here—leukaemia and thyroid cancer. We have every reason to believe that the linearity of these curves continues down to zero dose and that there is a similar linearity for other types of cancer that simply have a longer incubation period or have not been studied over such a wide range of doses to a human population. A dose of 0·8 rad is only 2 per cent of the 42 rad permitted by the International Commission on Radiological Protection (ICRP) to be accumulated each year in the act. e bone marrow of a radiation worker. And 6·5 rad is only 13 per cent of the 50 rad permitted each year to his thyroid.

If a million children each received 1 rad from exposure in the womb to X-rays we might expect 300 to 3000 leukaemias. Less data are available on the effects of low-level exposure of adults than of children. But recent observations by Thomas Mancuso and others on workers at the Hanford reprocessing plant in the US (*Health Physics*, vol 33, p 369) indicate that the risk of radiation-induced malignancies other than leukaemia may be as great or greater for adults than for children (perhaps as high as 7 cancers for every 1000 people exposed to 1 rem). Furthermore, other studies (Alice Stewart and George Kneale, *Lancet*, 1970, vol 2, p 1185) indicate that the incidence of focal cancers (such as central nervous system tumours) following *in-utero* exposure is about the same as the incidence of leukaemia. So the total number of fatal malignancies might be twice the number of leukaemias given in Table 1—600 to 6000 cancers for a million children exposed to only 1 rad.

Data on the survivors of the atomic bombings who were exposed *in utero* seem not to support these conclusions. On the basis of Stewart and Kneale's findings and the linear hypothesis, we should expect 36·9 excess cancers among atomic bomb survivors during the 10 years following exposure, but only one case of liver cancer was reported. As a consequence many people were quick to proclaim that there was something wrong with the retrospective studies of cancer induction by *in-utero* X-rays as reported by Stewart, M. MacMahon and others and that we could relax about radiation-induced cancer. Unfortunately, this is not the case. There is little doubt that the Japanese studies greatly underestimate this cancer risk. The fetuses which were most likely to have developed into cases of radiation-induced leukaemias received such high doses and were subject to so much trauma that they failed to survive. In fact, an unusually high incidence of abortions and high rate of infant mortality followed the atomic bombings.

Professor Joseph Rotblat recently confirmed the above explanation of why the cancer risk as determined from survivors of Hiroshima and Nagasaki atomic bombings is too low (*New Scientist*, vol 75, p 475). He compared the cancer risk in two groups: one that entered Hiroshima during the first three days after the explosion and were exposed to the residual neutron-induced activity and radioactive contamination from the fallout; and the other group that entered Hiroshima at a later date and received negligible radiation exposure. Neither of these groups was subjected to the trauma of blast, fire, burial under debris and so on. The leukaemia risk to the first group exposed to residual radiation was $1{\cdot}6\times10^{-4}$ leukaemias per person rad. This value for adults is in agreement with the leukaemia risk estimate in Table 1 of 3×10^{-4} which applies to children that received *in-utero* exposure from medical diagnostic X-rays. Rotblat points out that this risk estimate is eight times the estimate of ICRP.

Estimates of the risk of cancer associated with exposure to radiation at the Hanford plant have created considerable controversy. The average radiation dose of the 442 Hanford workers who died of cancer between 1944 and 1972 was only about 1 rem. Mancuso, Stewart and Kneale estimate that only 6 to 7 per cent of the cancer deaths (25 to 31 cancers) were induced by this radiation. The total number of deaths in the study group was 3520 so their cancer risk was 7 to 8×10^{-4} or about 10 to 25 times the commonly accepted total risk of radiation-induced malignances. I believe that the controversy about these findings developed because many people in the nuclear industry and in US Federal Agencies have been inadvisably proclaiming

Table 1: cancer risks and known range of linearity

Linearity of dose down to	Risk per person per rad	Source of dose
<10 rad	$0{\cdot}3$—$1{\cdot}0\times10^{-4}$** $0{\cdot}5$—$1{\cdot}7\times10^{-4}$***	Hiroshima and Nagasaki atom bomb survivors
270 rad	$0{\cdot}2$—$0{\cdot}3\times10^{-4}$*	arthritis of spine (ankylosing spondylitis) patients
$0{\cdot}2$—$0{\cdot}8$ rad	3×10^{-4}** 6×10^{-4}***	pelvimetry exposures
about $1{\cdot}0$ rad	3—10×10^{-4}*	pelvimetry exposures
20 rad	$0{\cdot}5$—$1{\cdot}1\times10^{-4}$***	X-ray therapy
$6{\cdot}5$ rad	$1{\cdot}2\times10^{-4}$***	X-ray therapy for ringworm (Tinea capitis)

* risk of leukaemia
** total risk of cancer
*** risk of thyroid cancer

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Keystone

Nagasaki: cancer rates among survivors are unreliable

that there is no radiation risk at low doses. If the proponents of nuclear energy had been more reasonable in their claims about radiation safety, they would not now be trying desperately to save face.

Radiation biologists have conducted thousands of experiments with various types of animals in order to determine the dose-effect relationships of radiation and in many cases have extrapolated these data to man (perhaps brazenly or at best with some misgivings). Some ecologists and health physicists have warned that much of this animal data may not be applicable to man for many reasons.

- The dose response of various kinds of animals can differ by orders of magnitude in going from one species to another (for example, fly to fish to mouse to monkey to man).
- Even slight differences in species or strains can cause a marked change in dose response. For example, there are very large differences in leukaemia induction and in life shortening between studies with different kinds of mice. Yet, the standards are based on observations of carefully controlled inbred, healthy animals. But man is a wild or heterogeneous animal living in many types of environment with various eating and drug habits, with many diseases and eccentricities, of various ages, and so on.

It is little consolation to a mother to know that the average risk to the persons living in her community is 3×10^{-4} cancers per man rem (or 0·003 per cent) from an environmental dose of 100 millirem accumulated over a 10-year period from a nuclear power plant when she learns that in fact her child with asthma has a risk of 50 times this (0·15 per cent chance) of developing cancer. It helps very little to tell the mother that natural background radiation is 100 millirem each year and this gives her child a 1·5 per cent risk of radiation-induced cancer over the same 10-year period. Neither does it help to tell her that if a coal-burning power plant (even an unusually clean one) were to replace the nuclear power plant, the risk from the power plant probably would go up from 0·15 to 5 per cent and the primary risk would then become one of chronic bronchitis and emphysema rather than cancer. It is difficult for this mother to understand why she should risk the life of her child so that the power plant can be located at a particular river site or, as she may rationalise, so the stockholders can expect a better return to their investments.

Many see the solution to this problem in reducing levels of maximum permissible exposure (MPE) for occupational workers and for the public by a factor of 10. A number of citizens' organisations in the US have petitioned safety agencies asking for such reductions. However, although sympathetic, I am not convinced this would be an acceptable solution: it seems like putting a finger in the hole of a leaking dyke. I see it this way primarily for three reasons:

First, our goal should be a radiation exposure that approaches zero and especially one that reduces the population dose (man × rem dose) as low as reasonably achievable (ALARA). This is partly a matter of education and acceptance of moral obligation by those responsible for human exposure.

Secondly, the real culprit for unnecessary population dose is not the nuclear industry but rather the medical profession.

Thirdly, a smaller reduction of occupational maximum permissible exposure—for example, from 5 rem per year to 2·5 rem per year rather than a reduction to 0·5 rem per year—probably could be accomplished without threatening the option of nuclear power.

There have been examples (in the US at least) of wanton disregard of the ALARA principle. I am very much concerned, for example, about the growing practice of "burning out" temporary employees: the fact that many nuclear power plants are finding it necessary to solve the individual exposure problem of repair work in persistently high radiation exposure areas of the plant by hiring temporary employees to spread out the dose on "hot" operations. This has increased the man rem dose and thus the overall cancer and genetic risks to the population and I believe this is exactly what we should strive to avoid.

I cannot be certain of the effect of the proposal in the US by a number of citizen's groups and scientists to lower the occupational maximum permissible exposure (MPE) to 10 per cent of its present level (that is, down to 0·5 rem per year). Certainly, it would reduce individual exposure levels; but I fear in many instances it would just mean the hiring of more people, each to receive small doses of less than 0·5 rem per year with a marked increase in the total man rem dose. The man rem dose would increase for the same radiation job because inexperienced persons always get more exposure and much of the exposure on a "hot" job is received going into and away from the hot operation.

Medical X-rays

The second reason for my hesitation on solving this problem by simply lowering the occupational MPE to 0·5 rem per year is because at present the medical professions are exempt from the recommendations suggested by the ICRP for the maximum permissible exposure from ionising radiation—even though they are delivering over 90 per cent of the man-made dose. The dose delivered by medical diagnostic X-rays could be reduced to 10 per cent of its present value, at the same time increasing the quality and amount of diagnostic information from medical radiography. Those who are responsible for over 90 per cent of the man-made dose from ionising radiation ignore almost completely the principle of ALARA.

When we have stopped unnecessary medical exposure to ionising radiations, which is [illegible] per cent of the [illegible]

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lem, then perhaps. I can see that the next step might be to reduce the maximum permissible exposure to 0·5 rem per year for workers and to reduce the corresponding value for members of the population at large. A reduction of only 1 per cent in unnecessary diagnostic exposures in the United States would reduce the population dose of man-made sources of radiation more than the elimination of the nuclear power industry to the year 2000.

There should be some tightening of the measures to reduce occupational exposures in the nuclear power plants that are now in operation; but the major effort should be with those power plants that are now in the design stage. The US Nuclear Regulatory Commission took the bold and commendable step of setting the dollar cost of the man rem at $1000 at a time when ICRP was suggesting a value as low as $10 per man rem. Although most of us probably recoil from the thought of setting a monetary value on a human life, in the practical world we must recognise that there may be no other alternative. Using an overall risk coefficient of 6×10^{-4} cancers per man rem, $1000 per man rem corresponds to $1·7 million per cancer. To put it bluntly, a nuclear plant should spend as much as $1·7 million to prevent an employee from developing cancer.

One of the most unfortunate recent developments in the setting of standards for exposures to ionising radiation is a recommendation of the ICRP published in 1977. ICRP's report recommended weighting factors for calculating maximum permissible doses to various organs, which I interpret may result in large increases in the present ICRP values of maximum permissible exposure (MPE) and in all values of total body burden and maximum permissible concentrations (MPC) of radionuclides in air, water and food, except where they are rather uniformly distributed throughout the body.

I consider this report from the commission a retrograde step because it comes at a time when ICRP's internal reports emphasise that the cancer risk is many times what we considered it to be 15 years ago.

In conclusion I suggest the following actions:

- Reject proposals to reduce the maximum permissible exposure by a factor of 10: but consider the possibility of reducing it by a factor of two.
- Consider the feasibility of reducing the maximum permissible exposure by a factor of 10 at some later date if it can be shown that all unnecessary exposure (especially medical) can be reduced and that there will be a net benefit to mankind by such action.
- Take immediate measures to reduce the man rem dose. This could be accomplished in several ways. For example, in the nuclear energy industry a limit of 500 man rem per 1000 megawatt (electrical) years might be set for presently operating plants and those under construction, and 200 man rem per 1000 megawatt (electrical) years for plants now on the design board.
- Take bold steps to reduce unnecessary exposure from medical sources of ionising radiation.
- Apply the principle of ALARA—as low as reasonably achievable—in all areas of exposure to ionising radiation and apply it to all hazardous agents, including, for example, non-ionising as well as ionising radiation, and chemical agents.
- In making the choice of fuel for a central power station consider all the risks and all the advantages of each type of fuel. In this evaluation keep in mind that exposure to ionising radiation is only one of the risks and in many instances the risks of chemical exposure may be far greater than those of radiation.
- Give adequate support to research programmes designed to define more accurately the risks from human exposure to ionising radiation. □

Jupiter's enigmatic variations

The latest spacecraft to visit the Jovian system has discovered features as diverse as volcanoes on one moon and ripples of ice on another

A sequence of views of the moon Io: Left Io (about the size of Earth's Moon) passing the Great Red Spot on 13 February, when Voyager I was 20 million km distant. The other moon visible here is Europa. Centre A closer view on 4 March from a range of 800 000 km. Right One of Io's active volcanoes throwing material more than 100 km above the moon's surface

Dr Christine Sutton The success of the Voyager 1 mission to Jupiter is clear from the superb pictures sent back to NASA's Jet Propulsion Laboratory over a distance of 800 million kilometres. These pictures produced a state of euphoric delight among the sober scientists at JPL when, after a journey lasting 18 months, Voyager 1 passed within 280 000 km of the swirling cloud tops of the largest planet in our Solar System at around noon GMT on 5 March (*New Scientist*, vol 75, p 400). And, thanks to colour TV, many non-scientists around the world were also able to view the awesome coloured whirlpools of Jupiter's atmosphere, in pictures likened by some viewers to J. M. W. Turner's paintings.

But the beauty of the pictures is only the icing on the cake as far as the JPL team is concerned. The scientific results from the mission are equally spectacular, revealing many unexpected aspects of the Jovian system, including the moons. Dr Gary Hunt, from University College, London, was the only UK scientist at JPL during the close fly-by, and he has sent back news of some of the discoveries which have left him elated by the success of the mission.

Clearly, the atmosphere and magnetosphere of Jupiter are highly energetic. As Voyager approached Jupiter, on 27 February when still more than 6 million km away, its

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY & LICENSING BOARD

In the Matter of	) Docket Nos. 50-250-SP
	) 50-251-SP
FLORIDA POWER & LIGHT COMPANY	)
	) (Proposed Amendments to Facility
(Turkey Point Nuclear Generating	) Operating License to Permit
Units Nos. 3 and 4)	) Steam Generator Repair)

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that copies of the attached "Licensee's Response to 'Supplemental Submission of Petitioner Mark P. Oncavage,'" captioned in the above matter, together with the attachment thereto, were served on the following by deposit in the United States mail, first class, properly stamped and addressed, this 20th day of June, 1979.

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Dated: June 20, 1979

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