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DESCRIPTION:
Ltr re discussion w/DRL regarding Proposed Appendix I to 10CFR50...trans the following:

DIST: Per W. Butler

PLANT NAMES: Duane Arnold

ENCLOSURES:
ATTACHEMTN I - Comments on Proposed Appendix I to 10CFR50.

ACKNOWLEDGED

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50-331

Regulatory File Cy.

January 16, 1973
IE-73-810

RECEIVED JAN 23 1973

Mr. Roger S. Boyd
Assistant Director for Boiling Water Reactors
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Re: Duane Arnold Energy Center #1
Subject: Proposed Appendix I
Files: A-104, A-116

Dear Mr. Boyd:

As a result of several discussions with the Regulatory Staff concerning the Duane Arnold Energy Center regarding the proposed Appendix I, this letter is submitted to document our response to the staff's position.

Based on the attached analysis (Attachment 1) the applicant is confident that gaseous effluent discharges from the DAEC will be "as low as practicable" and consistent with proposed Appendix I to 10 CFR Part 50.

Nevertheless, the applicant understands that if one were to use the staff's standard source terms, dose calculation methods and site meteorology assumptions, without allowance for reduction factors which the applicant believes will be demonstrated in actual plant operation, the resulting calculated dose would exceed the suggested guidelines of proposed Appendix I.

Accordingly, the applicant takes the commitment to submit for the staff's review by March 1, alternative design modifications which may be necessary to reduce gaseous effluents to a level consistent with the above proposed rulemaking together with the costs and dose reduction factors associated with each alternative. At the same time, the applicant will identify such reduction factors as may be appropriate in evaluating the efficacy of these design modifications; these reduction factors will be quantified and will be submitted for review by the regulatory staff together with suitable substantiation and documentation. Among others, reduction factors in addition to annual grazing fraction which, in the applicant's current thinking, are appropriate include: (1) use of actual meteorology at the DAEC site applicable to an elevated release of gaseous effluents during periods of light windspeeds (2) recognition of the fact that essentially all of the source term is attributable to the venting of lower turbine building air (i.e., air at an elevation less than 15 feet above the operating floor of the turbine building and all air below the floor) (3) recognition of the fact that radioiodine depletion from the plume exists due to intermediate ground deposition and that measured ventilation releases at operating BWR's are substantially lower than the values currently being used by the staff (4) recognition of the fact that pastured animals receive a portion of their daily food intake from non-pasture source. In any event, as noted above all such reduction factors will be identified and substantiated as part of the applicant's submission of design modifications.

In the interim, the applicant will comply with the regulations applicable to plants such as the DAEC (10 CFR 50.36 a.) including the commitment to use and maintain presently installed radioactive waste treatment systems in order to keep releases to unrestricted areas "as low as practicable."

In addition, the applicant will conduct an environmental monitoring program, satisfactory to the regulatory staff, and designed to determine whether, in actual operation, the real child thyroid dose from the radioactive release from the DAEC via the milk cycle is inconsistent with the above mentioned guidelines. In the event that the aforementioned monitoring program shows that the above mentioned guidelines cannot be satisfied with the current design, applicant will proceed to install one of the design modifications discussed above or a suitable alternative (reviewed by the regulatory staff) in order to keep effluent discharges as "low as practicable." The installation of such equipment, components or design modifications will be completed not later than the first refueling outage following a determination that the above mentioned guidelines cannot be satisfied with the current design or, if impracticable, the second refueling outage following such a determination.

Very truly yours,

C. W. Sandford

C. W. Sandford
Vice President

JNW:CWS:bw

cc: Mr. Duane Arnold
Mr. Jack Newman

ATTACHMENT I

The following is a discussion of Iowa Electric's calculation of the I-131 thyroid exposure as a result of the consumption of cow's milk at the nearest dairy herd location at 2575 meters in the WNW sector.

The calculation is based upon the following relationship:

$$D = \frac{500 \cdot X/Q \cdot Q \cdot Fd \cdot Ff \cdot Fg}{1.42 \times 10^{-7}}$$

where

D = annual dose to a 2 gm thyroid gland due to ingestion of cows milk at the nearest dairy farm to the DAEC site: 2575 meters in the WNW sector.

X/Q = annual average atmospheric dilution factor - sec/M^3

Q = annual average ventilation system I-131 release rate - μc/sec.

Fd = Factor to account for annual dose reduction due to I-131 depletion in the effluent plume due to ground deposition.

Ff = Factor to account for annual dose reduction due to the fact that during grazing season the animal receives supplemental dietary intake such that only a fraction of the dietary requirement is derived from grass.

Fg = Factor to account for annual dose reduction corresponding to fraction of year in which animal is grazed.

1.42×10^{-7} = Controlling air concentration in μc/M^3 at the dairy herd location which would result in a thyroid dose of 500 mr due to milk ingestion. (Ref. 1)

Pertinent assumptions regarding each of the factors in the above relationship are discussed in the following pages.

METEOROLOGY

The annual average X/Q value at the nearest farm (2575 meters) was determined by calculating a X/Q value for each hour of the year using the one year of data from the DAEC meteorological tower and integrating to provide an annual average X/Q value. This X/Q value is based upon one year of DAEC on-site meteorological data and the utilization of the ventilation system meteorological model described in FSAR Section E.3.3.5, namely that aerodynamic downwash occurs for wind speeds greater than 3 meters/second with a release height of 0 meters. For wind speeds equal to or less than 3 meters/second a release height of 40 meters was used. This is a reasonable assumption since the vent stack efflux velocity of 10 meters/second results in considerable momentum such that the jet escapes the building cavity during light winds and therefore is not subject to downwash at these times. Qualitative justification for this approach is given by Figure 5.25 of "Meteorology and Atomic Energy" which shows that for an efflux velocity/wind speed ratio of 4 the jet discharge escapes the building cavity. The figure is based upon actual wind tunnel tests employing a rectangular building with rooftop vent. The resulting annual average X/Q at 2575 m using this model is 2.7×10^{-7} sec/M^3. It should be noted that no credit has been taken for plume rise due to jet momentum when wind speeds are less than 3 meters/second. If the Holland plume rise correlation (Ref. 2) were to be used in conjunction with the model outlined in FSAR Section E.3.3.5 to account for the momentum of the jet discharge the annual average X/Q value would drop to 7×10^{-8} sec/M^3. However, no credit was taken for this factor. An additional conservatism is the assumption that aerodynamic downwash results in a point source ground level release. In reality, the downwashed plume would diffuse from an initial volume source with subsequent further reduction in annual average X/Q value. However, no credit was taken for this volume source term. It is concluded that the annual average X/Q value at the nearest farm, uncorrected for depletion, of 2.7×10^{-7} sec/M^3 is realistic. It is noted that the AEC staff assumption regarding this matter is that aerodynamic downwash occurs every hour of the year.

BUILDING VENTILATION I-131 SOURCE TERM

Measurements have recently been made by the General Electric Company on two operating BWR's which are of the same generation plant as the DAEC. Included in the measurement program was the determination of the I-131 concentration in the ventilation effluent. At the time these measurements were taken the stack noble gas release rate was on the order of 100,000 μc/sec. The corresponding I-131 coolant activity varied between 0.004 and 0.008 μci/gm. Correlating the ventilation measurements with the coolant activity results in a ventilation/coolant concentration ratio of .69 μci/sec/ μci/gm.

Correlating the SJAE noble gas measurements and the turbine building ventilation noble gas measurements indicated a steam leak rate of 4-7 gpm. An examination of coolant activities from operating BWR's would indicate an average I-131 concentration of 0.005 μci/gm as being expected on an annual average basis.

Correlating the expected coolant concentrations with the previously mentioned ventilation measurements would result in a ventilation system I-131 release rate of .0035 μc/sec for DAEC.

The AEC staff has indicated that their theoretical calculation would indicate a turbine building I-131 release rate of 0.6 ci/yr which, considering a 85% plant capacity factor, is equivalent to a release rate of 0.022 μci/sec.

A comparison of the AEC theoretical value and the measured value from operating BWR's indicates a factor of 6 conservatism in the AEC calculation. The expected annual average value of .0035 μc/sec is utilized in the Iowa Electric calculation.

CLOUD DEPLETION

Historically, routine operational I-131 releases from BWR's have been well below Technical Specification and 10CFR20 limits. Since off-site concentrations were sufficiently below 10CFR20 limits and also since only elevated releases of I-131 were significant from a calculational viewpoint there has been little incentive in the past to take credit for I-131 depletion from an effluent release plume as a result of intermediate ground deposition between the release point and receptor location. However, with the advent of the numerical guidance suggested by proposed Appendix I, presently being imposed by the staff in the licensing of DAEC, cloud depletion is a phenomenon which is appropriate for consideration.

Chamberlain (Ref. 3) has defined the ratio of the deposition rate to the immediate ground level air concentration as the deposition velocity. This relationship can be stated as follows:

$$\omega = Vd\,\bar{X}$$

This is identical to the relationship used by Burnett (Ref. 1) in deriving the commonly referred to "factor of 700" traditionally used to quantify the I-131 concentration amplification through the air-grass-cow-milk chain. If $\bar{X}$ is expressed in terms of the generalized Gaussian diffusion formula, the downwind surface deposition is:

$$\omega = Vd \cdot \bar{X} = \frac{Vd \cdot Q_x'}{\pi \sigma_y \sigma_z \bar{u}} \exp\left[-\frac{1}{2}\left(\frac{y^2}{2\sigma_y^2} + \frac{h^2}{2\sigma_z^2}\right)\right]$$

where:

ω = deposition rate, amount of I-131 removed per unit time

Vd = deposition velocity m/sec

Q_x = depleted source strength at distance x, μc/sec

σ_y, σ_z = Standard deviation of distribution of material in the plume in the y and z directions, meters

$\bar{u}$ = average horizontal wind speed m/sec.

h = height of source above ground, m

$\bar{X}$ = average ground level air concentration $\mu c/m^3$

The depletion of the source per unit distance is given by:

$$\frac{\partial Q'_x}{\partial x} = \int_{-\infty}^{\infty} \omega \, dy$$

which can ultimately be expressed by equation 5.48 of "Meteorology and Atomic Energy" as follows:

$$\frac{Q'_x}{Q'_o} = \left[\exp \int_0^x \frac{dx}{\sigma_z \exp(h^2/2\sigma_z^2)} \right]^{-(2/\pi)^{1/2} V_d \bar{u}}$$

which can be used to compute the depletion fraction $\frac{Q'x}{Q'o}$ as a function of distance.

This equation was solved by means of a 200 step numerical integration for the farm of interest (2575 m) for each Pasquill stability category, a wind speed of 1 mps and a deposition velocity of .01 mps, and for both a 0 meter and 40 meter release height. The appropriate correction factor was then applied to each hourly X/Q value depending upon the unique Pasquill stability category and wind speed for that hour. This was repeated for each hour of the year to arrive at an annual depletion corrected X/Q value. The numerically integrated depletion correction value was corrected each hour for the unique wind speed associated with that hour of data. This was done to minimize computer time for the numerical integration. The velocity correction utilized:

$$\left(\frac{Q'_x}{Q'_o}\right)_2 = \left(\frac{Q'_x}{Q'_o}\right)_1^{\bar{u}_1 V d_2 / \bar{u}_2 V d_1}$$

which is equation 5.49 of "Meteorology and Atomic Energy".

A value of deposition velocity of 1 cm/sec was conservatively assumed for each hour to be consistent with the accepted derivation of the "factor of 700". This assumption underpredicts deposition at intermediate points and therefore overpredicts the annual average depletion corrected X/Q value at 2575 m since as indicated by Bryant (Ref. 4), for iodine vapor, the deposition velocity depends upon wind speed and increases with increasing wind speed. Since approximately 52% of all wind speeds at DAEC are in excess of 3 mps, deposition velocities would be greater than 1 cm/sec a substantial number of hours per year with the result that cloud depletion correction factors would yield even lower doses.

Bryant (Ref. 4) also indicates that "... the iodine-131 which is deposited on pasture is subject to a number of influences which determine how much is retained by the edible portion of the grass and for how long. The particle size of the condensation nuclei on which the iodine is absorbed, or its presence as vapor, determines the initial retention on the edible portion of the grass. Experimental evidence indicates that approximately 25 per cent of the total deposition may be taken to be the average amount retained on the edible portion." Reference 5 is the experimental basis referred to.

It is noted that the dose conversion factor $500/1.42 \times 10^{-7}$ $\mu c/M^3$ used in this analysis is based upon the assumption that 100% of the deposited I-131 adheres to the edible portion of the pasture grass vs. the 25% experimentally determined by Reference 5. Accordingly, an additional dose reduction factor of .25 is appropriate; however, at the present time Iowa Electric has not included this factor in its calculation.

The results of the calculations indicate that the annual average depletion corrected X/Q value at 2575 meters = 2.3×10^{-7} sec/M^3 for the FSAR building ventilation meteorological model. The resulting Fd = $\frac{2.3 \times 10^{-7} \text{ sec}/M^3}{2.7 \times 10^{-7} \text{ sec}/M^3} = .85$

This relatively small correction results because the building ventilation meteorology model employs a 40 m elevated release for wind speeds less than 3 mps. This has the effect of minimizing depletion during these hours. On the other hand if the staff assumption of 100% ground level release for building ventilation is considered, the corresponding Fd = $\frac{1.6 \times 10^{-7} \text{ sec}/M^3}{8.8 \times 10^{-7} \text{ sec}/M^3} = .18$

based upon the above described cloud depletion calculational method.

In the opinion of Iowa Electric, the application of depletion to the calculation at hand is appropriate since the same relationship used to arrive at the depletion correction factors are implicit in the calculation of deposition leading to the staff's own estimate of thyroid dose at this farm location.

GRAZING FRACTION

Initial interviews with the owner of the farm of interest in the WNW sector indicated an approximate 7-month period during which the animals were on pasture. Subsequent discussion indicates that a portion of this estimate was for periods when the cattle were being put out for exercise and/or at times when the pasture conditions were such that the bulk of the dietary intake was from stored hay and grain. Accordingly, a more realistic estimate of effective grazing days as opposed to days on pasture is 160 days. The grazing fraction $F_g = .44$

GRASS FRACTION

An investigation of feeding practices during the months that the animals are pastured has been conducted for the farm of interest in the WNW sector.

To assist in this investigation, interviews were held with the farm owner and statistics were obtained from the Iowa State University Extension Office, Ames, Iowa, based upon Iowa DHI (Dairy Herd Improvement) herds covering 22,000 farms and 464,000 cows. Based upon these statistics, the average Iowa cow weighs 1,200 lb. If it is assumed that a cow consumes 3% of body weight on a dry matter basis per day (Ref. 6) the daily food intake is 36.0 lbs. Since the animals are fed a grain ration regardless of pasturing, the daily grain intake must be subtracted from the total food intake to arrive at grass intake. The average Iowa cow consumes 4,200 lb. of grain annually or 11.5 lb. per day. The maximum daily grass intake would then be 24.5 lb/day. Stored hay is always available in the mangers at each milking, even when the cows have been on pasture. During dry spells when pasture growth is minimal, grass intake may drop to 1% (Ref. 6) of body weight on a dry matter basis. However, during periods of lush vegetative cover, little, if any, stored hay would be consumed. This would mean that during poor pasture conditions grass intake may be on the order of 12 lb. per day or Ff = .33. However, since the farm in question has not kept records on grazing season stored hay consumption, no attempt has been made at this time to take credit for this dietary intake. Accordingly, a grass intake fraction of .68 has been used in the calculation.

DOSE CONVERSION FACTOR

The controlling air concentration that yields a 500 mr child thyroid dose is 1.42×10^{-7} uc/M^3 based upon Burnett's derivation which is a factor of 700 below the environmental MPCa for I-131. References 7 and 8 indicate that measured values of air-grass-cow-milk factors at Hanford and Idaho are approximately 400 instead of the derived value of 700 traditionally used. However, Iowa Electric's calculation utilizes the value of $500/ 1.42 \times 10^{-7}$ for converting annual average air concentration to child thyroid dose.

In addition it should be pointed out that the dairy farm referred to in the calculation is a Class B Dairy, i.e., the milk product is not commercially distributed for direct liquid consumption, but rather for cheese, dried milk, etc. Accordingly, radioactive decay coupled with the fact that the farm in question produces only 1/3 of 1% of total output of the distributor renders the dose a negligible fraction of the Federal Radiation Council's guidelines for the average of suitable samples of an exposed group in the general population. However, for conservatism it has been assumed that family consumption of liquid milk at the Class B farm is possible. In addition, infant consumption of the liquid milk is conservatively assumed.

SUMMARY

Based upon the above assumptions, the following is the calculated child thyroid dose at the nearest dairy location:

$$D = \frac{500 \frac{mr}{yr} \times 2.7 \times 10^{-7} \frac{sec}{M^3} \times .0035 \frac{\mu c}{sec} \times .85 \times .68 \times .44}{1.42 \times 10^{-7} \frac{\mu c}{M^3}}$$

$$D = .846 \frac{mr}{yr}$$

It should be noted that if the current staff assumption of 100% aerodynamic downwash with point source ground level release is utilized the dose would be as follows:

$$D = \frac{500 \frac{mr}{yr} \times 8.8 \times 10^{-7} \frac{sec}{M^3} \times .0035 \frac{\mu c}{sec} \times .18 \times .68 \times .44}{1.42 \times 10^{-7} \frac{\mu c}{M^3}}$$

$D = .58$ mr/yr

REFERENCES

1. "A Derivation of the "Factor of 700" for I-131", T. J. Burnett, Health Physics, January 1970.
2. "Meteorology and Atomic Energy", Eq. 5.2.
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5. "The Initial Retention and Subsequent Loss of Fission Products in Edible Tissues of Pastures", Annual Report 1962/1963 ARCRL 10, pp. 73, 74. Agricultural Research Council Radiobiological Laboratory (1963).
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