May 13, 1982

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Docket No. 50-206
L S05-82-05-034

Mr. R. Dietch, Vice President
Nuclear Engineering and Operations
Southern California Edison Company
2244 Walnut Grove Avenue
Post Office Box 800
Rosemead, California 91770

Dear Mr. Dietch:

SUBJECT: SAMPLING AND ANALYSIS OF PLANT EFFLUENT (NUREG-0737 - ITEM II.F.1, ATTACHMENT 2) - SAN ONOFRE UNIT NO. 1

Your letter dated February 24, 1982 expressed concern over sampling line losses of particulates and iodines relative to your equipment installed to meet the criteria of NUREG-0737 Item II.F.1, Attachment 2.

The guidance in NUREG-0737 references ANSI N13.1-1969. Information appended to ANSI N13.1-1969, but not comprising part of N13.1, predicts severe sample losses in lines leading from effluent sampling points to effluent sample collection stations for the proposed San Onofre, Unit No. 1, installation.

ANSI N13.1-1969 is currently undergoing extensive revision. In a recent draft of N13.1, determination of sampling line losses is suggested to be accomplished by actual test of systems or mockups rather than by calculational methods. While the NRC staff cannot endorse a preliminary draft of a standard undergoing revision, our evaluation of your concerns concludes that the staff would be willing to accept empirical data on sampling line losses based on tests of either the installed system or a full-scale mockup of the system in lieu of calculations based on ANSI N13.1-1969 appendices.

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DSU USE (08)

Our evaluation is enclosed.

Please contact W. Paulson, NRC Project Manager is you have any questions regarding this matter.

Sincerely,

Original signed by

Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

Enclosure:
Evaluation

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DATE		5-12-82	5/13/82	5/13/82			

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STAFF RESPONSE TO SAN ONOFRE, UNIT NO. 1, QUESTIONS ON DETERMINATION OF SAMPLING LINE LOSSES RELATING TO REQUIREMENTS OF NUREG-0737, ITEM II.F.1, ATTACHMENT 2 REF: SCEC LETTER OF 02/24/82

I. INTRODUCTION

Absent a representative sample and analysis of the radioiodine content of plant gaseous effluents, the operator of a nuclear power plant in which a nuclear accident has occurred is faced with the alternative of calculating projected offsite doses to the population based on extremely conservative assumptions. The requirements of Attachment 2, Item II.F.1, of NUREG-0737, were promulgated to assure that a plant operator would have the capability, under accident conditions, to obtain and analyze samples of his gaseous plant effluents which would be sufficiently representative of the actual discharge conditions to permit a realistic assessment of projected offsite doses to the population.

The staff recognizes that the collection of a "representative" sample of radioiodine from a plant gaseous effluent stream is subject to a number of problems or difficulties, not the least of which is the tendency for both radioactive particulates and radioiodines to deposit or "plate-out" in traversing long sample collection tubes or pipes. Also of concern is that while radioiodine is typically discussed and treated as though it is a gas or vapor, it actually exists in the plant atmosphere as both a gas or vapor and as a particulate aerosol. The relative proportions of the particulate and gaseous forms of iodine vary with such factors as age and ambient temperature and are not readily predictable, especially under accident conditions.

II. DISCUSSION

1. Licensee's Proposed System

We have reviewed the Southern California Edison Company letter of February 24, 1982, which enclosed a proposed design for the particulate and radioiodine sampling system for SONGS-1 to meet the criteria of Item II.F.1, Attachment 2, of NUREG-0737. The licensee is concerned that the proposed design, which incorporates long horizontal sample runs in order to meet the dose criteria of Attachment 2, may have inherent problems of sample deposition and plateout which could affect the validity of any samples obtained through use of the sampling system.

Installation detail drawings indicate a horizontal run of approximately 70 feet, and a vertical drop of approximately 50 feet, with a total length of approximately 120 feet. The sample lines are thermally-insulated and are heat-traced. Recommended standard installation practices have been specified, such as requiring bends in sample tubing to be of as large bend radius as practicable, avoiding sharp bends, the use of smooth-wall stainless-steel tubing, and provision for heat-tracing.

As described in the license's submittal, the SONGS-1 sampling system uses two lines of differing diameters and volumetric flow rates to accommodate a wide range of sampling conditions. Under normal conditions and for limited accident conditions, a 1/2" o.d. (1 cm i.d.) line is operated at approximately 1.0 scfm. The corresponding flow and velocity for calculational purposes are 470 cm^3/sec and 590 cm/sec. For severe accident conditions, a 1/4" o.d. (0.5 cm i.d.) line is operated at approximately 0.06 scfm. The flow and velocity of this line are 28 cm^3/sec and 140 cm/sec.

2. Staff Guidance in II.F.1, Attachment 2

Table II.F.1-2 of Item II.F.1, Attachment 2, cites ANSI N13.1-1969 for guidance on representative sampling. The aspect of representative sampling of principal concern to SCEC/SONGS-1 is the N13.1 criteria for quantification or determination of sampling line losses or deposition occurring over long runs of sample system tubing. Long runs are used in the SONGS-1 sample system to deliver the sample to a remote location, where shielding and distance provide the requisite control over radiation exposure to sampling personnel.

The guidance on sampling line loss calculations in ANSI N13.1-1969 appears in Appendix B, which addresses three forms of sampling line loss or deposition: (1) Gravity Deposition; (2) Brownian Diffusion; and (3) Turbulent Deposition.

Gravity Deposition is important in systems operating at relatively low linear velocities, where laminar flow conditions prevail. At the velocities calculated for the two SONGS-1 sampling lines, e.g., 140 cm/sec and 590 cm/sec, flow can be expected to be turbulent and, therefore, calculation of losses due to the deposition of particles by gravitational forces is not applicable.

Brownian Diffusion is important in systems where particle sizes are extremely small, e.g., 0.001 to 0.1 micron diameter and where linear flow velocities are low. For the SONGS-1 sampling lines, linear flow velocities are in excess of the regimes in which Brownian Diffusion is important; additionally, such particles as may be present tend to be of larger size than those of concern for this form of deposition (e.g., 0.1 microns to 30 microns and larger).

Turbulent Deposition is the mechanism most likely to be of importance in determining sample line losses in the SONGS-1 sampling system. However, due to the complexity of the mechanism of turbulent deposition, it is probably the least understood and least quantifiable mechanism of deposition and, therefore, the most difficult to predict by calculational methods when designing a sampling system.

Table B3 of ANSI N13.1-1969, while providing limited data for vertical sampling lines, can be considered to be applicable to a turbulent-flow sampling line with both horizontal and vertical components, as in the SONGS-1 design. For particles of small diameter, e.g., 1 micron or less, deposition is indicated to be negligible, regardless of sampling line diameter or particle density. At a particle diameter of 2 microns and a density of 4, indicated deposition increases to a fraction of 0.31 for a 0.5 cm (diameter) tube 65 feet long (2,000 cm) but is only 0.14 for a 1 cm (diameter) tube 65 feet long. Particles 6 microns and larger and with densities >1 are shown to deposit at fractions approaching 1.0 (100%) at tube lengths of approximately 16 feet.

The data reported in Table B3 of ANSI N13.1-1969 would seem to indicate that long sampling lines are not practicable where particles over about 6 microns are involved. In general, gaseous effluents from nuclear plants can be described as comparatively free of particulates, while such particulates as may be present are usually of small size (i.e., less than 5 microns diameter) as the result of upstream filtration. In some plants, almost all potential sources which could contribute radioactive particulates to the plant's gaseous effluent stream are filtered through one or more stages of HEPA filtration. Such particulates as might be present in such a stream would tend to be very small. In what is perhaps the more typical case, a single plant main vent discharge may consist of a "mixed bag" of HEPA-charcoal filtered air from potentially radioactive areas, roughly filtered air (i.e., as through a fiberglass "furnace" filter) from non-radioactive work areas, and unfiltered air from sources such as a PWR turbine building. What happens in the mixing of such sources is that small radioactive particulates from the radiation areas -- perhaps starting as sub-micron or even molecular-sized particles -- tend to agglomerate with each other and with the larger particles from the unfiltered "clean" areas, thus forming relatively large (i.e., greater than 10-20 microns) radioactive particles which then become subject to deposition in sample lines.

3. <u>Considerations in Determination of Line Losses By Deposition</u>

Application of the guidance in Table B3 of ANSI, N13.1-1969 to sampling of a nuclear plant gaseous effluent stream, such as that described previously, would lead one to the conclusion that long sampling lines are not practicable because calculated losses might well approach 100%. That this is not strictly true is indicated in recent discussions with persons having extensive field experience in nuclear plant sampling work. In several undocumented cases, samples of various types of plant atmospheres and plant effluents were taken through sampling lines ranging in length from about 50 feet to about 300 feet. In each case, particulate samples adequate to serve the purpose at hand were drawn through these sample lines. While some sample losses (probably by deposition) were observed at the time, the results being sought were largely qualitative in nature (e.g., isotopic identification) rather than quantitative, and no efforts were made to determine the precise extent of these losses.

The foregoing discussion leads us to the tentative conclusion that the guidance of Appendix B of ANSI N13.1-1969 may not be wholly valid. We note a clue to this in Section B4 of Appendix B, which points out that the data is for dry, clean tubes and does not consider such factors as re-entrainment.

The staff is of the opinion that re-entrainment or re-suspension may well be a significant factor in determining actual sample line losses. In particular, such behavior may be more likely to occur in a continuously-operating system where equilibrium conditions have been established, rather than in a system which is used infrequently or intermittently.

A sampling system could be designed to utilize enhanced entrainment by increasing system flow. If only a limited volumetric flow is desired at the sample collection point, the sampling flow could be split, with one portion going through the sample collection device and the other portion being bypassed around the sampler, thus maintaining the flow conditions enhancing the entrainment characteristic.

4. Current Status of Staff Guidance

The staff is aware that a revision to ANSI N13.1-1969 is being prepared by a currently-active ANSI working group. However, the expected dates of completion and publication are not known. The staff has seen a preliminary draft of the revision which deletes the guidance on sampling from stacks and on sampling line losses (Appendices A, B, and C of ANSI N13.1-1969). In lieu of the deleted guidance, the draft revision of ANSI N13.1 recommends that either the actual sample delivery system or a full-scale mockup be tested experimentally to determine the extent of sample loss.

The staff endorses the proposed approach of making actual system tests to determine line losses. At the same time, the staff is not prepared to either recommend a specific test method or endorse any given test method as being acceptable to the staff. Therefore, the staff will be receptive to proposals for technically sound test procedures for determining sample line losses for both particulates and iodine vapors.

It should be emphasized that the staff's principal concern in establishing the criteria of Item II.F.1, Attachment 2, was the quantitative determination of the rate at which radioiodines can be released from the plant in gaseous effluents under accident conditions. Radioiodine is usually considered to be in a gaseous or vapor form; while this is partially true, it also appears in significant fractions in particulate forms under certain conditions and, therefore, any discussion of sampling must consider the collection, transport, and retention of both the gaseous (elemental and organic) and particulate forms.

Under normal reactor operating conditions, the forms of radioiodine observed in plant atmospheres and plant gaseous effluents are: (1) the elemental form of iodine, which appears as the two-atom molecule, I_2, and which can exist at normal ambient temperatures (50 F to 100 F) as either a gas or adsorbed on a solid (particle); (2) the hypoiodous acid form, HOI, usually appearing as a vapor or gas; and (3) the organic form, usually assumed to be CH_3I. Historically, for design basis accident analysis, the staff has assumed iodine species distribution to be 5% particulate, 4% organic, and 91% elemental.

In the initial release of iodine from irradiated fuel, in either normal leakage or in the accident case, the staff is considering postulating that most of the iodine released is in the form of cesium iodide (CsI). Cesium iodide, while being nominally a solid having a melting point of about 620 C, is very soluble in either hot or cold water, and most of the iodine released from fuel tends to stay in solution; however, aerosols could be generated from steam leaks such as a high pressure primary coolant leak to atmosphere. Just how the other forms of radioiodine come into existence is not clear. Hypoiodous acid and organic iodides, representing the more stable chemical forms, are probably end products in a spontaneously-occurring cycle or chain of chemical reactions. That this latter hypothesis is valid is indicated by the increasing fraction of organic iodides found to be present in "older" atmospheres e.g., the longer radioiodine has been out of the reactor, the greater the fraction of organic iodides will be seen in iodine samples. Until research is completed on the CsI question, however, the staff will continue to use the DBA accident analysis approach.

III. POSITION

In view of all of the variables which can be introduced in the sampling of particulates and radioiodines, especially in long runs of sample collection tubing, a definition of "representative sampling" acceptable to the staff for Item II.F.1, Attachment 2, only, can be stated as follows: "REPRESENTATIVE SAMPLING: The obtaining of the best practicable sample, accompanied by the application to analytical procedures of such empirically-determined line loss or line deposition correction factors as may be needed to obtain results which can be considered "order-of-magnitude" approximations of the actual concentrations of particulates and radioiodines in plant gaseous effluents under accident conditions."

The design of systems for the sampling and analysis of radioiodine should take into consideration the multi-faceted nature of iodine. Both filtration (for particulates) and adsorption (for gases and vapors) sampling media should be used for the collection of iodine. Sampling lines should be designed to minimize losses due to deposition of particulates and should be heat-traced to minimize plate-out or deposition of iodine vapors on wall surfaces by minimizing temperature changes and eliminating "cold" spots. Flow control in sampling lines is sometimes achieved by the use of throttling valves, or by the use of limiting orifices; such devices should not be used in the line up-stream of the sample collection media because they introduce pressure and temperature changes in the sampling stream and could induce iodine plate-out.

Sampling lines should be as short as practicable, considering such limiting factors as ambient radiation from ducting or pipes leading to the discharge point and radiation from other items of plant equipment in the vicinity. The point of sample collection should be chosen with consideration being given to routes of access by sampling personnel, such that a sample can be retrieved and analyzed without incurring personnel radiation doses in excess of 5 rem whole-body exposure and 75 rem to the extremities.

When sampling line losses calculated in accordance with ANSI N13.1-1969 show deposition approaching 100%, an alternative determination of sampling line losses for particulates should be accomplished by test of sampling lines using the actual aerosols encountered in normal plant operation, or, preferably, by using test aerosols with particle sizes in the range expected to be present under accident conditions. In-situ or full-scale mockup test results will be acceptable to the staff in lieu of data or values determined by ANSI N13.1-1969 methodology.