UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

FORMAL DOCKET COPY

July 16, 1968

Docket No. 50-286

Consolidated Edison Company
of New York, Inc.
4 Irving Place
New York, N. Y. 10003

Attn: Mr. Donham Crawford
Administrative Vice President

Gentlemen:

As discussed during our meeting on April 16, 1968, we have concluded that additional information is needed in the area of the structural design of your proposed facility to permit us to determine the adequacy of the design. Specific needs are indicated by the questions attached which are identified as Appendix G to maintain sequence with the appendices of our February 19, 1968 letter.

Your reply to these questions should be submitted as an amendment to your application.

Sincerely yours,

Original signed by
Frank Schroeder, Jr.
for:
Peter A. Morris, Director
Division of Reactor Licensing

Enclosure:
Request for Additional
Information

cc: Arvin E. Upton, Esquire
LeBoeuf, Lamb, Leiby & MacRae
1821 Jefferson Street, NW.
Washington, D. C. 20036

ADDITIONAL INFORMATION REQUIRED

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

INDIAN POINT STATION NO. 3, DOCKET NO. 50-286

1.0 GENERAL STRUCTURAL DESIGN

1.1 Provide complete lists of:

(a) Class II structures and systems
(b) Combined structures (i.e., having elements of more than one class)
(c) Any Class I items housed in, adjacent to, or supported by, Class II or III structures.

1.2 Describe the protection to be provided any Class I equipment not in, or supported by, Class I structures.

1.3 State how the earthquake loads will be established for equipment in 1.2 above.

1.4 Describe the design methods used for the combined structures in 1.1(b) above.

1.5 In addition to the containment building crane, which is listed as a Class I item, information is requested as to the design of the other facility cranes to insure that they cannot be dislodged during an earthquake or otherwise cause damage which might impair safe shutdown and containment.

2.0 CONTAINMENT STRUCTURAL DESIGN

2.1 With respect to the design criteria for the tornado, (1) indicate the design wind loading and pressure drop considered, and the basis for their selection; (2) identify the equipment which will be designed to withstand these loadings; and (3) discuss the ability of the plant components and systems to withstand tornado-originated missiles.

2.2 List the spectrum of other external missiles that the containment will be designed to withstand and the procedures to be used in checking the containment design to withstand such missile hazards.

2.3 If the containment structure base is located below ground water level, describe the waterproofing or other protection to be used between the soil and the containment. Evaluate the possibility and consequences of base mat cracking and of ground water reaching the liner and the reinforcing. Include the effect on liner stability and liner and reinforcing corrosion.

2.4 For the containment structure, provide:

(a) A preliminary design drawing of the containment presenting details of the base slab, dome-cylinder junction, cylinder-slab junction, showing reinforcing and liner features, including liner anchors.

(b) Scaled load plots for moment, shear, deflection, longitudinal force, and hoop tension, in order that an appraisal can be made of the significance of the various loadings which influence the containment design. Provide these plots for several containment heights for the following loadings: dead, pressure, operating basis earthquake (smaller earthquake), wind, liner thermal (normal and accident) and concrete thermal (normal and accident).

(c) The normal operating and transient accident thermal gradients to be used in the design of the containment for the typical winter and summer days.

(d) A description of how torsional loads will be handled.

(e) The analytical procedures used for arriving at the forces, shears, and moments in the structural shell, and the analytical procedures used for determining discontinuity stresses at the base and dome. State the assumptions, with regard to structural stiffness, that form the basis for these stress determinations and indicate the extent to which variations of E_c and μ_c are considered.

(f) The values of E_c and μ_c for cracked and uncracked reinforced concrete structure for different elevations and explain their use in the design of the concrete shell and in thermal liner loading computations. Include the effect of shrinkage and creep. State whether the computer program to be used takes into account these variations of E_c and μ_c, and also axisymmetric loads.

(g) Provide additional information on the proposed use of the one-third increase in allowable stresses. Use of this increase is not considered in keeping with normal practice, particularly with respect to the D + L + S + T loading. Discuss the problem and provide a criterion that considers biaxial and triaxial loading effects. Justify the values of shear (as a measure of beam strength in diagonal tension) for a structure of this type. Discuss the proposed design criteria in this area, keeping in mind possible biaxial tension stresses, and two dimensional cracking.

(h) Under incident conditions, concrete may be cracked and the crack pattern may be two-dimensional. Explain how, under this condition, the shears are transferred through the section, and justify the length required to anchor the reinforcing bars.

(i) The reinforcing steel may be stressed to the yield point. Justify the use of this stress which is larger than the guaranteed minimum yield point of the liner (30,000 psi). Clarify whether, under certain conditions, the liner may be stressed beyond the yield point.

(j) Because of cracking of concrete due to shrinkage, to testing, to thermal stresses, and during an accident, the problem of adequate bar anchorage is of special concern. Provide information on how the reinforcing bars are anchored at certain critical points, such as: center of the dome, intermediate terminal points of radial bars in the dome, bars provided to take discontinuity stresses, some diagonal bars, etc.

2.5 Indicate whether the following have been or will be considered:

(a) The cracking of the cylindrical wall, compared with the behavior of the uncracked mat.

(b) The fact that the mat is under radial tension and is supported on a rigid foundation, restraining certain deformations of the mat.

(c) The fact that the adjacent ground restrains the deformation of the wall.

2.6 For the base slab, describe:

(a) The analytical procedures used to arrive at the forces, moments, and shears, considering the rigid support afforded by the ground. State whether transient thermal gradients have been considered.

(b) State the elastic properties of the bedrock that have been used for the design.

2.7 With respect to seismic design of the containment, describe:

(a) The general analytical model for the containment including mass distribution, stiffness coefficients, modes of vibration, and analytical procedures for arriving at a loading distribution on the containment structure.

(b) The order of magnitude of lateral earth pressure under seismic loading and how this is factored into the design.

(c) The manner in which damping will be considered in the structural design. Justify the damping values employed for the various components of the structure considering possible cracking and different modes.

(d) The extent and manner in which the horizontal, vertical, and rocking motions will be considered in the design, and how the corresponding damping will be included. Describe the motion of the structure with respect to ground using the above three components of action.

(e) The earthquake design response spectra shown in the PSAR have been scaled from the El Centro spectrum. Indicate the degree to which the validity of this scaling was examined in connection with this site.

(f) Discuss the stress levels and loading criteria that will be employed in the design for the design basis earthquake (larger earthquake) and the operating basis earthquake (smaller earthquake) and the limitations on deformations utilized.

2.8 With respect to liner design, describe:

(a) Types and combinations of loading considered with regard to liner buckling, and the safety factors provided. Include the influence of large tangential strains due to cracks in the concrete under the load combination that includes accident and earthquake loads.

(b) The geometrical pattern, type, and spacing of liner attachments; and the analytical procedures, boundary conditions, and results with respect to buckling under the loads cited above.

(c) Tolerances on liner plate thickness and liner yield strength variation and the bases for the selected values.

(d) The possibility of elastic and inelastic buckling especially at base of the wall. Provide sample calculations showing the influence of all pertinent parameters, such as:

Variation of plate thickness;
Variation of yield point of liner steel;
Influence of Poisson's ratio for steel;
Erection inaccuracies (local bulges, offsets at seams, wrong anchor location);
Creep of concrete;
Shrinkage of concrete;
Variation of Young's modulus and Poisson's ratio for cracked and uncracked concrete, and as a function of stress level in concrete (elastic and plastic);
Ground water infiltration, earthquake, temperature loading, etc.

(e) The stress and strain limits used for the liner, the bases for these limits, and the extent to which these limits relate to liner leakage.

(f) The type, character, and magnitude of cyclic loads for which the containment liner will be designed. Discuss the pressure/thermal load variations considered and include an evaluation of the number of cycles generated by earthquakes.

(g) How, if the effect of temperature rise on the liner is to be represented by a uniform pressure increase, this approach is justified.

(h) How variations in liner thickness and yield point are taken care of in the design.

(i) The plastic strains that the liner material can accommodate without cracking.

(j) The design approach that will be used where loadings must be transferred through the liner, such as at crane brackets or machinery equipment mounts. Provide typical design details and computations.

(k) How the shears, especially those due to thermal expansion and earthquake, will be accommodated. It is noted that the bottom liner is not accessible for inspection during the life of the plant. It is therefore very important to avoid any unnecessary stresses and strains in the bottom liner. The arrangement for load transfer through the liner under the bottom of the interior structure should provide for transfer of shears parallel to the liner.

(l) Describe the liner arrangement to be used at the base-cylinder to liner juncture, the strain limits imposed at the juncture, and provide an analysis of the capability of the chosen liner arrangement to absorb these strains under design basis accident and earthquake conditions.

(m) Describe the procedures for analysis of liner stresses around openings. Also, provide the method of liner design to accommodate these stresses and the related stress limits. Justify the proposed thickening of the liner at penetrations. Discuss the liner anchors at this location.

2.9 For the design of the liner anchorages, describe:

(a) The analytical procedures and techniques to be used in the anchorage design including sample calculations.

(b) The failure mode and failure propagation characteristics of anchorages. Discuss the extent to which these characteristics influence leaktightness integrity. Indicate what design provisions will be incorporated to prevent anchorage failures from jeopardizing leaktight integrity.

(c) How elastic and inelastic buckling of the liner will be considered in the design of the anchors. Discuss the possibility of unbalanced loads acting in one or several anchors and provide a study showing that no chain reaction can occur and that massive buckling of the liner, and mass failure of anchors, is excluded.

(d) Anchorage and weld sizes and spacings.

2.10 With regard to penetration design, describe:

(a) The design criteria that will be applied to ensure that, under postulated design basis accident conditions, potential resultant torsional, axial, bending, or shear piping loads will not cause a breach of the containment. Include the design criteria intended to prohibit pipe rupture between the penetration and containment isolation valves. Specify the codes that will be used. Provide design details for typical penetrations to illustrate how the criteria will be applied.

(b) The extent to which the penetrations and the applicable surrounding liner regions will be subjected to vibratory loading from equipment attached to the piping systems. Indicate how these loads will be treated in design.

(c) Criteria for concrete thermal protection at penetrations; include the temperature rise to be permitted in the concrete under operating conditions and the time dependent effect that loss of thermal protection would have on the containment's structural and leaktightness characteristics. Indicate the thermal gradients that will be used for design purposes.

(d) The capability of the penetration design to absorb liner strain without severe distress at the opening.

(e) The manner in which axial stresses, loop stresses, shear stresses, bending stresses (in two directions) and shear stresses due to torsion will be combined in the plastic domain, if the full plastic strength of a pipe with regard to torsion, bending and shear is to be used. State the failure criterion to be used. Indicate how the exterior loads including jet forces will be combined. Give factored loading combinations for all the loads for all types of penetrations considered in the design. Explain how the Standard Code for Pressure Piping-Power Piping, B31.1.0-1967 will be used for these loading cases. Indicate whether factored load combinations will be used with this code.

(f) For all penetrations, the criteria that will be used for the bending of reinforcing bars which have to clear the opening. Criteria defining maximum slopes and minimum bending radii to avoid local crushing of concrete should be included.

(g) For penetrations between approximately 9 inches and 4 feet in diameter, explain how normal, shear, bending, and torsional stresses will be covered by the reinforcing bars.

2.11 For large openings, describe:

(a) Criteria with regard to opening sizes that constitute large openings; hence, meriting special design consideration. List the number and indicate the size of the large openings for the containment.

(b) The primary, secondary, and thermal loads that will be considered in design of the openings.

(c) The stress analysis procedures that will be used in design.

(d) The method that will be followed for the design (working stress design method, ultimate strength design method, or both). If ultimate strength is used, the factored load combinations should be given together with corresponding capacity reduction factors.

(e) How the existence of biaxial tension in concrete (cracking) will be taken care of in the design and how the normal and shear stresses due to axial load, two-directional bending, two-directional shear, and torsion will be combined. Also, state the proposed criteria for the design of the thickened part of the wall around the opening (ring girder).

(f) The method to check the design of the thickened stiff part of the shell around large openings and its effect on the shell. Include the manner of considering creep and shrinkage. Comparison with stresses in a circular flat plate would not be convincing, since it eliminates the effect of torsion which is one of the most important effects involved. How will torsional stresses be checked?

(g) Additional information on reinforcing patterns that will be used around large openings.

(h) The safety factor provided in design at large openings. Sample computations should be provided, listing all the criteria and analyzing the effect of all pertinent factors, such as cracking, etc.

2.12 If insulation is required, present preliminary design information, including proposed design requirements and performance specifications to ensure that the necessary insulating qualities will be achieved under accident conditions. The presentation should also include:

(a) The specified and tolerable temperature rise in the liner and the design safety factor provided on insulation performance.

(b) Means provided for fastening the insulation to the backing liner, for precluding steam channeling behind the insulation (through the top or joints), and for removing insulation panels.

(c) An analysis of the consequences of one or more insulation panels being displaced from the liner during, or as a consequence of, an accident situation.

(d) The consideration given to increased conductivity due to humidity and compression during accident pressure transients and precompression from structural and leakage testing.

(e) An evaluation of the compatibility of the insulation materials and steel liner (chemical reaction, etc.).

3.0 MATERIALS

3.1 Justify the type of cement to be used, explain the basis for the selection, and describe the user verification testing to be performed.

3.2 Indicate the specifications to be used for the concrete aggregate, and indicate the quality control testing to be performed to assure the conformance to specifications of delivered aggregate. Similarly, indicate specifications and tests for the mixing water.

3.3 Describe the concrete mix procedures including extent of trial mix testing. Describe the type and usage of admixtures, their compliance with ASTM specifications, and extent of testing.

3.4 Provide the detailed material selections for containment penetrations, list the corresponding ASTM specifications and indicate NDTT considerations in their selection.

4.0 CORROSION PROTECTION

4.1 Describe the proposed concrete cover provisions for reinforcing steel for the dome, slab, and cylinder. Include the minimum ACI 318-63 code requirements for comparison.

4.2 Discuss the extent of consideration given to the need for cathodic protection. What protection will be provided? If soil resistivity surveys have been conducted, report the results.

4.3 Discuss the extent to which protective coatings will be applied to the liner.

4.4 Refer to item 2.2 which notes lack of a layer of porous concrete between the soil and the containment. Justify the omission of such drainage provisions.

Especially, consider the fact that the containment structure is continuously subjected to thermal gradients. These generate tensile stresses in the outside concrete layers which increase the likelihood of cracking, thus opening paths for water entrance.

5.0 CONSTRUCTION

5.1 Indicate the codes of practice that will be followed in the containment construction.

(a) Indicate where and to what extent ACI 301 standard practice for construction will be equaled, exceeded, or not followed.

(b) Indicate the specific extent to which ASME fabrication standards will be adhered to in liner manufacturing.

(c) Supplement the listing with an additional list of any documents (U. S. Army Corps of Engineers, Bureau of Reclamation, etc.) which may be used as the basis for your specifications to contractors to cover items not recognized by specific codes. State the basis on which these supplementary mandatory specifications will be prepared.

5.2 Since ASME Standards do not define erection tolerances in sufficient detail to ensure a satisfactory erection of the liner (e.g., they do not cover local curvature deviations), provide the comprehensive set of erection tolerance standards selected for the liner, and show that they identify and satisfactorily limit all inaccuracies likely to occur during erection.

5.3 Based on the preliminary construction schedule, describe the general procedures and sequence of events applicable to construction of the containment. Include excavation, ground water control, base slab construction liner erection and testing, and concrete construction in cylinder and dome regions. Describe the concrete placing and curing procedures, especially at the center of the dome.

5.4 Indicate the extent to which splice stagger will be achieved.

5.5 Indicate the extent to which splicing of reinforcing steel will be made by welding. State the location of these welds.

5.6 Describe the "splicing" of inclined bars, or horizontal stirrups provided to take the radial shears in the base of the walls with the vertical bars. If done by lapping the diagonal bar with a vertical bar or by bending the stirrup around a vertical bar, demonstrate that, despite biaxial tensile stresses in concrete and vertical and horizontal crack patterns, the load in the diagonal bars or stirrups can be transmitted safely to the vertical bars.

5.7 Describe the procedure for bonding between concrete lifts and indicate the manner in which the lifts will be placed and staggered.

5.8 Describe those quality control procedures and standards for field welding of liner plate that differ from the general procedures and standards. Include welder qualifications, welding procedures, post-weld heat treatment, visual inspection, magnetic particle inspection, liquid penetrant inspection, and construction records.

5.9 Indicate the requirements that will be placed on seam welds to assure adequate ductility.

5.10 Indicate the applicable ASME or API code sections that will be adhered to in liner erection.

5.11 Provide a detailed description of the proposed erection of the bottom liner. Show how a good bearing of the liner on the concrete below will be ensured. State if grouting is to be used and indicate how the liner plates will be fitted to the embedded anchors.

6.0 <u>CONSTRUCTION INSPECTION</u>

6.1 Describe the organization for inspection as requested on page 3 of our letter of February 19, 1968. Indicate the manner in which inspectors are divorced from construction pressures and the manner in which the engineering design group works with the inspection organization.

6.2 Indicate the qualification, minimum experience, and authority of inspectors.

6.3 Indicate the degree to which material preparation and construction activities will be subject to inspector surveillance.

6.4 Discuss the manner in which records of quality control and inspection will be kept.

6.5 Describe the extent of concrete compression and slump testing to be used. Include the statistical basis for the proposed program and the standards for rejection and pour removal.

6.6 Indicate the planned program of user testing of reinforcing steel for strength and ductility. Include the statistical basis for the program and the basis for reinforcing steel shipment rejection.

6.7 Indicate the controls that will be provided to ensure that the properly specified reinforcing bars are received, and, if different grades of steel are used, how mistakes will be avoided during erection.

6.8 Indicate the Cadweld splice procedures that will be used, including operator qualification procedures to be followed, inspection and testing, and standards for rejection.

6.9 Indicate the minimum percentage of Cadweld splices to be tested. A tolerance limiting the offset of two bars to be spliced should be provided.

6.10 Specify the proposed quality control procedures for the strength welds of reinforcing bars to structural elements, such as plates, rings, sleeves, and for occasional strength weld splicing of heavy reinforcing bars.

6.11 Describe the reinforcing bar welding procedures and quality control to be used in performing reinforcing bar strength welds. Include bar preparation, user verification testing of reinforcing steel composition, maximum permissible alloy specifications, temperature control provisions, radiographic and strength testing requirements, and the basis for welded splice rejection and cutout. State whether any tack welding of reinforcing steel will be permitted.

6.12 Indicate the minimum percentage of reinforcing splices to be checked by the welding inspector, using nondestructive inspection methods (X-raying, dye penetrant test, etc.).

6.13 Indicate the controls to be employed in reference to liner plate out-of-roundness and local bulges.

6.14 Indicate the extent of user verification testing of certified liner NDTT properties, liner thickness, ductility, weldability, etc.

6.15 Discuss the seam weld radiography program. Also, provide an evaluation of the proposed liner radiography program to provide assurance that flaws capable of developing into positive leakage paths under design basis accident conditions will not, in fact, exist.

6.16 Describe the quality control procedures for liner angle and stud welding.

6.17 Indicate the procedures and criteria for control of seam weld porosity.

7.0 TESTING AND IN-SERVICE SURVEILLANCE

7.1 Describe the sequence for structural testing.

7.2 Describe the instrumentation program for structural testing. Include:

(a) Identification of structural, and liner areas to be instrumented.

(b) Purpose, type, expected accuracy, and redundancy of instrumentation.

(c) The range of strains and deformations expected.

(d) The protective measures that will be taken to insure instrument performance during structural testing, considering the interval between instrument installation and its use.

7.3 Derive a relationship between two test pressures and the actual pressures they represent, showing the validity of the test pressures. Use one test pressure for design basis accident alone, the other for earthquake plus accident. Include the following:

(a) Thermal stresses at large openings: evaluation of temperature gradients, stress computations for concrete and reinforcing steel, methods of combining stresses due to normal, tangential, bending, and torsional load, assumptions on cracking, stresses in stirrups, etc.

(b) Influence of shrinkage.

(c) Creep.

(d) Influence of liner elastic and plastic deformations.

(e) Liner stresses before cracking of concrete occurs.

(f) Influence of transient thermal gradients.

7.4 Describe the surveillance capabilities provided by the containment design with reference to both periodic inspection of the steel liner and periodic structural testing of the containment. If the leak rate testing is intended to be performed at reduced pressure, provide an evaluation of the minimum level of such tests that would also serve to verify continued structural integrity. Consider in the evaluation structural response and surveillance instrumentation requirements.