U. S. NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT

REGION I

Report No. 50-245/80-02

Docket No. 50-245

License No. DPR-21 Priority -- Category C

Licensee: Northeast Nuclear Energy Company

P.O. Box 270

Hartford, Ct. 06101

Facility Name: Millstone Nuclear Energy Station, Unit 1

Investigation At: Corporate Offices, Berlin, Ct.; Plant Site, Waterford, Ct.

Investigation Conducted: January 2-4, 1980; January 9-11, 1980; January 29-31, 1980; February 13-15, 1980; February 20-22, 1980

Investigators:

S. K. Chaudhary, Reactor Inspector — 4/16/80 date

W. F. Sanders, Reactor Inspector — 4/16/80 date

for A. A. Varela, Reactor Inspector — 4/16/80 date

for A. J. Lee, Senior Mechanical Engineer — 4/16/80 date

L. E. Tripp, Chief, ES Section #1 RC&ES Branch (Exit interview only) — 4/16/80 date

Approved by:

L. E. Tripp, Chief, Engineering Support Section #1, RC&ES Branch — 4/16/80 date

Investigation Summary:

Areas Investigated: Special announced investigation conducted by three regional based investigators of Isolation Condenser System piping, pipe support, and dry-well concrete for their ability to withstand loads imposed by seismic, blowdown, or water-hammer event. The investigators reviewed stress reports of piping and pipe supports, witnessed tests and NDE examination of the piping and supports, visually examined cracked concrete, interviewed engineering and technical personnel, and conducted a technical evaluation of data and other information presented by the licensee to determine the structural adequacy of this system. The investigation involved 174 investigator hours by three regional based investigators, 34 hours by a NRR engineer and 6 hours by a regional based section chief at the licensee's corporate offices, the licensee's contractor's offices and the plant site.

Results: One item of noncompliance was identified. (Infraction - failure to promptly identify, evaluate, and document a nonconformance.)

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I. BACKGROUND

A. Reason for Investigation

On December 21, 1979 and January 8, 1980, NRC Region I received anonymous telephone calls alleging that the Millstone Unit 1 Power Plant Isolation Condenser System is not safe for plant operation. A summary of allegations as understood by Region I personnel are as follows:

1. The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads, because of:

   1.1 Loose anchor bolts in pipe supports

   1.2 High stresses in piping, pipe support and nozzles

   1.3 Concrete cracking in the drywell wall at penetration X-10A

   1.4 Damage to welds in piping and anchor X-10A due to water-hammer

2. Northeast Utilities Service Company (NUSCO) has known these conditions for some time through an in-house stress analysis and inspections. They, however, have failed to correct the deficiency and alleviate the unsafe conditions.

B. Identification of Involved Organizations

1. Northeast Nuclear Energy Co. (NNECo)
   P.O. Box 270
   Hartford, Ct.

   NNECo is the licensee of NRC authorized to operate the nuclear generating facility Millstone Unit 1 at Waterford, Ct.

2. Northeast Utilities Service Co. (NUSCO)
   P.O. Box 270
   Hartford, Ct.

   NUSCO is a part of Northeast Utilities providing engineering and technical services to operating entities of Northeast Utilities on a company wide basis. NUSCO is involved in providing engineering and technical guidance in the areas of maintenance, modifications, and operation of Millstone Unit 1.

3. Ebasco Services, Inc. (Ebasco)
   Two Rector Street
   New York, N.Y.

Ebasco is an architect-engineering firm providing design, construction, and construction management services to power and other heavy engineering and manufacturing industries. Ebasco was engaged by Northeast Utilities to provide design and construction services for Millstone Unit 1 plant.

4. Teledyne Engineering Services (TES)
303 Bear Hill Road
Waltham, Massachusetts

TES is an engineering firm providing engineering and consulting services to power and other industry in design and analysis of specialized problems in a wide spectrum of technical disciplines. TES was engaged as a consultant by NUSCO to provide services in inspection, analysis, development of engineering criteria, and design modification in the Isolation Condenser System which might be necessary in the wake of water-hammer incidents in this system.

II. SUMMARY OF FINDINGS

A. Allegations and Investigation Findings

The NRC representatives investigated the allegations conveyed to the regional office via telephone on December 21, 1979, and January 8, 1980. The allegations and a summary of NRC findings on each are as follows:

1. Allegation No. 1.1

   The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads because of loose anchor bolts in pipe supports.

   The NRC investigation found that the licensee was aware of the loose anchor bolts, and had taken actions to repair these bolts. However, the documentation of the inspection and the repairs was not in compliance with the requirements of 10 CFR 50, Appendix B.

2. Allegation No. 1.2

   The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads, because of high stresses in piping, pipe supports, and nozzles.

   The NRC investigation found no information or evidence to indicate that there was any overstressing in the Isolation Condenser System.

3. Allegation No. 1.3

   The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads because of concrete cracking in the drywell wall at penetration X-10A.

   The NRC investigators determined that the licensee was aware of the cracking of concrete in the drywell wall in the vicinity of penetration X-10A. However, the investigators determined that the licensee's inspection and evaluation of these cracks after the water-hammer event were not adequate. The basis of licensee's determination of the characteristic and the potential safety significance of the cracks was erroneously based on an earlier inadequate inspection and evaluation. This was not in compliance with the requirement of 10 CFR 50, Appendix B.

4. Allegation No. 1.4

   The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads because of damage to welds in piping and anchor X-10A due to water-hammer.

The NRC investigators found no information or evidence to indicate that there was any damage in any piping or anchor welds in the Isolation Condenser System.

5. Allegation No. 2

Northeast Utilities Service Company (NUSCO) has known these conditions for some time through an in-house stress analysis and inspection. They, however, have failed to correct the deficiency and alleviate the unsafe condition.

No information or evidence was found by the NRC investigators to indicate that NUSCO was aware of any deficiencies or unsafe conditions, or had suppressed or tried to suppress any adverse observation regarding system safety of the Isolation Condenser System.

B. Conclusions

None of the allegations were substantiated by the NRC investigation. One item of noncompliance with regulatory requirements was identified during the investigation.

A management meeting was held in Region I offices on March 13, 1980, with licensee representatives to discuss other concerns that developed during the course of this investigation. This meeting will be the subject of a separate inspection report (50-245/80-05).

III. DETAILS

A. Introduction

The investigation was initiated by NRC Region I as a result of the allegations received from an anonymous caller on December 21, 1979. A subsequent allegation (Allegation 1.4) was received in a second telephone call on January 8, 1980.

Following receipt of the initial allegations, a series of telephone conversations were held between Region I and licensee engineering representatives on December 21, 1979. The licensee described followup inspection/evaluation activities that had been accomplished since the water-hammer event of December 19, 1979, and an earlier event in 1978. NRC found that the licensee was aware of some concrete cracking and spalling at the vicinity of the penetration and at the ceiling attachment of support X-10A (Allegation 1.3) plus loose anchor bolts (Allegation 1.1) through their evaluation and followup activities. Licensee representatives stated that they were unaware of any stress analyses that indicated any piping or component overstressing. At the same time these telephone conversations were being conducted, the Millstone NRC Resident Inspector also independently conducted a walkdown inspection of the Isolation Condenser System; reviewed drawings, inspection procedures and records; and interviewed licensee personnel at the plant site. This effort supported and confirmed the information received via telephone from licensee representatives as discussed above with respect to system damage.

NRC Region I contacted the licensee by telephone on December 26, 1979, to announce the initiation of further investigation efforts at the site and licensee engineering offices. The licensee was also requested to provide documents and other pertinent information to NRC investigators upon their arrival at the plant site and at the licensee's corporate offices. A preliminary list of documents and information considered pertinent by NRC Region I was transmitted to the licensee by Region I via telecopy to make them available to the Region I investigator during the investigation.

B. Scope of Investigation

The scope of the investigation included examination of design and analysis documents, interviews with personnel, review of records, direct observations of the system in the plant, and witnessing of inspection and tests on the system piping and supports.

C. Persons Directly Contacted and/or Interviewed during the Investigation

1. Northeast Utilities

*E. A. DeBarba, Supervisor Generation Mechanical Engineering
C. Glanding, Mechanical Engineer
R. Hanschka, Mechanical Engineer

R. J. Herbert, Unit 1 Superintendent
W. Hibberd, Mechanical Engineer
*J. M. Kufel, Superintendent of Nuclear Operations
*T. J. Mawson, Mechanical Engineer
*L. Nadeau, Mechanical Engineer
*J. F. Opeka, Station Superintendent
M. Powers, Mechanical Engineer
D. Robinson, Civil Engineer
*P. F. Santoro, Chief, Generation Mechanical Engineering
K. Thomas, Plant Test Engineer

2. Ebasco Services, Inc.

M. Seminatore, Engineer (by telephone)

3. Teledyne Engineering Services

R. D. Ciatto, Principal Engineer
P. Bangser, Engineer
D. F. Landers, Vice President (by telephone)
L. Sempruicci, Engineer

(*Persons attending exit interview)

D. Investigation of Allegations

1. Allegation No. 1

a. Allegation

The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads because of loose anchor bolts in pipe supports.

b. NRC Investigation

The investigator conducted a walk-down inspection of the system from the drywell penetration X10-A to isolation condenser tank. The object of this visual inspection was to determine any obvious damage to piping, pipe supports, or other appurtanances to the system. The investigator noticed that there were indications of repair/retorquing of anchor bolts on supports ICH-4 and ICH-5. On further inquiry, the licensee informed the investigator that these anchor bolts were found to be loose in the inspection following the water-hammer event of December 19, 1979. However, the licensee had retorqued the bolts to the original torque value required for each bolt, and because the bolts were able to be retorqued to original value, they were not considered to have failed due to water-hammer stresses. The licensee also indicated that the depths of embedment for the bolts were verified after

retorquing, and the embedment meets the required criterion of depth for such bolts. There were no other visible indications of structural damage and/or repair on the system piping and pipe supports.

c. NRC Findings

The NRC investigation showed that the licensee was aware of the loose anchor bolts and had taken actions to evaluate and repair these bolts. The NRC investigation found that a proper evaluation of the cause of bolt loosening was not carried out by the licensee before the retorquing was effected. The repair performed by retorquing was not properly controlled and documented. The repair instructions were issued on a plain sheet of paper without any traceability as to the originator, reviewer, date, or proper approval. The repair instruction specified that the bolts be torqued to meet the criteria specified in IEB:79-02, however, the inspector did not find any documentation verifying the actual torque value to which the bolts were tightened.

This is violation of criterion XVI of 10 CFR 50, Appendix B.

2. Allegation No. 1.2

a. Allegation

The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads because of high stresses in piping, pipe supports, and nozzles.

b. NRC Investigation

The NRC investigators examined and reviewed the stress reports, associated computer outputs and data to verify the substance of this allegation. The investigators reviewed the following stress reports and associated documents:

1. The original Ebasco analysis of Isolation Condenser supply line.

2. Stress report no. 78-765.89 GM, Rev. 1, done by NUSCO in October, 1978.

3. Stress report no. 79-162-150 GM, Rev. 0, done by NUSCO in January 1980 for the purpose of incorporating results of IEB:79-14.

4. Stress report no. 79-162-151 GM, Rev. 1, done by NUSCO in February 1980, with corrected input for geometry and seismic anchor displacement.

5. A stress analysis computer run identified as ICONS2, done by NUSCO (preliminary).

6. A stress analysis computer run identified as ICONSN, done by NUSCO (preliminary).

7. TES drawing no. A5182, Rev. 3 for penetration X-10A.

8. TES drawing no. A5182, Rev. 4 for penetration X-10A.

9. Ebasco drawing no. 22040-3300A for penetration X-10A.

10. Bechtel calculation sheets for support modification for penetration X-10A, dated June 8, 1979.

The investigators also examined and reviewed various other correspondences and documents relevant to the scope of this part of the allegation. The investigators also conducted private interviews with NUSCO engineering and technical personnel associated with and responsible for the stress analysis and engineering of the Isolation Condenser System.

NRC investigators made an inspection of the work in progress relative to the Isolation Condenser System at Teledyne Engineering Services facility at Walham, Massachusetts to verify the technical adequacy of analysis performed by TES for the modification of the pipe anchor at penetration X-10A.

c. NRC Findings

Based on the examination and review of the documents, and discussion with NUSCO engineering personnel, and also the direct inspection of as-built system in the plant, the investigators' findings are as follows:

1. There was no apparent overstress found in original analysis by Ebasco Services.

2. Review of stress report 78-765-89 GM, Rev. 1 did not show any discrepancy in the analyses, and stresses were found to be within allowable limits.

3. Review of stress report no. 79-162-150 GM and 79-162-151 GM disclosed that NUSCO has used the currently allowable stresses of S_c and S_h in the ASME B&PV Code instead of the more conservative B.31.1 piping code to which the plant is committed. However, it was found that the difference in final allowable stresses computed by both methods was quite insignificant.

The valve weight used in an earlier analysis was considerably higher than that used in these analyses. However, NUSCO presented acceptable documentary evidence to support the as-built condition and lower valve weight. (Crane Co. drawing no. 142652; valve shipping invoice no. 4280 from Chapman Division of Crane Co. dated July 31, 1969)

4. The computer run identified as ICONS2 was designed to find the high stress points in case of a water-hammer incident to facilitate in-service inspection. To achieve this, two simultaneous loads of 50,000 lbs. and 25,000 lbs. were arbitrarily applied at two support locations where water-hammer induced loads were expected to act. The support stiffners in the direction of applied loads were not considered in the computation for conservatism. The analytical approach and the basic technical rationale underlying this approach was found acceptable by the NRC investigators.

5. The computer run identified ICONSW did not reveal any discrepancy in analytical approach or show any overstress in the system.

6. The other relevant documents, correspondence or drawings did not disclose any discrepancy or overstress condition in this system piping, pipe supports, and nozzles.

The investigators found no evidence or information to indicate that there was any overstressing in the Isolation Condenser System.

3. Allegation No. 1.3

a. Allegation

The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads because of concrete cracking in the drywell wall at penetration X-10A.

b. NRC Investigation

The investigator visually examined the containment drywell wall in the vicinity of penetration X10-A. Several cracks were easily noticeable from the floor level. Also, there was some spalling of concrete in the ceiling at the point of support attachment. In response to the investigator's inquiry, the licensee indicated that these cracks on the wall had been observed in June 1979 during routine inspections, and were evaluated and considered insignificant surface cracks due to concrete drying and shrinkage. The licensee provided a letter from Ebasco Services Inc. to NUSCO covering inspection and evaluation of the cracks in

support of the above statement. The licensee indicated that there was no indication of any additional damage in these areas after the December 1979 event. This determination was made by evaluation and comparison with the damage observed in June 1979. However, the evaluation by Ebasco only identified two cracks on the wall and did not explain the method of crack evaluation and the basis of such conclusions. After a closer reexamination of the cracks and spalling in concrete, the investigator questioned the adequacy and validity of Ebasco's evaluation. At this time the licensee suggested a telephone call to Ebasco Services, Inc. for obtaining the background information and further clarification of the crack evaluation. In the conference call established by the licensee, the investigator was informed by the Ebasco engineer responsible for the evaluation in question that:

1. There was no visible damage present on the ceiling (spalling) at the time of June 1979 inspection.

2. He did not observe any horizontal crack in the drywell wall.

3. The inspection was not a close examination, rather it was done from the floor level under poor lighting conditions.

4. The conclusions were based on his judgement.

5. The inspection was oriented more towards the pipe support structure than the structural soundness of concrete.

In light of the above information, the investigator did not accept Ebasco's evaluation of the cracks as adequate and valid, and requested the licensee to provide some better evaluation of concrete damage than the Ebasco letter. The licensee did not produce any other inspection, examination, and/or evaluation support from the records. Therefore, the licensee indicated that a consultant would be called in to reinspect and reevaluate the concrete cracks and other apparent damage.

Pursuant to the above commitment, the licensee called in Teledyne Engineering Services (TES) for the work. TES engineers arrived at plant site in late evening of January 3, 1980, and initiated an inspection and examination of cracked concrete and other damages. The investigator witnessed the inspection and examination of the support by licensee and their consultant TES. The investigator noted that the design drawing for the support showing the anchor bolt type, size, and embedment length was not available for inspection of the support. The investigator was informed that the licensee had not been able to locate the applicable drawing.

At the conclusion of this examination the licensee informed the investigator that the licensee considers the cracks and spalling a serious matter, and TES would evaluate the results of this inspection and recommend any required follow-up actions.

The following morning the investigator was informed by the Resident Reactor Inspector, and later by licensee that the support X-10A has been determined to be inoperable due to concrete damage, and the licensee had initiated the following actions:

1. Isolated the Isolation Condenser System.

2. Reduced reactor power to 40% of the maximum operating level.

3. Requested TES to further evaluate the pipe support X-10A, and recommend modifications.

4. Initiate further NDE of the pipe support structure at TES request.

(Details of support modification are discussed in Section E.3 of this report)

c. NRC Findings:

The NRC investigation found that the licensee had not conducted a proper and complete evaluation of the cracked drywell wall concrete, and had failed to verify the basis adequacy of the evaluation carried out by Ebasco Services, Inc. This is a violation of 10 CFR 50, Appendix B, Criterion XVI.

4. Allegation 1.4

a. The Isolation Condenser System is not capable of withstanding seismic, blowdown, and water-hammer loads, because of damage to welds in piping and anchor X-10A due to water-hammer.

b. NRC Investigation

The NRC investigators inspected and examined the welding in support X-10A in particular and in the system piping and other supports in general.

Visual examinations were performed on the welds in the piping anchor assembly of penetration X-10A. This anchor is located at elevation 79.75 on the outside wall of the primary containment wall (drywell). The records of the visual examination performed by the licensee using procedure NU-VT-1, Rev. 0, were also reviewed as follows:

ICBC-E-1-2	ICBC-E-2-2
ICBC-E-1-3	ICBC-E-2-3
ICBC-E-1-4	ICBC-E-2-4
ICBC-E-2-1	ICBC-E-2-5
ICAC-E-1-1	ICAC-E-2-1
ICAC-E-1-2	ICAC-E-2-2
ICAC-E-1-3	ICAC-E-2-3
ICAC-E-1-4	ICAC-E-2-4

Additional visual examinations were performed by the investigator for indications of service induced cracks resulting from the water-hammer events and the resulting stresses. These inspections and examinations covered the system from the X-10A anchor support base plate outside the drywell to the Isolation Condenser because this portion of the system had experienced the major part of the water-hammer event. Specific attention was directed to the heavy restraints ICH-4 and ICH-5 which had suffered the apparent loosening of anchor bolts. None of the inspection and examination disclosed any apparent indication of weld or structural distress, and all the welds were judged to be sound. However, to further inhance the confidence in the soundness of welds, magnetic particle examinations were requested by NRC and performed by the licensee on welds that join the structural steel to the vertical and overhead bolted base plates. These welds were examined by DC-MT techniques. The investigators observed that the welds were cleaned of paint and other foreign materials prior to the examination, witnessed these examinations, and verified that the personnel carrying out the examination were qualified to the requirements of SNT-TC-1A in the level-2 and level-3 categories. These tests revealed two indications which were evaluated and resolved as weld bead anomalies from original construction. They were not considered to be related to the water-hammer or other overstress conditions. Both indications were removed and the welds were considered acceptable by NRC investigators.

The investigators also reviewed the licensee's inspection and evaluation of welds after the water-hammer event. The licensee conducted an inspection and evaluation of the system using the in-service inspection standards of the plant. The in-service inspection standards included UT examination of welds which were categorized as high stress welds in the high energy pipe whip restraint program. The welds identified in this program were the four 16 inch diameter elbow welds between supports ICAC-E-1-3 and ICAC-E-1-4 at elevation 79.75, and the 14 inch diameter welds on both sides of the outboard isolation valve (V-16-2) of the system. The investigators witnessed the calibration of UT instruments and the calibration of the test system to establish test

parameters. Observations were made of the examination techniques including direction of scanning and evaluation of results. After the examination, a recheck of the test system calibration was made. The investigators found no discrepancies in the whole process.

c. NRC Findings

Based on the above findings, the conclusions of the investigators are as follows:

1. The welds in the Isolation Condenser piping have not suffered any deterioration due to high stresses caused by water-hammer events. The licensee has assured the soundness, serviceability, and acceptability of welds by proper inspections and adequate evaluations.

2. The welds in the pipe support X-10A have not suffered any damage due to high stresses of water-hammer or otherwise.

The investigators' direct observation, review of documents, and discussions with engineering and technical personnel revealed that the licensee has carried out an extensive program of inspections and evaluation concerning the soundness of welds in piping and pipe supports of the Isolation Condenser System.

No information or evidence was found to indicate that there was any damage in any piping or anchor welds.

5. Allegation No. 2

a. Allegation

Northeast Utilities Services Company (NUSCO) have known these conditions for some time through an in-house stress analysis and inspection. They, however, have failed to correct the deficiency and alleviate the unsafe condition.

b. NRC Investigation

The investigators reviewed and examined the stress reports and analyses performed by NUSCO (discussed in detail in Section D.1, allegation 1.2 of this report). The engineering and technical personnel associated with these analyses were separately and privately interviewed. The investigators also reviewed related correspondence and records maintained by NUSCO in their corporate offices in Berlin, Ct. The investigation determined that the analyses and stress reports did not disclose any stress concentration which was outside the code allowable limits. The inspection of

the system in the plant was documented and had noted the cracks in concrete. Although the evaluation and the corrective action with regard to concrete was not considered adequate by the investigator, there was no evidence that NUSCO or the operators of the plant (NNECO) have tried to overlook the condition or suppress the information (discussed in detail, in Section D.1, allegation 1.3).

c. NRC Finding

Based on the above findings, the investigators concluded as follows:

There was no information or evidence found to substantiate that any of the in-house stress analysis performed by NUSCO revealed any stress concentration outside the code allowable in piping or pipe supports, or indicated any unsafe condition of the system. The investigators confirmed by direct observation of the licensee inspections that there was no indication of unsafe condition or deterioration in the system that could have been revealed by inspection. Therefore, the investigators found nothing to indicate that the licensee and NUSCO had any knowledge of any unsafe condition in the system. No evidence or information was found to indicate that NUSCO suppressed or tried to suppress any adverse observation regarding system safety of the Isolation Condenser System.

E. Investigator Identified Items

During the conduct of this investigation, several other items of concern were identified by the investigators. Some of these concerns were minor, and were resolved by more information presented by licensee. However, a few of these concerns required a detailed followup by new analysis, evaluation, and in some cases, modifications in the existing structural design or re-design of the pipe support at penetration X-10A as follows:

1. Drilled in Expansion Anchor Bolts

While evaluating the structural integrity of concrete supporting the penetration X-10A, the investigators discovered that the base plates attached to the wall of drywell were not anchored by cast-in-place "Williams Rock Bolts", rather, the bottom row of anchor bolts were drilled in expansion anchors. The license was unaware of this variance in as-built condition of the support. Because of this oversight, the drilled-in anchor bolts in the support had not been included in the evaluation process for such bolts pursuant to IEB:79-02. The investigators also discovered that due to this discrepancy, the as-built system evaluation carried out for IEB:79-14 was inaccurate. It also became evident to the investigators that this discrepancy was not identified in IEB:79-14 program because the detailed drawings of

the anchor were not used in the as-built verification inspection. The licensee subsequently located a detail drawing for the support and corrected the errors in IEB:79-02 and 79-14 evaluations.

2. Structural Design of Anchor at X-10A

In reviewing the structural design of penetration X-10A anchor, the investigators became aware of two apparent design errors. During the initial design of the support anchor, the design load combination included a "high energy pipe rupture" load. However, in structural design of the support and sizing of the structural members, only a fraction of the high energy pipe rupture loads were taken in account. Therefore, the pipe support anchor was not sized, fabricated or erected to meet the original design assumptions and criteria. Furthermore, in the licensee's evaluation of the system stresses, this load was not considered in combination with normal operating loads. Hence, the apparent factors of safety computed by the licensee for the support were in error. However, once this omission was identified, the licensee referred this discrepancy to their consultants for resolution and recommendation for corrective action.

Teledyne Engineering Services, the licensee's consultants, reanalysed and reevaluated the new information and concluded that the anchor in fact was undersized to resist the assumed design loads and moments. To correct this deficiency, TES recommended an extensive modification of the support anchor with additional structural elements to enhance the load carrying capacity and structural integrity of the support. The load conditions and combinations for which the support was modified were discussed and agreed to by NRC during conference telephone calls between the licensee and NRC (IE and NRR). The load condition which the support was modified to meet, and resultant factors of safety are as follows:

Condition 1 = Normal Operation + DBE

Condition 2 = Normal Operation + HEPB

The factors of safety: (Pu/P)

Condition 1 $\geq$ 4

Condition 2 $\geq$ 2

In performing the analysis for condition 2, TES applied all High Energy Pipe Break (HEPB) loads simultaneously assuming that they could be positive (+) or negative (-) except for Fx, which could only be applied in -x direction. The conservatism of this approach

was acceptable to NRC. Consequently, the discrepancy was considered to be resolved for plant operational safety. Additionally, the licensee made a commitment to review and evaluate other penetrations and pipe supports where a similar error might have been made, and to inform the NRC of the result of such review.

3. Modification of Anchor at X-10A

The modification of the support at penetration X-10A required two new elements to be attached to ceiling by plates attached to concrete by drilled-through anchor bolts attached to a coverplate on the floor above. However, during the installation of this base plate in the ceiling and the coverplate on the floor, it was discovered that there was a high incidence of cut rebars in the floor slab in the area of plate, and more seriously, the rebar arrangement in the slab did not conform to the design drawing which certified the as-built rebar arrangements by the A/E (Ebasco Services, Inc.). This discrepancy again required that a review and further evaluation of the integrity of support be carried out by the licensee. The investigators followed up this new development by reviewing the design documents, and through discussions with licensee and their consultants' personnel. The licensee initiated an independent review and reevaluation of this discrepancy with its consultants, TES and the original A/E.

Following is the summary based on the investigators' direct observation and the information provided by the licensee to the investigators after review and evaluation:

1. The slab thickness at elevation 82.75 is 2 feet thick in the vicinity of the anchorage of penetration X-10A; the balance of the slab is 1 foot thick.

2. The installed rebar condition consists of number eight (8) bars at twelve (12) inches on centers each way, at top and bottom of the slab and in the middle.

3. The design drawing (G-187811, Rev. 1) called for number eleven (11) bars, six (6) inches on centers at the bottom of the slab, and number eight (8) and number eleven (11) bars alternately on six (6) inch centers at the top of slab.

4. Several of the existing rebars were found to have been cut partially or completely, probably during the installation of the rock bolts fastening the plate to the underside of the slab.

5. Masonry drawing G-187810 as revised reflected a 2 foot thick floor slab in area of X-10A (NOTE: reinforcement details are not indicated on masonry plan.) This drawing was not approved until June 10, 1968.

6. Reinforcement drawing G-187811 (Rev. 1) as revised reflected both 2 foot thick floor slab and increased steel requirements for anchor X-10A rupture loads. Bar bending schedule also revised. This drawing was not approved until June 10, 1968, on or about the date of the concrete placement.

7. One to two weeks before concrete placement, rebar mats were installed in the slab, according to G-187811 (Rev. 0), No. 8's at 12 inches top and bottom, both ways.

8. Concrete placement SW and SE section of floor slab at El. 82.75 was started on June 7, and was finished by June 10, 1968.

9. The slab as-built at Elevation 82.75 in the area of X-10A support anchor was not capable of withstanding the maximum design pipe break load with the original anchor configuration.

In light of the above observations and evaluation, the licensee referred this matter to its consultant (TES) for resolution and recommendations. Based on further reevaluation, the licensee initiated the following corrective action for the discrepancy:

1. Additional sections of rebar were welded to cut rebars to make them continuous.

2. Two additional elements were installed connecting the top cover plate of the anchor to the drywell wall. Two additional elements were provided from the underside of the slab base plate to drywell wall.

3. The additional structural elements were designed to support the anchor independently without transmitting any significant load to the floor slab.

4. The licensee initiated a program of design document review to determine if a similar condition exists at any other place in the plant.

During the implementation of above corrective action by the licensee, the investigators observed the following:

1. In rebar welding, weld procedures and welder qualifications were in conformance to ANS D12.1 and ACI-318, Section 7.5.

2. Weld simulated in-place test results fulfilled the requirements of ACI-318.

3. Concrete repair procedure was adequate to assure concrete replacement.

4. Quality control of the operation was satisfactory.

5. The assumptions and techniques (finite element) used by TES for designing the modification of support were acceptable.

No noncompliance or deviation was identified by the investigators in this area.

4. Development and Determination of Water-Hammer Loads

Due to transient and unpredictable nature and the magnitude of water-hammer loads, it is very difficult to develop any realistic design criterion for stresses imposed by such events. However, due to the sensitivity of the Isolation Condenser System to water-hammer loads (three events in past six years) it is imperative that a reasonable criterion must be developed, and the system safety evaluated against this criterion.

Recognizing this safety concern, the licensee has initiated a program of developing such a criterion for water-hammer loads in the Millstone 1, Isolation Condenser System. The licensee's consultant, TES, has initiated a study by computer modeling of the system, generating various parameters for the criterion. The method is based on "Time-Force History" analysis of water-hammer pulses in the system piping.

The investigators reviewed the work done in this area by TES at its Walham, Massachusetts offices. The review consisted of discussion with TES engineers and inspection of some preliminary data generated in this effort.

The investigators did not identify any apparent item of noncompliance in this area.

5. Development of Pipe Rupture Load

The investigators found that the licensee has also initiated a program for developing more realistic pipe rupture load for the Isolation Condenser System. In reviewing the design of the support, it was discovered that the pipe rupture load used by Ebasco during the initial design may have been arbitrarily derived by the design engineer, and was unrealistically high. No documentation, background design assumptions, and/or technical justification was available in Ebasco Services' files to support this load. The licensee contends that the support anchor can never be subjected to such a load as the structural ability of the piping, i.e., the ultimate strength, is lower than the stresses assumed due to such a load combination, therefore the piping will fail before the stresses in the support ever reach the critical level.

The dynamic design analysis of the plant was carried out by the "static" equivalent method prevalent at the time. Therefore, it is more reasonable and realistic to develop a high energy pipe rupture load in accordance with present day criteria with more sophisticated and reliable methods acceptable to NRC. This new pipe rupture load will be used to evaluate the Isolation Condenser System stresses by the currently acceptable dynamic analysis to satisfy the present criteria of NRC for an acceptable analysis.

F. Exit Interview

The investigators met with licensee representatives (denoted in Section C.1) at the conclusion of the investigation on February 22, 1980. The investigators summarized the scope and the findings of the investigation. In response to the findings and concerns expressed by the investigators, the licensee made a commitment for a written submittal to Region I office for the items listed below. The schedule of submittal as agreed to by Region I and the licensee is noted after each item.

1. A detailed description of design errors in original Ebasco design involving pipe restraints at penetration X-10A. The response will cover at least the following: (3/31/80)

   a. Results of the licensee's investigation as to the circumstances surrounding these design errors.

   b. The licensee's basis for providing assurance that similar design errors have not been made at other high energy pipe restaints (as much as possible by 3/31/80, and remainder in ten months).

2. A detailed description of cut reinforcing in the floor slab at the 82.75 foot elevation in the area of the containment penetration X-10A pipe restraint covering at least the following: (3/31/80)

   rocedural requirements in effect during plant construction regarding the cutting and documentation of cut reinforcing steel.

   b. Results of the licensee's investigation as to the circumstances causing the cut reinforcing steel.

3. A detailed description of differences in the placement of reinforcing steel between as built conditions and as-built drawings for the floor slab at the 82.75 foot elevation in the area of the containment penetration X-10A pipe restraint. (3/31/80)

   a. Procedural requirements in effect during plant construction regarding the verification of proper implementation of reinforcing steel design requirements.

b. Results of the licensee's investigation as to the circumstances causing the differences between reinforcing steel design requirements and the as-built conditions.

c. The licensee's basis for providing assurance that similar differences in reinforcing steel of other class one structures will not prevent those structures from performing their design functions.

4. The effect of water-hammer stresses on the margin of safety of the pipe restaints presently provided for the Isolation Condenser System. If modifications are found to be necessary, a schedule will be provided. (4/30/80)

5. The effects on the primary containment structure of the pipe stress forces transmitted by the present isolation condenser restraint to that structure at containment penetration X-10A. (3/31/80)

G. Management Meeting

A followup management meeting with the licensee was held in Region I offices on March 13, 1980, to discuss concerns that developed during the course of this investigation (see Inspection Report No. 50-245/80-05).