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Region 3, Office of Director

SUBJECT: Responds to NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants." Util in process of developing long term insp plan to detect & monitor erosion in high energy single phase water piping & dual phase steam piping sys.

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Iowa Electric Light and Power Company
September 11, 1987
NG-87-3091

Mr. A. Bert Davis
Regional Administrator
Region III
U.S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Response to NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants"
File: A-101a, A-103, A-107a, A-286

Dear Mr. Davis:

The purpose of this letter is to provide information requested in NRC Bulletin 87-01. In this Bulletin, the NRC staff requested that we submit information concerning our program for monitoring the wall thickness of pipes in condensate, feedwater, steam, and connected high energy piping systems, including all safety-related and non-safety-related piping systems fabricated of carbon steel. The attachment to this letter provides the requested information.

Should you have any additional concerns on this matter, please contact this office.

This letter is true and accurate to the best of my knowledge and belief.

IOWA ELECTRIC LIGHT AND POWER COMPANY

BY [signature]
William C. Rothert
Manager, Nuclear Division

Subscribed and sworn to Before Me on
this 11th day of September 1987.

[signature] Kathleen M. Furman
Notary Public in and for the Sate of Iowa

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PDR ADOCK 05000331
Q PDR

WCR/NKP/gj*
Attachment: Iowa Electric Response to NRC Bulletin 87-01: Thinning of Pipe Walls in Nuclear Power Plants

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IOWA ELECTRIC RESPONSE TO NRC BULLETIN 87-01: THINNING OF PIPE WALLS IN NUCLEAR POWER PLANTS

NRC Bulletin 87-01 requests that all nuclear power plant licensees submit information concerning their respective programs for monitoring the thickness of pipe walls in condensate, feedwater, steam, and connected high-energy piping systems, including all safety-related and non-safety related carbon steel piping systems.

Iowa Electric has been monitoring the development of information on the subject of erosion/corrosion in dual-phase steam piping and single-phase high energy water piping since these phenomena were identified as problem areas in the nuclear industry.

In 1985, inspections designed to detect evidence of erosion/corrosion in dual-phase steam piping systems were conducted at the Duane Arnold Energy Center (DAEC) in response to the Institute of Nuclear Power Operations (INPO) Significant Operating Experience Report Number 82-11 (SOER 82-11).

In 1987, following notification of the Surry pipebreak described in NRC Information Notice 86-106 and INPO Significant Event Report 1-87 (SER 1-87), a preliminary inspection program was developed which would determine if erosion/corrosion had occurred in single-phase high energy water piping in the DAEC feedwater and condensate systems. This program was initiated during the Spring 1987 Cycle 8/9 Refueling Outage.

Preparation of a comprehensive erosion/corrosion inspection plan covering all of the DAEC turbine-cycle piping was also initiated. It is expected that the long term inspection plan will be approved by Iowa Electric management during the fourth quarter of 1987 with implementation beginning during the Fall 1988 Cycle 9/10 Refueling Outage. The plan will be responsive to both INPO SOER 87-3 and NRC Bulletin 87-01.

This report provides the information requested in the NRC bulletin 87-01.

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NRC BULLETIN 87-01, ITEM 1.

Identify the Codes or standards to which the piping was designed and fabricated.

RESPONSE:

The DAEC piping systems which are susceptible to erosion/corrosion include the systems operating with dual-phase (wet steam) conditions and single-phase high energy water conditions. These systems were fabricated and installed to the following codes and standards:

System	Construction Code	Edition	Addenda
Main Steam	ANSI B31.1.0 Power Piping	1967	1970
Turbine Cross-Around	ANSI B31.1.0 Power Piping	1967	1970
Extraction Steam	ANSI B31.1.0 Power Piping	1967	1970
Feedwater Heater Drains	ANSI B31.1.0 Power Piping	1967	1970
Feedwater (Outside Drywell)	ANSI B31.1.0 Power Piping	1967	1970
Feedwater (Inside Drywell)	ANSI B31.7 Nuclear Power Piping	1969	1970
Condensate	ANSI B31.1.0 Power Piping	1967	1970

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NRC BULLETIN 87-01, ITEM 2.

Describe the scope and extent of your programs for ensuring that pipe wall thicknesses are not reduced below the minimum allowable thickness. Include in the description the criteria that you have established for:

a. selecting points at which to make thickness measurements
b. determining how frequently to make thickness measurements
c. selecting the methods used to make thickness measurements
d. making replacement/repair decisions

RESPONSE:

The erosion/corrosion inspection programs incorporated to date at DAEC have used different criteria for inspection, replacement, or repair depending upon whether the piping contained dual-phase wet-steam or single-phase water. This response is structured to identify the past criteria. Criteria applied to the future program are described in our response to Item 5.

A. DUAL-PHASE STEAM PIPING:

Steam cycle piping was inspected in 1985 in response to INPO SOER 82-11. The scope included high pressure turbine extraction steam piping, high pressure turbine exhaust piping, and feedwater heater drains subject to flashing. The materials in these systems include carbon steel pipe and fittings of the following specifications and grades: ASTM A-53 Grade B, ASTM A-106 Grade B, "Yoloy", copper-bearing ASTM A-155 Grade KC-55, and ASTM A-234 Grade WCB.

a. Criteria for Selection of Inspection Points. - Locations carrying steam with greater than 5 percent moisture or with steam velocities greater than 150 ft/sec and in the proximity of significant flow disturbances were identified as the most likely locations for erosion to occur. Forty percent of the locations identified were examined.

b. Criteria for Determination of Inspection Frequency. - The 1985 program for inspection of steam cycle piping was conducted to determine whether erosion/corrosion of any concern had occurred. The plan did not establish a repeat inspection schedule for piping found to have normal or less than normal wear. However, it did specify that, in the event more than expected erosion was detected, thickness examinations be performed on the remaining susceptible locations in a particular piping line and any eroded locations found would be reinspected during future outages.

   The 1985 post-inspection report recommended that the dual-phase steam piping locations which had been examined and found to be within expected wear should be subjected to similar examinations during the next 10 year inspection outage (i.e. 1995). The report also recommended that any locations which had been identified as eroded, but which were evaluated as acceptable without corrective action for at least one additional fuel cycle, be reinspected during the 1987 Cycle 8/9 refueling outage.

c. Criteria for Thickness Measurement Method. - The 1985 inspection program for steam cycle piping recommended that the examinations for evidence of erosion be performed by the ultrasonic method but did not indicate specific details regarding techniques or equipment to be used. The program recommended a 2-inch rectangular grid be used to inspect tees, elbows, and straight pipe. Pipe was to be inspected for a length of 5 pipe diameters downstream of flow restrictions. Pipe not initially scheduled for inspection, but located downstream of fittings in which the inspection results indicated erosion had occurred, were to be examined for a distance of 2 pipe diameters downstream of the fitting.

d. Criteria for Repair/Replacement Decisions. - The 1985 DAEC program for erosion/corrosion inspection of steam cycle piping considered erosion to have occurred if the inspected wall thickness was found to be less than 87.5 percent of the originally-specified nominal wall thickness. However, the piping was considered acceptable without engineering evaluation if the amount of erosion detected was less than that allowed for the length of time in service. Since the subject piping had a specified 40 year corrosion allowance, and the plant had operated for nearly 10 years, the inspection program indicated that piping exhibiting a thickness less than 87.5 percent of the nominal wall thickness minus 25 percent of the design corrosion allowance shall be evaluated and considered for possible replacement, subject to specific engineering analysis and judgment for each case so identified.

The steam piping inspection plan discussed is prescribed in detail in office letter NG-84-0631, Lessly to Mineck, dated February 7, 1984.

B. SINGLE-PHASE HIGH ENERGY WATER PIPING:

DAEC feedwater and condensate piping subject to single-phase high energy water conditions were inspected for evidence of erosion/corrosion in 1987 in response to NRC Information Notice 86-106 and INPO SER 87-1. The materials in these systems include piping of ASTM A-106, Grade B and A-333, Grade 6 and fittings of ASTM A-234, Grade WCB and A-420, Grade WPL-Special material specifications, respectively. The chemical and mechanical requirements for these materials are identical with the exception that the A-333 and A-420 materials require additional testing to verify impact resistance.

a. Criteria for Selection of Inspection Points. - The preliminary 1987 erosion/corrosion inspection program reviewed the DAEC feedwater and condensate piping systems to identify locations which:
(1) are fabricated of carbon steel without specific corrosion inhibiting alloys,
(2) encounter changes in flow direction or other flow disturbing characteristics within 10 pipe diameters,
(3) maintain a bulk flow rate of greater than 10 ft/sec during normal power operations,
(4) have normal operating temperatures between 195 and 440 degrees F,
(5) have an oxygen concentration of 600 ppb or less, and
(6) have continuous flow during operation.

Those portions of these systems which are used only during start-up or shutdown or do not experience continuous flow during normal power service were not considered for examination due to lesser service exposure. Sample selection priority was given to those locations with more severe flow disturbing characteristics and which are located relatively close to points where personnel may need access during power operation.

b. Criteria for Determination of Inspection Frequency. - The primary concern of the 1987 erosion/corrosion inspection program was to determine whether the DAEC had experienced single-phase erosion of a nature and magnitude similar to that experienced by the Surry Unit 2 Nuclear Power Station. Therefore the preliminary plan did not specify an inspection frequency, it concentrated upon identifying an appropriate representative sample to ensure that locations of highest concern were examined as soon as possible.

It was recognized that a long term erosion/corrosion inspection plan would be appropriate and parallel planning was initiated to develop such a plan. Refer to the response to Item 5 below, for details regarding the long-term inspection plan.

c. Criteria for Thickness Measurement Method. - The 1987 preliminary feedwater and condensate erosion/corrosion inspection plan specified that the ultrasonic (UT) method of thickness measurement be used. The plan recommended that a digital readout UT device be used for initial measurement, coupled with an "A" scan Cathode Ray Tube-type UT device for more detailed and final determination of thickness in the event erosion was located with the digital UT device. The plan indicated a two inch grid pattern be used, with grid points marked such that repeat examinations may be performed at a later date. It also specified that, if nearby points in the two-inch grid revealed significant differences, these areas should be examined using a one inch grid. Specific examples of grid patterns were provided within the plan for tees, elbows and reducers to aid repeatability for future examinations.

d. Criteria for Repair/Replacement Decisions. - The acceptance standard for the 1987 feedwater and condensate erosion/corrosion inspections was the same as that for the steam piping inspection conducted in 1985. That is, any piping component exhibiting a thickness less than 87.5 percent of the specified nominal wall thickness minus 25 percent of the design corrosion allowance shall be evaluated and may be subject to replacement, subject to specific engineering analysis and judgement for each case so identified.

These acceptance criteria were designed to identify any areas which exhibit a degree of erosion greater than that expected and allowed for in the design and to provide a measure of conservatism above the minimum allowable material thickness required by design parameters. Examination results below the established acceptance standard do not necessarily indicate that such piping or fittings automatically need replacement, but do indicate that such areas require immediate evaluation by engineering for determination of current acceptability of remaining wall thickness. If the component was deemed acceptable for continued service, these areas will require additional monitoring through repeated future examinations at a frequency determined on the basis of the degree of erosion observed.

The above single-phase high energy water piping inspection plan is described in detail in office letter NG-87-0632, Lessly to Matthews/Mineck, dated February 23, 1987.

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NRCB 87-01, ITEM 3.

For liquid-phase systems, state specifically whether the following factors have been considered in establishing your criteria for selecting points at which to monitor piping thickness (Item 2a):

a. piping material (e.g. chromium content)
b. piping configuration (e.g. fittings less than 10 pipe diameters apart)
c. pH of water in the system (e.g. pH less than 10)
d. system temperature (e.g. between 190 degrees and 500 degrees F.)
e. fluid bulk velocity (e.g. greater than 10 ft/s)
f. oxygen content in the system (e.g. oxygen content less than 50 ppb)

RESPONSE:

This response specifically addresses the factors which have been considered to date in the planning and implementation of erosion/corrosion inspections of high energy single-phase water piping at DAEC. Refer to the response to Item 5 below regarding any changes to the factors being considered for future inspection program criteria. The following factors were considered for selecting locations to be examined within the program:

a. Piping Material - Piping without specific alloy content known to inhibit erosion/corrosion was considered for inclusion in the inspection plan. All piping in the DAEC feedwater and condensate systems is plain carbon steel piping of material specifications for pipe ASTM A-106, Grade B and A-333, Grade 6 and fittings ASTM A-234, Grade WCB and A-420, Grade WPL-Special, respectively. These materials are all identical with regard to chemical content and mechanical property requirements, with the additional requirement that the A-333, Gr. 6 and A-420, Gr. WPL-Special materials be verified as impact resistant. None of the material specifications require a specific alloy content for elements known to inhibit erosion/corrosion, therefore all piping in these systems is considered to be susceptible from the material point of view.

b. Piping Configuration - Areas in the DAEC feedwater and condensate systems within ten (10) pipe diameters of flow-disturbing devices or changes of flow direction were identified and considered for examination. The piping locations which were most severe with regard to flow disturbing configuration were given a priority for subsequent inspection.

c. pH Factor - The pH factor of the DAEC feedwater and condensate system piping was considered. Information from DAEC Plant Chemistry section indicates the feedwater and condensate systems have consistently operated at less than 8.6 pH. This is less than the value above which erosion/corrosion susceptibility appears to be diminished according to several written reports. The feedwater and condensate systems are considered not to have benefited from a high pH and therefore, remain susceptible to erosion/corrosion if the other factors which promote erosion/corrosion are present. No locations were eliminated from the need to inspect because the pH factor history did not warrant it.

d. <u>System Temperature</u> - The normal system operating temperature was a basis for selection of piping to be inspected. All feedwater and condensate piping operating between 195 degrees F. and 440 degrees F. was considered to be an inspection candidate. All temperatures in this range were given the same relative consideration during the selection process.

e. <u>Fluid Bulk Velocity</u> - Piping with flow velocities over 10 ft/sec were included in the selection process. The feedwater and condensate system piping is calculated to have flow rates of 11.5 ft/sec to 19.0 ft/sec, therefore, no portions were elimimated from consideration merely on the basis of bulk fluid velocity.

f. <u>Oxygen Content</u> - Dissolved oxygen content of 600 ppb or less was an inspection candidate criterion. It has been determined that the DAEC feedwater and condensate systems have historically operated with 15 tp 20 ppb oxygen with occasional spikes to 60 ppb, therefore none of the feedwater and condensate piping was excluded from the inspection plan merely on the basis of oxygen content.

g. Other factors not listed in NRC Bulletin 87-01 which were considered:
   1. <u>Service factor</u> - Piping that does not see operating conditions as part of standard day-to-day activities was not included in the selection due to a lower effective exposure to service conditions.
   2. <u>Proximity to personnel</u> - Piping locations considered to be likely targets for erosion/corrosion and which are proximate to locations where personnel may need access during power operation were identified and assigned a higher priority in the inspection schedule than other locations.

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NRC BULLETIN 87-01, ITEM 4.

Chronologically list and summarize the results of all inspections that have been performed, which were specifically conducted for the purpose of identifying pipe wall thinning, whether or not pipe wall thinning was discovered, and any other inspections where pipe wall thinning was discovered even though that was not the purpose of that inspection.

a. Briefly describe the inspection program and indicate whether it was specifically intended to measure wall thickness or whether wall thickness measurements were an incidental determination.

b. Describe what piping was examined and how (e.g., describe the inspection instrument(s), test method, reference thickness, locations examined, means for locating measurement point(s) in subsequent inspections).

c. Report thickness measurement results and note those that were identified as unacceptable and why.

d. Describe actions already taken or planned for piping that has been found to have a nonconforming wall thickness. If you have performed a failure analysis, include the results of that analysis . Indicate whether the actions involve repair or replacement, including any change of materials.

RESPONSE:

This response deals separately with the two inspection programs applied to date as previously described in the response to Item 2 above.

A. DUAL-PHASE STEAM PIPING:

a. Purpose of Inspection: During 1984, in response to INPO SOER 82-11, Iowa Electric developed an inspection plan to determine whether pipe wall-thinning had occurred in DAEC steam piping subject to dual-phase conditions. This plan was implemented during the 1985 refueling outage.

b. Scope and Method of Inspection: The plan encompassed steam cycle piping with greater than 5 percent moisture content or steam velocities greater than 150 ft/sec in the proximity of significant flow disturbances. Examinations were performed using a digital readout ultrasonic device. The standard applied for acceptance without additional evaluation was based upon 87.5 percent of the original nominal wall thickness (nominal wall thickness less the normal manufacturing tolerance) less 25 percent of the original design corrosion allowance (based upon having operated for 25 percent of the plant design life). Refer to Part A of the response to Item 2 above for greater detail regarding the plan description.

A total of 153 DAEC steam cycle locations were identified in 1985 as probable candidates for erosion/corrosion. A sample of sixty-two (62) of the identified locations were inspected. The inspected locations included 20 pipe segments, 32 ells, and 10 tees.

c. Results of Inspection: Sixty (60) of the dual-phase steam piping locations examined were found to be within expected wear and therefore acceptable. Two (2) fittings were reported with a few minor localized thickness measurements below the established acceptance criteria.

d. Actions Taken or Planned: Both of the locations where wall thickness measurements was less than the criteria were judged to be acceptable for continued service.

One of the two locations of wall-thinning was determined to be due to external corrosion resulting from an environment of high moisture content and leachable chlorides from the surrounding insulation.

This location was on a section of pipe from the fifth low pressure heater on the "A" feedwater loop (1E-5A) to the condenser. All pipes in the same vicinity were visually examined for evidence of similar external corrosion and no further corrosion was detected. The location was re-examined during the 1987 refueling outage and found that no additional wall-thinning had occurred. This location will be re-examined again during the next scheduled refueling outage.

In the second location, the identified wall-thinning was attributed to internal erosion/corrosion but was considered to be of a minor degree and highly localized. The location was on an elbow upstream of a control valve (CV-1109) near the flash chamber (1T-2A) in the drain line from the second low pressure heater (1E-2A) on the "A" feedwater loop. The 1985 post-inspection report stated the location had been evaluated as safe for continued operation for at least one additional fuel cycle and was recommended for reinspection at the next outage. This fitting was re-examined during the 1987 refueling outage and found acceptable as discussed below.

Review of the data indicates the fitting discussed above was in fact acceptable in 1985 without need for engineering evaluation. The acceptance standard applied to this fitting in 1985 was in error; it assumed the nominal thickness was 0.500 inch when in fact it was 0.375 inch. The measured readings in 1985 were very close to the correct nominal thickness indicating that this fitting had not experienced undue erosion as previously thought. The 1987 re-examination has verified this conclusion.

The 1985 post-inspection report recommended that the accepted steam piping locations be subjected to similar examinations during the next 10 year inspection outage (i.e. 1995). The report is documented in office letter NG-85-2225, dated May 7, 1985.

B. SINGLE-PHASE HIGH ENERGY WATER PIPING:

a. Purpose of Inspection: During early 1987, due to the feedwater suction pipe break incident at the Virginia Power, Surry Unit 2, Nuclear Power Station, Iowa Electric developed a preliminary inspection program to determine whether the DAEC feedwater and condensate piping had experienced erosion/corrosion of a similar nature. The program was implemented during the 1987 refueling outage.

b. Scope and Method of Inspection: The preliminary inspection program covered feedwater and condensate piping. It utilized information received regarding the Surry Unit 2 incident provided in NRC Information Notice 86-106, Supplements 1 and 2 to NRC Information Notice 86-106, INPO SER 1-87 and other documents concerning the erosion/corrosion phenomenon. The preliminary program was designed to verify adequacy of wall-thickness of piping:
(1) fabricated of carbon steel materials,
(2) with fittings and other flow disturbing devices less than 10

pipe diameters apart,
(3) with pH less than 8.6,
(4) with operating temperature between 195 and 440 degrees F.,
(5) bulk flow rate over 10 ft/sec,
(6) oxygen content less than 600 ppb, and
(7) which is not idle during power operation.
Refer to Part B of the response to Item 2 above for greater detail regarding the plan description.

A total of 159 feedwater and condensate piping locations were identified as probable candidates for single-phase erosion/corrosion based on a review of piping conditions. A representative sample of 50 of these locations was selected for inspection. The piping locations selected for examination were determined by review of drawings and selecting locations subject to the most severe flow disturbances, giving a priority in the examination schedule to locations proximate to personnel during power operation.

Examinations were performed using the pulse-echo ultrasonic method with zero degree longitudinal beam transducers of 2.25 MHz, 0.50 inch diameter and 5.0 MHz, 0.25 inch diameter. The reference thickness acceptance standard established for this examination was the same as that used for the steam piping examinations conducted in 1985. That is, any piping component exhibiting thickness measurements less than 87.5 percent of the original specified nominal wall thickness minus 25 percent of the design corrosion allowance would require immediate evaluation for continued acceptability. Grid patterns based upon a two inch grid were provided for elbows, tees, and reducers and pipe to aid in locating data points for future examinations.

c. <u>Results of Inspection</u>: During the 1987 refueling outage 21 of the 50 selected locations were examined. All of the 21 locations exhibited satisfactory wall-thicknesses and are considered acceptable. Six (6) of the locations examined and accepted yielded localized thickness measurements which are above the established minimum by an amount which may be within the limitations of accuracy of the inspection system. These six locations are all in the condensate piping. They include a section of 24" diameter piping (GBD-7-1) downstream of a tee, a 24"x16" reducer at a tee on the "A" feedwater loop (GBD-7-2), a 16" 90 elbow at a reducer on the "A" feedwater loop (GBD-7-2), an 18"x16" reducer at feedwater pump 1P-1B (GBD-10-5), 18" diameter pipe section between a gate valve and reducer near feedwater pump 1P-1B (GBD-10-5), and a similar 18" diameter pipe section between a gate valve and reducer near feedwater pump 1P-1A (GBD-10-6). In addition to the condensate locations listed above, one of the re-examined steam drain locations mentioned above (a 10" diameter pipe section downstream of a control valve on HBD-4-1) yielded similar results. Plans are to re-examine these seven locations during the next refueling outage.

Details regarding the 1987 inspections are documented in a report entitled "Report Of The 1987 Refueling Outage Investigation For

Evidence Of Possible Erosion/Corrosion In The Feedwater And Condensate Piping Systems At The Duane Arnold Energy Center, Palo, Iowa", dated July 31, 1987. The report was transmitted in office letter NG-87-2911, Lessly to Rothert, dated July 31, 1987.

C. SPECIFIC CASES OF DAEC PIPE WALL-THINNING DISCOVERED THROUGH MEANS OTHER THAN THE INSPECTION PLANS DESCRIBED ABOVE

During the evaluation of INPO SOER 87-03 by the Plant Technical Support group several cases of maintenance activities regarding correction of erosion degraded piping were identified. Several sections of 1 inch and 1 1/2 inch diameter common header steam drain piping (EDB-3) from the High Pressure Coolant Injection (HPCI) and Reactor Core Isolation (RCIC) drain pots to the condenser have been replaced due to erosion. In addition, two 10 inch diameter elbows with inner wall erosion were discovered during periodic inspection of the Moisture Separator Reheaters (MSRs) and were replaced during the 1987 refueling outage. The steam drain and MSR piping involved is non-safety related. These replacement activities are documented on Corrective Maintenance Action Requests (CMARs) and are outlined below:

a. July 14, 1984 (CMAR 57655) A hole was reported in the 1 1/2" EBD-3 steam drain line common header from the HPCI/RCIC steam supply drain pot to the condenser. This line is subject to normal operating conditions of 1000 psig pressure at 545 degrees F. A socket welded elbow was cut out and replaced with a 6000 lb. rated socket welded elbow of A-105, Grade II material. The replacement welds (FSK-3560, Welds A and B) were examined with liquid penetrant and verified satisfactory. The construction code was ANSI B31.1.0. No failure analysis was performed.

b. February 6, 1985 (CMAR 60561) A weld with a pinhole leak was reported in the 1 1/2" EBD-3 steam drain common header from the HPCI/RCIC steam supply drain pot to the condenser. This is a different portion of the line discussed in a. above. A socket welded elbow was cut out and replaced with a 6000 lb. rated socket welded elbow of A-181, Grade II material. The replacement welds (FSK-3561, Welds A and B) were examined with liquid penetrant and verified satisfactory. The construction code was ANSI B31.1.0. No failure analysis was performed.

c. November 21, 1985 (CMAR 69131) An elbow was reported as needing replacement in the 1 1/2" EBD-3 steam drain common header from the the HPCI/RCIC steam supply drain pot to the condenser. This is again a different portion of the same line discussed in a. and b. above. In this case, a section of piping and the elbow were replaced with a bent section of new pipe of A-106, Grade B material. The pipe was bent in lieu of replacing the elbow. The replacement welds (FSK-3560, Rev. 1, Welds A and B) were examined with liquid penetrant and verified satisfactory. The construction code was ANSI B31.1.0. No failure analysis was performed.

d. November 30, 1985 (CMAR 70517) An elbow was reported as needing a repair to an existing temporary sealant patch on the same line as discussed in a., b., and c. above. The old temporary patch was replaced with a new temporary sealant patch. The line was post-maintenance tested to verify satisfactory repair. No failure analysis was performed.

e. December 12, 1985 (CMAR 70592) An elbow was reported leaking due to erosion in the same line as discussed in a. through d. above. The leak was reported to be just upstream of a prior leak. The leak (and the prior leak) was stopped with a temporary sealant patch. No failure analysis was performed.

f. December 13, 1985 (CMAR 70048) The same elbow which was repaired with a temporary patch on December 12 (e. above) was reported as requiring replacement. This time, a section of pipe and the elbow were replaced with new pipe of A-106, Grade B material with 5 O.D. bends. One replacement weld (FSK-3560, Rev. 1, Weld C) was examined with liquid penetrant and verified satisfactory. The construction code was ANSI B31.1.0. No failure analysis was performed.

g. December 27, 1985 (CMAR 70751) Several leaks were reported in the 1 1/2" EBD-3 drain pot drain line to the condenser. This is the same line discussed in a. through f. above. The entire line, including the 1" EBD-3 portion, was visually inspected and major portions were replaced in March 1986. The replacement pipe and socket welded fittings were of A-106, Grade B and A-105, Grade II, respectively. The replacement welds (FSK-3560 Welds B and C; FSK-3561 Welds A, B, C, D, E, F, G, H, K, and L; FSK-4493 Welds I and J) were examined with liquid penetrant and verified satisfactory. The construction code was ANSI B31.1.0. No failure analysis was performed.

h. May 19, 1987 (CMARs 76494, 76495, 82606, 82607) Erosion was reported in two 10 inch elbows in the vent line from the moisture separator drain tank to the Moisture Separator Reheaters. The erosion was discovered during a scheduled internal inspection of the reheaters. The elbows were replaced with new elbows of ASTM A-234, Grade WCB during the 1987 outage. The construction code was ASME Section VIII. No failure analysis was performed.

i. June 3, 1987 It was reported the 4A feedwater heater has experienced tube leaking on the shell side. The feedwater heaters are being monitored for tube leaks with a periodic eddy current inspection program. To date approximately 9 percent of the tubes in the 4A heater have been plugged due to leaking tubes. Causes of the feedwater heater tube leakage have been investigated and are discussed in a report entitled "Report and Comments on Observations of the Number 4A Feedwater Heater" by Fred Linley of Southwest Engineering Services Company. One of the causes of erosion was determined to be maintenance of an inadequate level of water in the heater.

Considerable vibration was also reported within the 4A feedwater heater, possibly due to turbulence from two phase conditions. Discussions are currently in progress regarding refurbishment or possible replacement of heater 4A at the next outage.

While the above discussion concerns feedwater heater tubes internal to the heater, it was recommended the heater 4A drains be included in the long term erosion/corrosion inspection plan. This proposal will be incorporated into the plan under development. (Note - a 16" tee in the 4A feedwater heater drain and a similar tee in the 4B feedwater heater drain were inspected as part of the 1985 steam erosion inspection, no erosion was detected in these items at that time).

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NRC BULLETIN 87-01 - ITEM 5.

Describe any plans either for revising the present or for developing new or additional programs for monitoring pipe wall thickness.

RESPONSE:

As mentioned in Part C of the response to Item 2 above, Iowa Electric is in the process of developing a long term inspection plan to detect and monitor erosion in high energy single-phase water piping and in dual-phase steam piping systems. Information regarding plant experiences and suggested approaches for monitoring the erosion and erosion/corrosion phenomena as provided by the NRC, INPO, NUMARC, EPRI and other industry sources are being considered for incorporation into the plan as such data becomes available. Appropriate consultant services with expertise in this field are being utilized as needed. Details regarding the specific components and quantity to be inspected are not final as of this date but the generic approach to the plan has been determined and is described below. The plan is expected to be reviewed and approved by Iowa Electric management during the fourth quarter of 1987 for initial implementation during the next scheduled (Cycle 9/10) refueling outage, currently planned for October/November 1988.

It is expected the DAEC long term erosion/corrosion inspection plan currently under development will modify the earlier DAEC inspection programs. The program differences will probably relate specifically to the quantity of items to be inspected, specific sample selection, and frequency of inspection.

Currently, it is planned that erosion/corrosion inspections be limited to turbine cycle piping since it is considered to be the piping most susceptible to the erosion/corrosion phenomenon. This includes the following systems:

Condensate and Condensate Demineralizer
Feedwater
Main Steam and Turbine Crossover Piping
Extraction Steam
Heater Drain

Other systems using carbon steel piping but which are not subject to continuous operating conditions (i.e. Emergency Core Cooling Systems, etc.) will not be considered in this program because of the relative lower service factor.

The piping lines to be considered are those in the main flow path of the turbine cycle that have fluid flowing during power operations, startup and shutdown. Small diameter piping (2 inch and less) is currently not included in the scope. The sample selection criteria will be based upon factors which contribute to erosion/corrosion and additional safety considerations as listed below:

Piping materials	(relative alloy content)
Operating conditions	(flow velocity, temperature, pressure)
Fluid conditions	(moisture content(steam), oxygen content, pH)
System configuration	(relative severity of changes in fluid momentum, flow restrictions, low points(steam), flash points)
Relative Service Time	(accumulated time at operating conditions)
Safety considerations	(proximity to personnel or to equipment needed for safe shutdown, accident mitigation, security or fire protection)

The relative weights assigned to each erosion/corrosion contributing factor will be compiled for each piping component in the systems reviewed. This compilation will produce an empirical erosion/corrosion probability ranking for each piping component. The components which have the highest ranking will be listed as the prime components in the inspection sample.

The plan under current consideration will inspect at least 25 percent of the prime component sample list during each refueling outage in a manner which will ensure that 100 percent of the sample will have been inspected within each successive set of four refueling outages. The plan will provide a mechanism for prudently increasing the number of inspections during an individual outage in the event erosion/corrosion damage is detected. Components with thickness measurements near or below the established acceptance standard but evaluated as acceptable for continued use will be added to the 25 percent sample to be examined at each successive refueling outage.

The long-term erosion/corrosion inspection plan will address a mechanism for locating specific data points for future repeat inspections.

The acceptance/rejection criteria will be those used previously: i.e., components which indicate thickness measurements which are less than a value equivalent to 87.5 percent of the original specified nominal thickness (minimum permitted original thickness based upon manufacturing tolerance) minus the relative percent of the design corrosion allowance based upon service life vs. design life (40 yrs). Areas revealing thicknesses below the acceptance value will be evaluated by Design Engineering taking into account the specific value recorded, the extent of the condition, supplementary thickness readings, and design requirements.

The thickness of all samples will be tracked and trended to determine relative erosion rates and predict when an item may require eventual replacement.