Central Files

# DUKE POWER COMPANY

POWER BUILDING

422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

JUL 15 AM 11:49

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

July 10, 1980

TELEPHONE: AREA 704
373-4083

Mr. James P. O'Reilly, Director
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

Re: Oconee Nuclear Station, Unit 2
Docket No. 50-270
IE Bulletin 79-13

Dear Mr. O'Reilly:

With regard to my letter of June 19, 1980 which provided preliminary results of the examinations of the Unit 2 feedwater nozzles, please find attached a copy of the final report of this examination prepared by Helmut Thielsch.

Very truly yours,

William O. Parker, Jr.

RLG:scs
Attachment

T

8007290267

Q

OFFICIAL COPY

**HELMUT THIELSCH**
METALLURGICAL ENGINEER

# EXAMINATION OF RADIOGRAPHIC FILMS AND CONSIDERATIONS OF WELD INTEGRITY OF PIPE BUTT WELDS IN 3" OD BY 0.300" WALL AUXILIARY FEEDWATER PIPING UNIT No. 2 OCONEE NUCLEAR POWER STATION DUKE POWER COMPANY

Helmut Thielsch, PE

May 31, 1980

Report No. 1999

## INTRODUCTION

In May 1979, the Indiana and Michigan Power Company discovered cracking in two feedwater lines in Unit No. 2 of the D. C. Cook Power Station. The cracks resulted in leakage through the two pipe sections involved. Subsequent examinations confirmed that the cracks had occurred in and progressed through the base metal adjacent to the weld deposits.

The pipe size which leaked at the D. C. Cook Power Station was 16" diameter. The cracking occurred in elbows adjacent to the girth welds to the steam generator nozzles. The circumferential cracks resulting in the steam leaks were located on the elbow side of the girth welds.

Similar cracking has occurred in the feedwater piping at other nuclear power stations. In each instance, the cracks developed in the base metal adjacent to the girth welds.

The cracking conditions have been associated primarily with corrosion fatigue, where the fatigue represents the primary cause.

Many similar failures have occurred in piping in fossil fuel power plants, chemical plants, paper mills, and related installations. The failure patterns generally are very similar. The gradually progressive cracking is primarily caused by fatigue and corrosion. These types of failures normally result in leaks. The pipes involved generally are, and have been readily repair welded subsequent to the discovery of the leaks.

To determine the possibility and the extent of similar conditions of cracking in various other nuclear plants, the Nuclear Regulatory Commission issued Bulletin No. IE 79-13 (Appendix A). This Bulletin required that Licensees operating steam generators fabricated by Westinghouse Electric or Combustion Engineering perform radiographic examinations of feedwater nozzle-to-pipe welds. The evaluations are to be performed in accordance with Section III of the ASME Boiler and Pressure Vessel Code, Subsection NC, Article NC-5000 (Appendix B).

The radiographic examination was to be performed to the 2T penetrameter sensitivity level.

Although the concern should involve primarily evidence of cracking in the pipe base metal, the Licensees were also asked to identify weld defects apparent on the radiographic films.

Evidence of cracking or weld discontinuities were to be reported to the Nuclear Regulatory Commission.

ORIGINAL WELD FABRICATION

The feedwater piping system in Unit No. 2 at the Oconee Nuclear Power Station originally was subject to the requirements of ANSI B31.1. This Standard did not require radiographic examination of the butt welds in the auxiliary feedwater piping, which involves 3" Schedule 80 piping (0.300" wall). (Other ASME Standards similarly would not require radiographic examination of these butt welds at the applicable design conditions).

Isometric sketches of the auxiliary feedwater piping on Steam Generators 2A and 2B are shown in Figs. 1 and 2.

The auxiliary feedwater piping involved is normally subject to a temperature of 90°F and a pressure of 1300 psig. (The design temperature is 100°F and the design pressure is 1440 psig).

The nozzle connections involve welding neck flanges with butt welds between the flanges and the header nozzle sections, and between the flanges and the pipe sections. On the other pipe ends, elbows are welded to the welding neck flanges. The pipe sections between the welding neck flanges are 18" long. Each section consists of a butt weld between two 9" long pipe sections, and a butt weld between the pipes and elbows.

The weld end preparation involved a standard $37\frac{1}{2}^{\circ}$ bevel with a 1/8" thick land at the weld root. The weld was fit up without a backing ring and with a weld root spacing of approximately 1/8".

Welding of the root pass was done by the inert-gas tungsten-arc process. Each butt weld was then completed by shielded metal-arc welding utilizing AWS E7018 electrodes.

The welding procedures and welders were qualified to

Section IX of the ASME Boiler and Pressure Vessel Code.

RADIOGRAPHIC EXAMINATION

In accordance with the requirements detailed in Bulletin IE 79-13, nozzle welds in the feedwater piping of Unit No. 2 at the Oconee Nuclear Power Station were inspected by radiographic examination.

The radiographic examination was performed by Duke Power Company personnel. The radiographic examination was done with Iridium 192 isotopes and Kodak Type R film.

The radiographic examination involved the butt weld between the welding neck flange at the steam generator connection and the 90$^{o}$ elbow and butt weld between the 9" long pipe sections. Both of these welds represented field welds.

The butt welds between the 90$^{o}$ elbows and the pipe sections were not radiographed, as these welds represented shop welds.

The radiographic film technique is considered acceptable, as the penetrameters were discernible on the radiographic films.

Copies of the original inspection reports are provided in Appendix C for Steam Generator "2A", and in Appendix D for Steam Generator "2B".

The radiographic films were subsequently examined by this Examiner. In addition to the welds, the radiographic films covered at least 1½" of the base metal adjacent to the weld joints. This is the area where normally, cracking associated with fatigue enhanced by corrosion (or corrosion fatigue) has occurred.

## WELD INTERPRETATION

There was no evidence of any cracking in the flange, elbow or pipe base metals adjacent to the butt welds examined.

There was also no evidence of cracking in any of the weld deposits.

The final interpretation reports are provided in Appendices E and F.As would be expected in welds not subject to radiographic examination requirements,intermittent weld defects were apparent in a number of these welds. Typical examples are illustrated in Figs. 3 to 11, showing prints of the original radiographic films examined.

The interpretations are based upon the examination of the original radiographic films. (It is recognized that prints of the radiographic films will define somewhat less clearly penetrameters and weld contour variations than the original radiographic film negatives).

In weld 2A, 1-FLG-ELB, a half-inch long root concavity is located in film section 0-1, Fig. 3. At the location of the root concavity, the density of the film confirms that the weld thickness is greater than of the adjacent pipe base metal. Thus, at the location of the root concavity, the pipe weld thickness meets the minimum wall thickness requirements.

A slight root edge condition may also be present.

In girth weld 2A 5-FLG-ELB, a 1/4" long root concavity is apparent. Along one side of the land, the root edge is apparent. The root edge on the other side has been fused and is tapered gradually.

The film density confirms that the wall thickness at the location of the concavity is greater than the wall thickness of the pipe base metal. A print of the radiographic film is shown in Fig. 4.

On weld "2A" 6-FLG-ELB, concavity was also apparent at station marker 0, Fig. 5. The edge of the land is uneven, confirming fusing into the original land. The density of the film also confirms that the wall thickness at the location of the concavity exceeds the thickness of the adjacent pipe material.

It may be noted in these welds that the concavity indications occur at the same locations around the pipe circumference. It is thus apparent that welding was started at the "O" station marker location. The initial welding heat, as frequently applies, tended to provide somewhat greater heat, resulting in the local concavity conditions.

In weld "2A" 7-FLG-ELB, a concavity was apparent on film section 2-3, Fig. 6. The extent of the concavity was 3/16". The density at this location exceeds the thickness of the elbow material.

In weld "2A", 7-pipe-pipe, a 1/4" long root edge (RE) is apparent. However, the cross section has been filled with weld metal, Fig. 7.

Very minor concavity with acceptable porosity is illustrated in Fig. 8 for weld "2B" 2-FLG-ELB on film section 4-0.

The majority of film sections actually provided essentially "water clear" films without any defect indications. A typical section is shown in Fig. 9 representing weld "2B" 5-pipe-pipe, film section 4-0.

In weld "2B" 6-FLG-ELB, a 1/2" long lack of penetration was apparent along the inside surface of the pipe at station marker 3. Nevertheless, the depth of this indication has not encroached on the minimum wall thickness of the pipe. Its consequence thus is identical to concavity, which at the extent apparent, does not result in service failures, when the minimum wall thickness requirements are met. A print of the radiographic film involved is shown in Fig. 10. This defect has not resulted in cracking, and is not expected to result in cracking. If a fatigue failure should develop at this location, it would tend to occur in the heat-affected zone of the base metal adjacent to the weld deposit because of the reinforcement provided by the weld. Repair welding of this area would not improve the weld quality.

In weld joint "2B" 7-pipe-pipe, a root edge was apparent on several of the film sections. The most pronounced condition is shown in Fig. 11 for film section 0-1. Since the first pass was made by inert-gas tungsten-arc welding, and this welding process readily produces fusion, the defect condition is the result of a root edge, representing nearly complete penetration of the weld bead to the inside surface. The weld cross section exceeds by a significant margin the minimum wall thickness of the pipe. In a severe fatigue environment with additional superimposed stresses, failure would occur in the base metal adjacent to the weld deposit.

Other occasional weld defects apparent in the weld joints involved primarily intermittent porosity and slag, and tungsten inclusions. None of these are of significance.

The weld roots generally exhibited good ID root appearance. In some instances, where the underside of the weld and the inside of the pipe were accessible from the open flange end, the welder also appears to have done some grinding of the underside of the root weld beads.

Root weld beads, particularly where they penetrate below the inside pipe surface, may exhibit root bead edges. This may give the appearance of a slag line on radiographic films. This condition tends to occur at tack welds, or in weld repairs. It is neither harmful nor rejectable.

## DISCUSSION

The weld quality is typical of acceptable pipe welds made under Section I of the ASME Boiler and Pressure Vessel Code, or the American National Standards Institute Standard B31.1, as applicable to feedwater piping involving sizes not subject to radiographic examinations.

Where subsequent radiographic examinations are performed for purposes of background information or quality assurance, these welds generally have been judged as acceptable. Failures have not resulted from the types of internal weld defects apparent on the radiographic films examined from Unit No. 2.

Many of the defects are well within the acceptable limits of the ASME Boiler and Pressure Vessel Code. In a few instances, the defects would be considered borderline under the interpretation standards, even though they would not cause cracking and weld failure. Moreover, where these defects are considered borderline, different examiners may apply different interpretations. Thus, one Level II Examiner may consider a particular weld acceptable, whereas a second Examiner may consider the same level of weld defects as not acceptable.

Based on normal requirements applicable to feedwater piping, there were no rejectable weld defect conditions which would affect weld integrity, or the ability of the pipe welds to perform satisfactorily.

None of the minor weld defects apparent involving primarily minor concavity, slag or tungsten inclusions, or porosity would either cause or contribute to the type of nozzle, or pipe cracking conditions described in Nuclear Regulatory Commission Bulletin No. IE 79-13.

The weld appearance is good and adequate for weld joints welded to American National Standards Institute Standards ANSI B31.1, or B31.7, and to Section I of the ASME Boiler and Pressure Vessel Code.

Inconsequential internal weld defects which do not reduce significantly the pipe wall thickness at the locations of the weld joints, and which do not tend to propagate into cracks, generally should not be repaired by welding. The reason is that the weld repairs tend to produce higher levels of localized residual stresses. These are far more significant than the inconsequential internal weld defects.

There have been many instances where excessive weld repairs have subsequently led to cracking (usually starting in the adjacent base metal), whereas the original welds did not evidence cracking originating from weld defects.

In most piping systems, a high residual stress, which is not detectable on radiographic films or in ultrasonic examinations, may be far more detrimental to the integrity of a weldment than a weld defect such as a slag line, porosity, or even lack of fusion, which do not extend significantly through the pipe wall thickness.

The weld defect conditions apparent in the butt welds examined in the feedwater piping covered by this report are considered entirely inconsequential, and not of a type which results in weld failures. This applies even to piping systems subject to significant fatigue. If such significant fatigue should occur with or without corrosion (i.e., fatigue or corrosion fatigue), the resulting cracking will tend to initiate and propagate in the base metal from the inside surface through the wall thickness along either side of the weld joint. This has been confirmed by large numbers of failure analyses performed on piping systems subject to fatigue, and involving piping in fossil fuel power plants, nuclear power plants, petrochemical plants, paper mills and other installations.

## CONCLUSIONS

The butt welds in the feedwater piping adjacent to the welding neck flanges on the "A"and "B" Risers at the steam generator connection represent acceptable quality levels in accordance with the requirements of American National Standards Institute Standards ANSI B31.1 and B31.7. The same conclusions apply to the butt welds in the 18" long pipe sections.

The weld defects apparent represent intermittent defect conditions generally considered acceptable in radiographic film interpretation standards applicable to weld joints in critical high-temperature high-pressure piping.

These defects have not reduced the integrity of the feedwater pipe welds involved. They will not result in failures in piping systems subject to fatigue and/or corrosion fatigue.

Repair by welding of specific isolated weld defects would not improve further the acceptable level of integrity of the piping.

The radiographic examinations also confirm the absence of cracking in the welding neck flange, elbow or pipe base materials, where cracking in some feedwater system piping has occurred in other nuclear power plants.

The feedwater piping at the "A" and "B" Riser connections in Unit No. 2 is suitable for continued service.

IE BULLETIN NO. 79-13

REVISION 2

CRACKING OF FEEDWATER SYSTEM PIPING