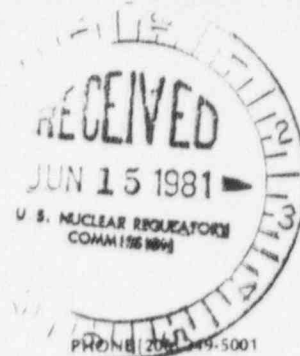


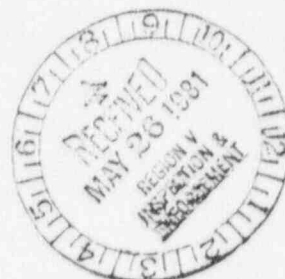
Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. BOX 1223

ELMA, WASHINGTON 98541



May 21, 1981
G03-81-2011



Nuclear Regulatory Commission, Region V
Suite 202, Walnut Creek Plaza
1990 N. California Boulevard
Walnut Creek, California 94596

Attention: Mr. B. H. Faulkenberry
Chief, Reactor Construction Projects Branch

Gentlemen:

Subject: PROJECT NOS. 3 AND 5
NRC INSPECTION OF WNP-3 AND WNP-5
DOCKET NUMBERS 50-508 AND 50-509
FINAL REPORT OF POTENTIAL 10CFR50.55(e)
HYDROGEN EMBRITTLEMENT OF 3/4 INCH
LOCKWASHERS

References: 1) Supply System Record of Telecon, J. C. Lockhart
to D. Kirsch, dated April 28, 1981.

2) Supply System Record of Telecon, J. C. Lockhart
to D. Kirsch, dated May 12, 1981.

Ebasco Engineering has determined that the hydrogen embrittlement of the 3/4 inch lockwashers is not reportable as a 10CFR50.55(e) as the present design of the cable tray seismic supports preclude the use of lockwashers.

These lockwashers were purchased by Fischbach and Moore from the Ray Bristow Company, Inc., in Portland, Oregon. Please find attached a copy of analysis on subject washers performed by Charlton, Inc., also of Portland, Oregon, for your information.

Should you have any questions or desire further information, please feel free to contact me directly.

Very truly yours,

R. S. Leddick
R. S. Leddick

Program Director, WNP-3/5

Attachments

cc: D. Smithpeter - BPA
Ebasco - New York
WNP-3/5 Files - Richland

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RECORDS

Reference No. 4608132

Mei MEI-

CHARLTON, INC.

2233 S.W. CANYON ROAD
PORTLAND, OREGON 97201
503/228-9663

ENGINEERING AND APPLIED SCIENCES working with MATERIALS ENVIRONMENT INDUSTRIAL PRODUCTS AND PROCESSES

TO: Ray Bristow Company, Inc.
Attention: Ray E. Bristow, Jr.
1640 N. W. 14th Avenue
Portland, OR 97209

CLIENT NO.:

REFERENCE NO.: 4608132

DATE: 2-20-81

SUBJECT: DETERMINE CAUSE OF FRACTURE OF
3/4-INCH PLATED LOCK WASHERS

Memorandum Report

from Ralph Hudson, P.E.
Project Director

You requested that MEI-Charlton, Inc. examine fragments of electrozinc plated 3/4-inch helical lock washers for cause of cracking during installation. You submitted washers which had been returned from service that fractured during installation, and two types of washers which had not yet been in-service. One was electrozinc plated and the other mechanically zinc plated.

As a result of our metallographic examination of these washers, we have arrived at the following conclusions.

1. The lock washers which fractured in-service were embrittled and contained severe intergranular and transgranular cracks.
 - 1.1 The embrittled cracks in these washers occurred prior to the application of the electrozinc plating on the surface.
 - 1.2 Washers which had been electrozinc plated and not yet been installed also showed evidence of incipient embrittled cracks.
 - 1.3 The probable cause of the cracking would be a hydrogen embrittlement that occurred during the pickling stages of the electrozinc plating process. No evidence of oxide scales or decarburized zones were found within the cracks indicated.

DETERMINE CAUSE OF FRACTURE OF
3/4-INCH PLATED LOCK WASHERS

Ray Bristow Company, Inc.

Reference No. 4608132

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CHARLTON, INC.

2233 S.W. CANYON ROAD
PORTLAND, OR 97201
503/228-9663

TO: Ray Bristow Company, Inc.
SUBJECT: FRACTURE OF 3/4-INCH PLATED LOCK WASHERS
REF.NO.: 4608132

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(Text continued on next page.)

TO: Ray Bristow Company, Inc.
SUBJECT: FRACTURE OF 3/4-INCH PLATED LOCK WASHERS
REF.NO.: 4608132

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3. The mechanically coated zinc washers showed no evidence of an embrittled structure or incipient cracks.
4. Both the mechanically coated and electrozinc coated washers conformed to the specified requirements for hardness and decarburized zone depth.

As a result of our examination, we would recommend that all washers that were electrozinc plated be rejected. Incipient embrittlement could result in failure of those washers which do not yet show evidence of failure by cracking.

Details of this examination are described in the following photographs and captions.

Don Valley, P.E./CA
Account Director

RH:ksb
3 copies

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PORTLAND, OR 97201

0.13/4511

TO: Ray Bristow Company, Inc.

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SUBJECT: FRACTURE OF 3/4-INCH PLATED LOCK WASHERS

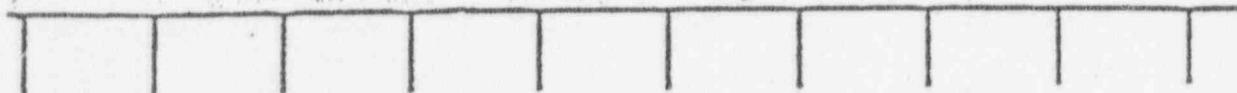
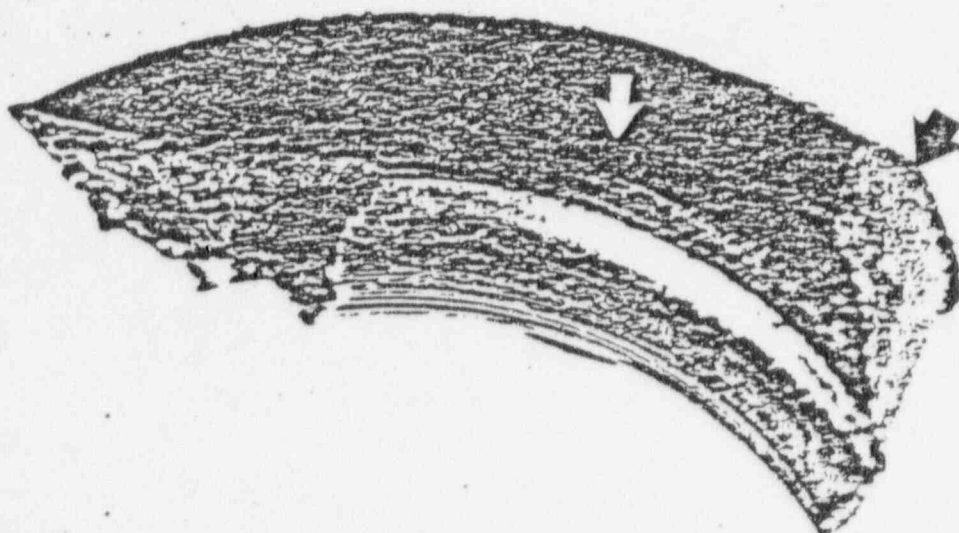
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Figure 1 (66594)

This photograph shows one of the typical examples of the fracture fragment. Many of these fractured lock washers had more than one fracture plane as is evident by this fragment which has both ends fractured. Examination of the fracture surface showed that portions were darkened, as indicated by the right arrow, whereas the remainder of the fracture was a bright crystalline structure. These darkened areas were established as portions of the embrittled structure in which the incipient cracks occurred. An extension of the crack, which caused the transverse fracture across the section of the lock washer, is shown as a crack running parallel to the longitudinal axis of the washer as indicated by the left arrow.

Two metallographic specimens were removed from this fragment for a microscopic examination. They are shown in the next figure.

FIGURE 1 (66594)



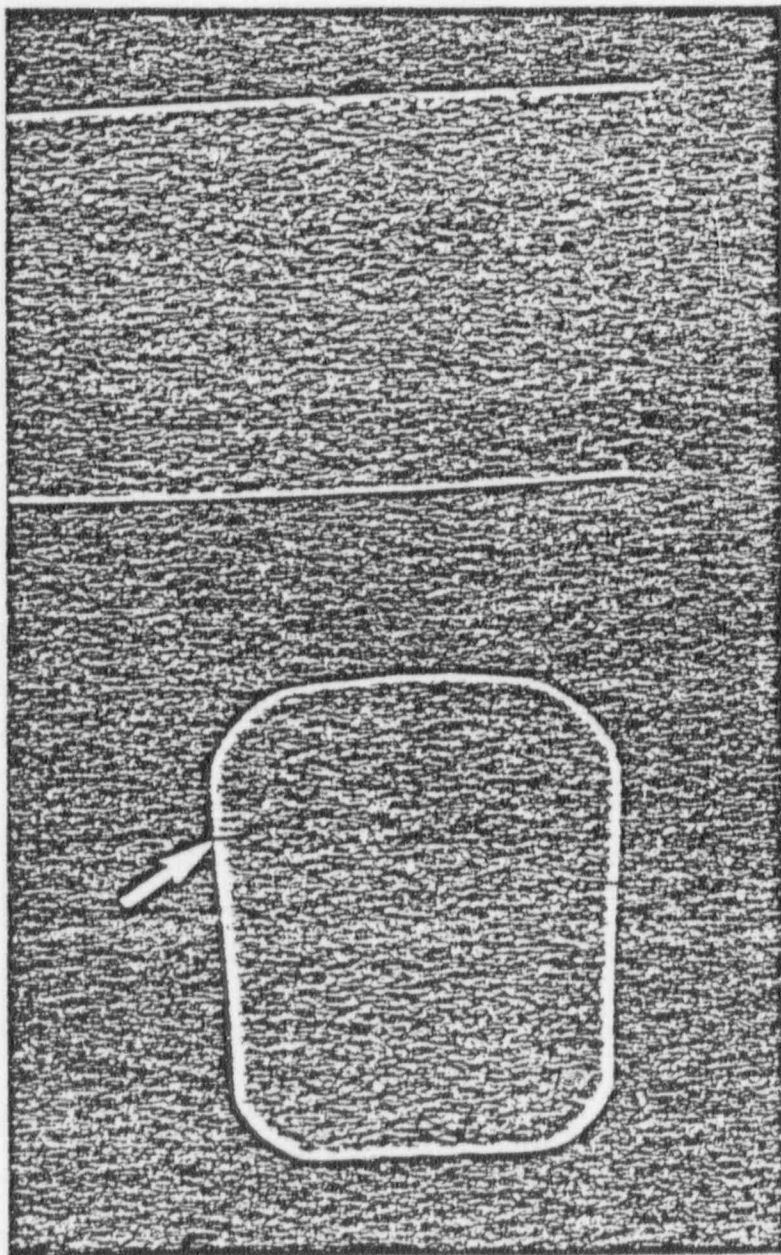
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FIGURE 2 (66609)



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Figure 2 (66609) 14X Etchant: Picric Hydrochloric Acid

This photomicrograph shows the two metallographic specimens removed from the fractured fragment shown in Figure 1.

The specimen at the top of this photograph was taken parallel to the longitudinal axis of the washer including the fracture surface, which is oriented in this photograph towards the left. The cracks, indicated by the arrow in Figure 1, are evident on the top surface of this specimen.

The specimen at the bottom was taken transversely through the washer. The specimen is oriented so that the inside circumferential surface is towards the top. The compression surfaces of the washer are to the right and left, and the outside circumferential surface is at the bottom. The crack shown by the arrow in Figure 1, is on the left side of this specimen (arrow).

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Figure 3 (66600) 100X Etchant: Picric Hydrochloric Acid

This photomicrograph shows the microstructure along the fracture surface of the washer. This portion of the fracture was dark in color. The embrittled structure was found to be intergranular in its progression and coincided with a high degree of secondary intergranular cracks adjacent to the fracture surface.

The fracture characteristic of the bright crystalline structure was primarily a transgranular cleavage type of cracking as a result of overload on the remaining section. The fracture occurred because of the presence of the incipient embrittled structure.

Figure 4 (66602) 500X Etchant: Picric Hydrochloric Acid

This photomicrograph shows more detail of the microstructure in the fractured washer. The fracture plane along the darkened area of the fracture was primarily intergranular as was the secondary cracking adjacent to this fracture surface. Close examination of these cracks indicated no evidence of significant oxidation or decarburization, as would have been present from the last heat treating process applied to the washers as they were manufactured. The characteristics of these cracks were highly indicative of a hydrogen type embrittlement due to the pickling process which would have occurred at the time the washers were plated.

This is shown in more detail in the next figure.

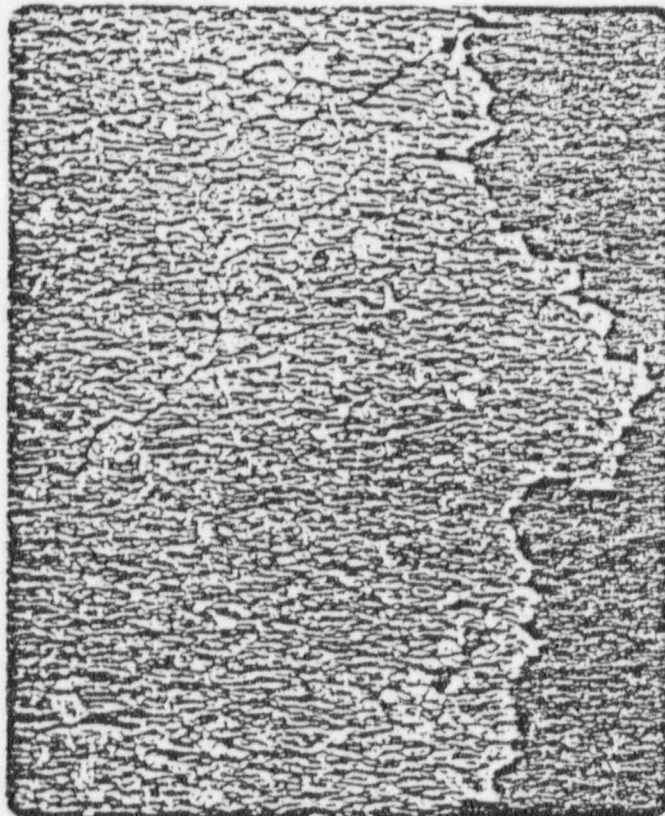


FIGURE 3
(66600)



FIGURE 4
(66602)

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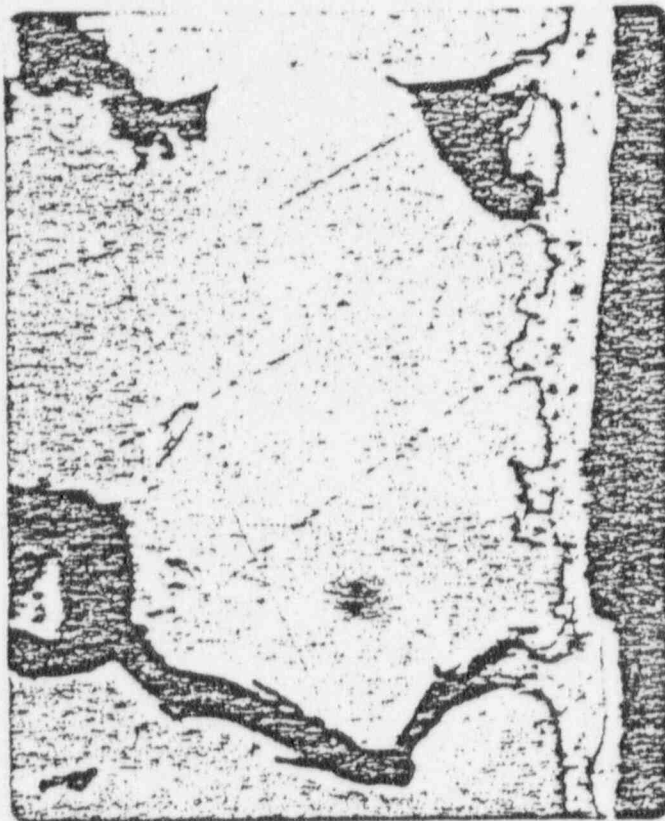


FIGURE 5
(66595)

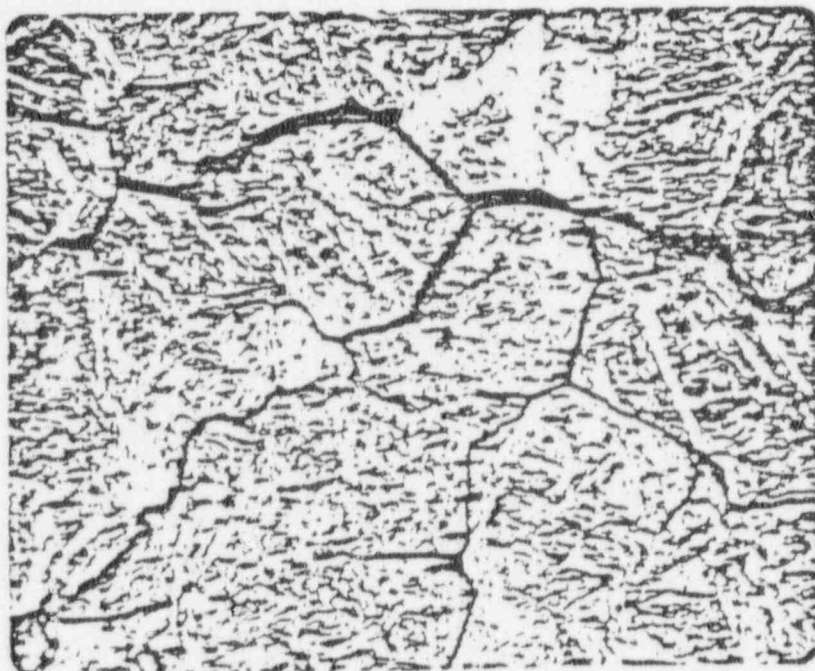


FIGURE 6
(66606)

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Figure 5 (66595) 500X Unetched

This photomicrograph shows the surface of the electrozinc plated washer from the transverse specimen shown in Figure 2. Cracks which extended to the surface showed evidence of zinc plating extending down within the crack indicating the crack was present prior to application of the electrodeposited zinc. This confirms the most likely cause for cracking in the pickling or acid wash stages of the electrozinc plating process. No intermediate baking or processing of the washers was reported to us for the electrozinc plating procedure.

Figure 6 (66606) 500X Etchant: Picric Hydrochloric Acid

This photomicrograph shows more detail of the microstructure away from the fracture surface. The structure shows a high degree of intergranular embrittlement as well as transgranular branching. The severity of this embrittlement indicates the potential danger for delayed cracking which may occur in washers which had not yet failed.

Metallographic examination and hardness tests indicated that portions of the washers which were not embrittled were within the hardness range specified for the American National Standards Institute, Specification B 27.1. Hardness was specified between the range of 45 to 53 on the Rockwell C Scale. The hardnesses of the fractured and new washers were measured at 46 to 49 HRC. These washers also met the requirements for an acceptable decarburized zone and were within the limits of the maximum depth of free ferrite as specified by the ANSI specification.

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Figure 7 (66610) 7X Etchant: Picric Hydrochloric Acid

This photomicrograph shows two metallographic specimens removed from a new washer. Approximately 50 new washers were submitted for examination for embrittlement. These washers were inspected by magnetic particle inspection using a wet fluorescent method specified by the American Society for Testing and Materials, Specification E 138. The magnetic particle inspection showed no evidence of surface indications.

A washer selected at random was sectioned and prepared for metallographic examination as shown by the two specimens in this photograph. Metallographic examination of the specimens revealed evidence of embrittled cracking at the surface which was finer than the detectable limits of the magnetic particle inspection (arrow).

This is shown in more detail in the next figure.

Figure 8 (66599) 500X Etchant: Picric Hydrochloric Acid

This photomicrograph shows the embrittled structure found in a new washer. Embrittled cracks extended to the surface and showed evidence of secondary branching beneath the surface. The crack shown in this photograph had a total depth of 0.010 of an inch. Cracks of this size were not detected by magnetic particle inspection. Evidence of this cracking on new washers indicates that the entire lot of new washers should be rejected, as delayed cracking potentially can occur even though washers which were installed had not shown evidence of fracture.

The picric hydrochloric etchant used for preparation of this metallographic specimen attacked the zinc coating on the surface. The electrozinc plated layer is not visible in this micrograph.

In addition to the specimens of the electrozinc plated washers, a specimen of the mechanically plated washer was also metallographically examined. No evidence of incipient cracks or embrittled structure were found on the mechanically plated washer. We do not know at this time whether the mechanically plated washer was from the same lot or heat as the washers originally supplied and then later electrozinc plated.

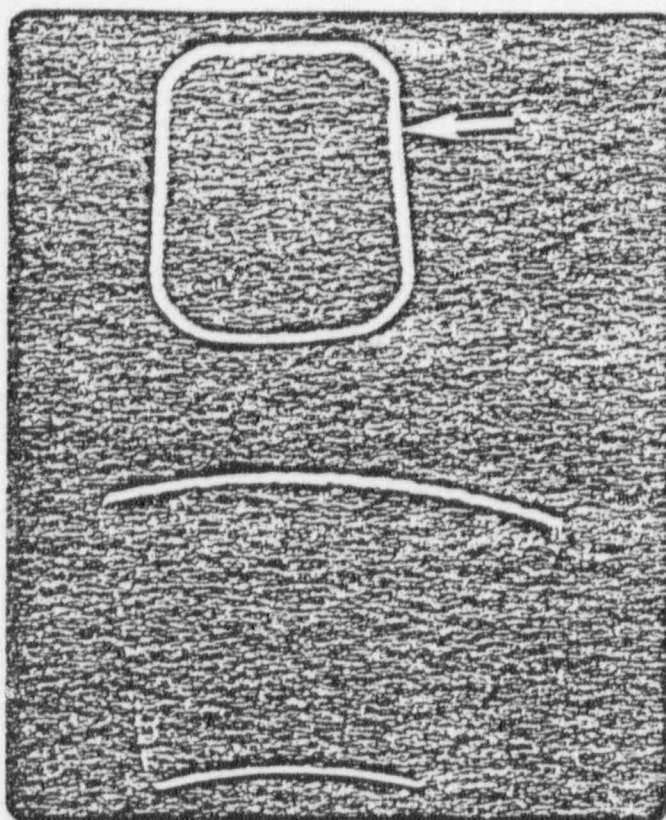


FIGURE 7
(66610)

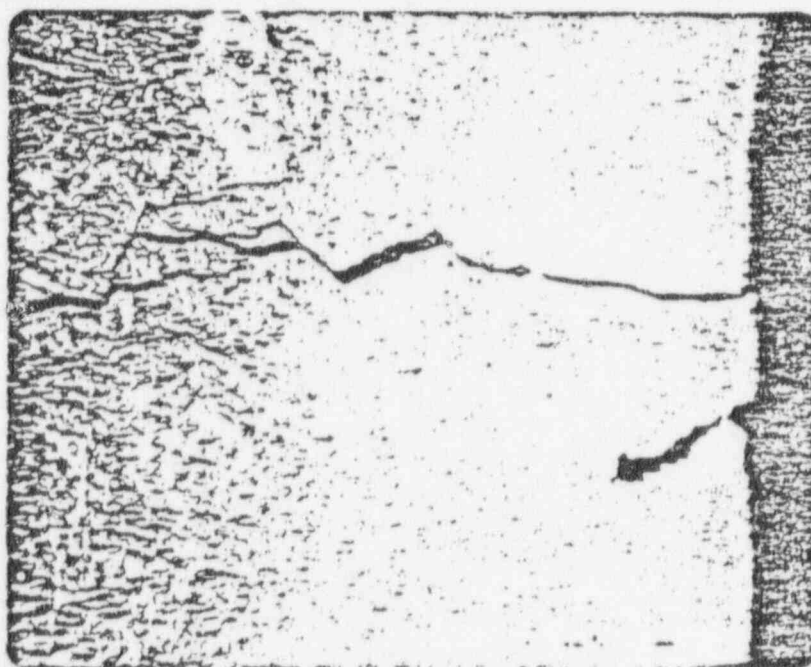


FIGURE 8
(66599)

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