EXHIBIT 4

J771

CENTRAL LABORATORIES SERVICES TECHNICAL REPORT	Report No. 95-1021 Sheet No.: 1 of 2 Date of Report: JUN 19 1995
Plant/Project: Watts Bar Nuclear Plant	
Subject: ICE CONDENSER BASKET SCREWS	
Standards Used: 904694, 901387, 516825	
Copies Sent to: Vonda Sisson, IOB 1M-WBN (4); RIMS; Lab Files	
Prepared by: Daryl A. Smith / LAB	Approved by: Delsa L. Frazier

Eight sets of self-tapping, plain carbon steel screws were received by Central Laboratories Services (CLS) with a request to determine the failure mode and verify the material type. Westinghouse Equipment Specification No. 678956 (attached) stated that the screws were made from 1022 plain carbon steel, heat treated to surface hardness minimum C-52, a core hardness of C-32-40, and a protective coating of either cadmium plating, zinc plating, or zinc phosphate. The eight sets of screws received by CLS were labeled as follows:

Set "A" : Ten fractured screw heads that were in service (seen in the upper left view of Figure 1) , and one whole screw that was not in service (not shown).
Set "B" : Twelve new screws, seen in the upper right view of Figure 1.
Set "C" : Two screws removed from service, labeled "Bay '24' Top Ring D-6".
Set "D" : Two screws removed from service, labeled "Bay '24' Bottom Ring D-6".
Set "E" : Two screws removed from service, labeled "Bay '12' Top Ring A-6".
Set "F" : Two screws removed from service, labeled "Bay '12' Bottom Ring A-6".
Set "G" : Two screws removed from service, labeled "Bay '1' Top Ring A-6".
Set "H" : Two screws removed from service, labeled "Bay '1' Bottom Ring A-6".

All screws removed from service had varying amounts of corrosion products on them, mostly in the threaded region. The lower view of Figure 1 shows a typical set of screws that were removed from service.

The chemical compositions of representative screw samples from each set was checked with Energy Dispersive X-ray (EDX)* analyses, and the results are presented in Table I. Note that the screws examined had chemistries similar to that of plain carbon steel. The surface coating on the whole screw from set "A" was examined by EDX* analysis as seen in Table I. Note that zinc and phosphorus were detected, which indicates that the screws probably have a zinc phosphate coating.

Carbon and sulfur amounts were measured using Induction Furnace Combustion Techniques on a representative sample from each set of screws, and the results are presented in Table II. Note that each representative sample from each group had chemistries similar to 1022 carbon steel; however, Westinghouse Equipment Specification No. 678956 requires a hardened surface. The screws appeared to have a carburized case, as indicated by the carbon contents that were measured in Table II and the microhardness traverses depicted in Figures 13 through 15. Note that the microhardness traverses shown in Figures 13 through 15 were obtained on screw samples from a representative new screw from set "B", a screw removed from service in set "H" that was noticed to contain cracks at its thread roots, and a screw removed from service in set "D" in which no cracks were detected in examined sections.

Microhardness values were obtained at the case and core for a fractured screw from set "A", the whole screw from set "A", a representative new screw selected from set "B", and a screw removed from service in set "G". The average results are presented in Table III.

The fractured screws that were in service in set "A" were examined in a Scanning Electron Microscope (SEM) in order to determine the mode of failure. Figures 2 and 3 show that the screws fractured in a brittle manner

(continued on next page)

as indicated by the intergranular failure mode seen on the screws that were examined. There was usually a small final-fracture area on the fracture surface near the center of the shank that failed in a ductile manner.

An arbitrarily selected fractured screw (that was in service) from set "A" was cut so that a longitudinal cross-section through the fracture surface could be examined. Note that a secondary crack of intergranular nature was noticed above the fracture surface as seen in Figure 4. A screw from set "G" was similarly sectioned, and two cracks were found in adjacent thread roots as seen in Figures 5 and 6. Similar intergranular cracks were discovered in a transverse section of the whole screw from set "A" and at the thread roots of a screw from set "H" (Figure 7).

EDX* analysis of the material in one of the cracks seen in the longitudinal cross section of a screw from set "G" revealed the presence of zinc as seen in Table I. Note in the upper view of Figure 6 that a lapped area was present at the thread roots of a screw from set "G". Similar lapped regions were discovered at the tip, face, and roots of every screw that was examined and is typical of the thread rolling process.

Screws from sets "C", "G", and "H" contained intergranular cracks similar to those seen in Figures 5, 6, and 7. Note that the intergranular crack found in a representative sample taken from a fractured screw in set "A" seen in Figure 4 differed from the intergranular cracks seen in Figures 5 through 7 because it was probably a secondary crack (since it is above the primary fracture and perpendicular to the curved neck of the screw rather than at the thread roots).

Two screws, one from set "A" and one from set "G," were intentionally fractured with a hammer in order to determine the failure mode. SEM photography shows in Figures 8 and 9 that the screw from set "G" failed by intergranular fracture in the case and mixed-mode fracture (cleavage and void coalescence) in the core, while the whole screw from set "A" failed by quasi-cleavage in the case and void coalescence in the core. At the customer's request, additional screws were broken (two from set "C" and two new screws from set "B") in the same manner, except at 15°F. Subsequent SEM analysis of the resultant fracture surfaces revealed that the screws failed by void coalescence.

The general microstructure of representative screws from each set was determined to be tempered martensite (see Figures 10 and 11). Note in Figure 12 that slack-quenched areas consisting of ferrite networks on prior-austenite grain boundaries in a matrix of intermediate transformation products was discovered near the thread roots of four new screws from set "B" and one screw from set "H". The screw samples from set "G" were destroyed for other testing and could not be checked for the presence of the slack-quenched microstructure.

In conclusion, the failure mode of the fractured screws from set "A" was intergranular separation. The screws that were checked for chemistry were similar to the 1022 carbon steel which was specified in Westinghouse Equipment Specification No. 678956.

All test equipment and instrumentation used in the performance of this evaluation are calibrated in accordance with applicable TVA standards and Quality Assurance (QA) Procedures and conform to applicable portions of ANSI N45.2, 10 CFR 50/Appendix B, and 10 CFR 21. Standards used are traceable to the National Institute of Standards Technology (NIST), natural physical constants, or commercially accepted practices. All personnel, procedures, and instructions used comply with the requirements of the Central Laboratories Services (CLS) QA Program.

In the event that additional information or subsequent testing regarding this sample should be required, please refer to Report No. 95-1021.

*EDX is a semi-quantitative technique which uses no standards.

DAS
Attachments: Tables I through III
Figures 1 through 12
Westinghouse Equipment Specification No. 678956 (2 pages).

TABLE I

REPORT OF CHEMICAL COMPOSITION BY
ENERGY DISPERSIVE X-RAY ANALYSIS (EDX)*

REPORT NO. 95-1021

Elemental Weight Percent (Wt%)

Element	Base Metal**	Surface Coating**	Material in crack of screw from set "G"
Aluminum	–	0.4	3.4
Silicon	0.6	0.9	3.2
Phosphorus	–	24.8	0.5
Calcium	–	0.3	1.2
Manganese	1.0	0.6	0.7
Iron	Bal.	Bal.	Bal.
Zinc	–	28.5	2.8
Copper	–	0.4	–
Potassium	–	0.6	–
Chlorine	–	0.3	–

* EDX analysis is a semi-quantitative technique which uses no standards. TVA No. 453855
** The base metal and surface coating were checked on the whole screw from set "A".

Analyzed By: Daryl Smith

Date: 5/31/95

TABLE II

REPORT OF CHEMICAL COMPOSITION ANALYSIS (WEIGHT PERCENT)

BY INDUCTION FURNACE COMBUSTION TECHNIQUES

REPORT NO. 95-1021

STANDARDS: 904694 (NBS 19h)

Sample	Carbon	Sulfur
Fractured Screws from Set "A"	0.24	0.023
New Screws (Set "B")	0.22	0.021
In-service Screws (Set "C")	0.26	0.029
In-service Screws (Set "D")	0.27	0.31
In-service Screws (Set "E")	0.27	0.027
In-service Screws (Set "F")	0.27	0.023
In-service Screws (Set "G")	0.25	0.027
In-service Screws (Set "H")	0.21	0.028
1022 carbon steel	0.18-0.23	Typically 0.050 max.

Comments: The carbon and sulfur limits for 1022 carbon steel are listed for reference purposes only.

Analyzed by: Phillip Gass

Date of analysis: 5/22/95

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TABLE III

REPORT OF MATERIAL HARDNESS

REPORT NO. 95-1021

STANDARD(s): 901387 (62GM)

Set	Average Hardness*, Shank Case (Tip of Thread)	Average Hardness*, Shank Core	Average Hardness*, Head Case	Average Hardness*, Head Core
A**	54.6 HRC (625.6 HK)	44.6 HRC (460.6 HK)	61.6 HRC (768.2 HK)	44.9 HRC (465.7 HK)
A***	52.1 HRC (579.3 HK)	43.6 HRC (447.7 HK)	Not Measured	44.1 HRC (454.8 HK)
B	64.0 HRC (823.0 HK)	44.1 HRC (454.4 HK)	Not Measured	Not Measured
G	59.5 HRC (723 HK)	42.5 HRC (432.3 HK)	Not Measured	Not Measured

LABORATORY STANDARD TEST BLOCK SET TVA No. 901387

Serial No.	Standard Value	Measured Results and Average				
62GM	556 ± 15 HK	557.1	553.2	555.1	$\bar{X}$	555.1 HK
62GM	556 ± 15 HK	557.1	552.2	555.1	$\bar{X}$	554.8 HK

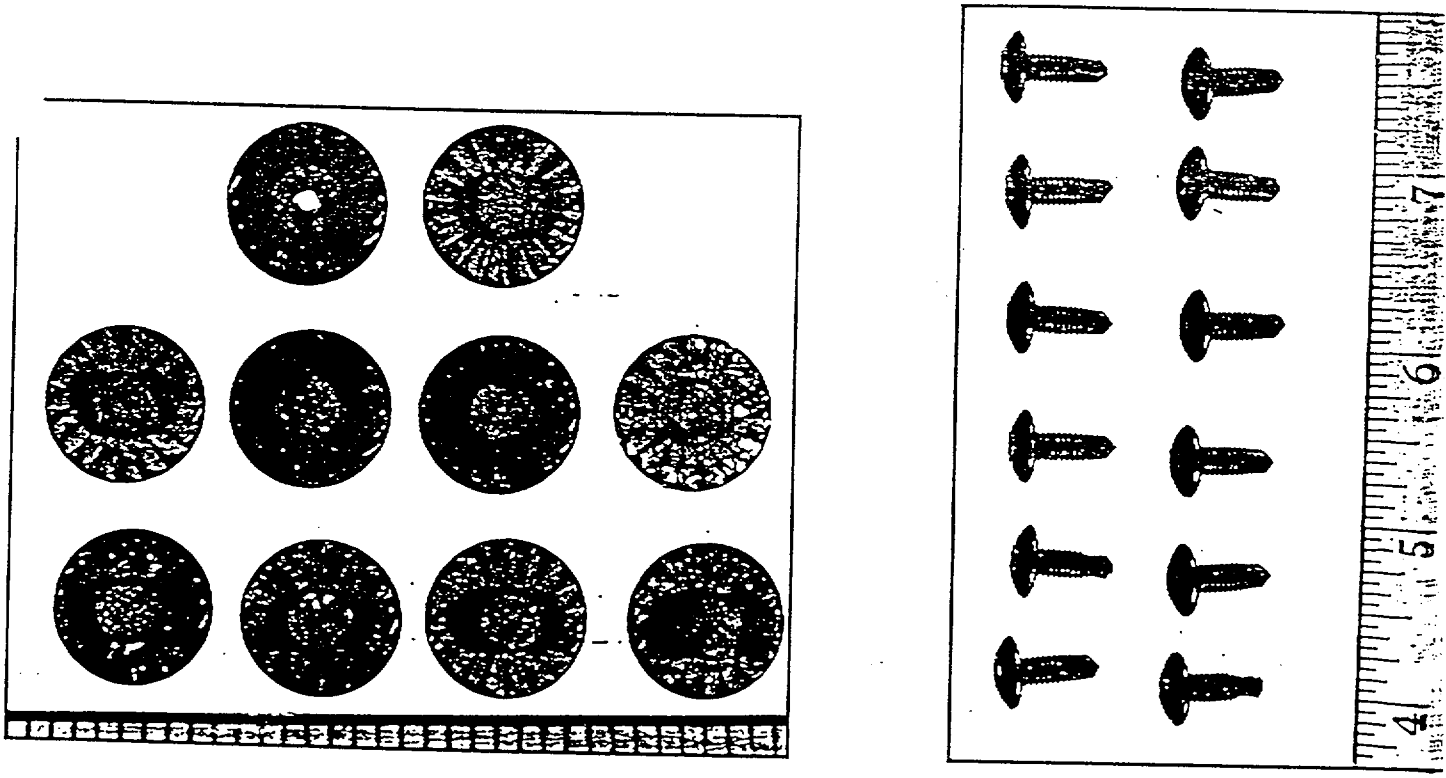
Measured By: Daryl Smith

Date: 5/26/95, 6/16/95

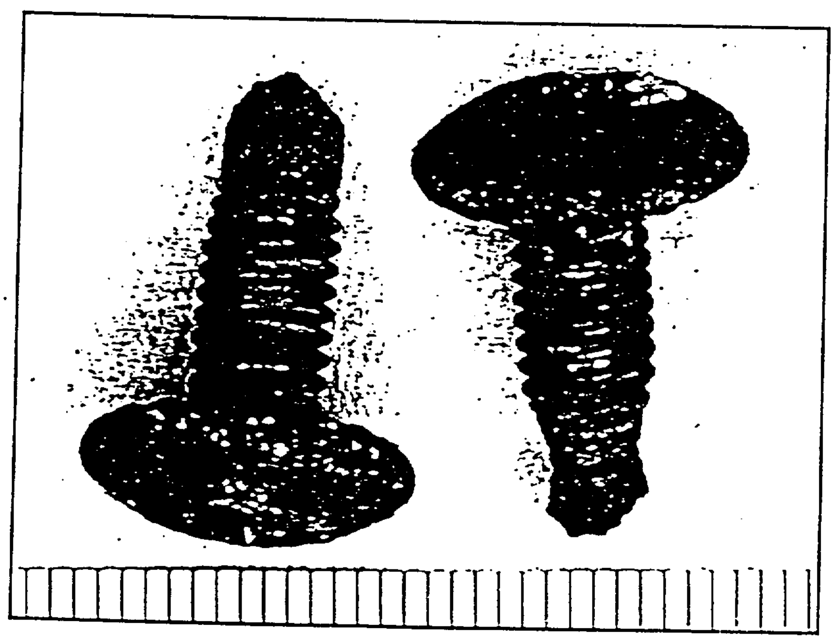
* The value reported is an average of three readings. Measured values are shown in parenthesis following converted values. Source of conversion is the Wilson Digital Microhardness Tester, which is based on ASTM A370.

** Measurements made on a representative fractured screw from set "A".

*** Measurements made on the whole screw from set "A".



Left: As-received photograph of the fractured screws (set "A"). Note that the unfractured screw from this set is not shown. Right: As-received photograph of the new screws (set "B").



As-received photograph of a typical pair of used screws. Note that each set of used screws (set "C" through set "H") varied in degree of corrosion.

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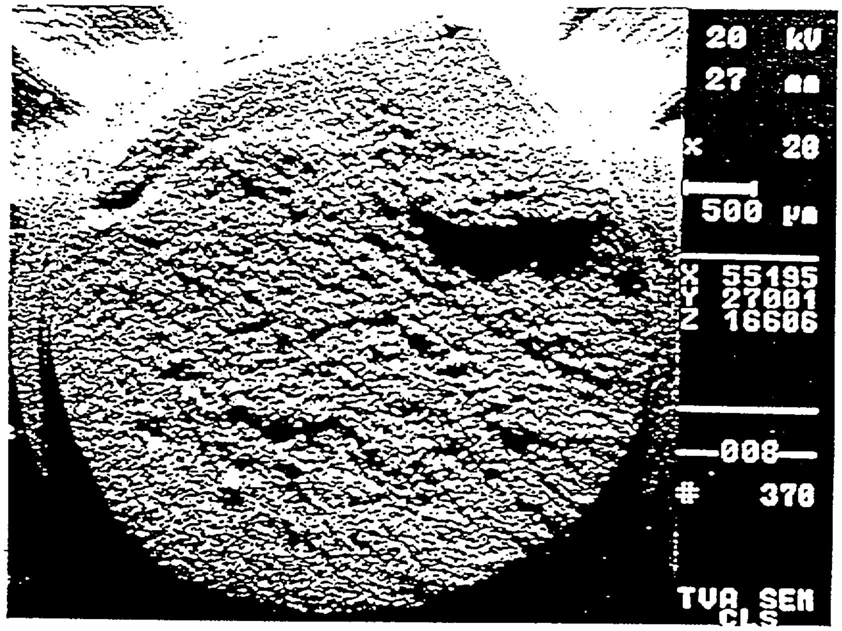
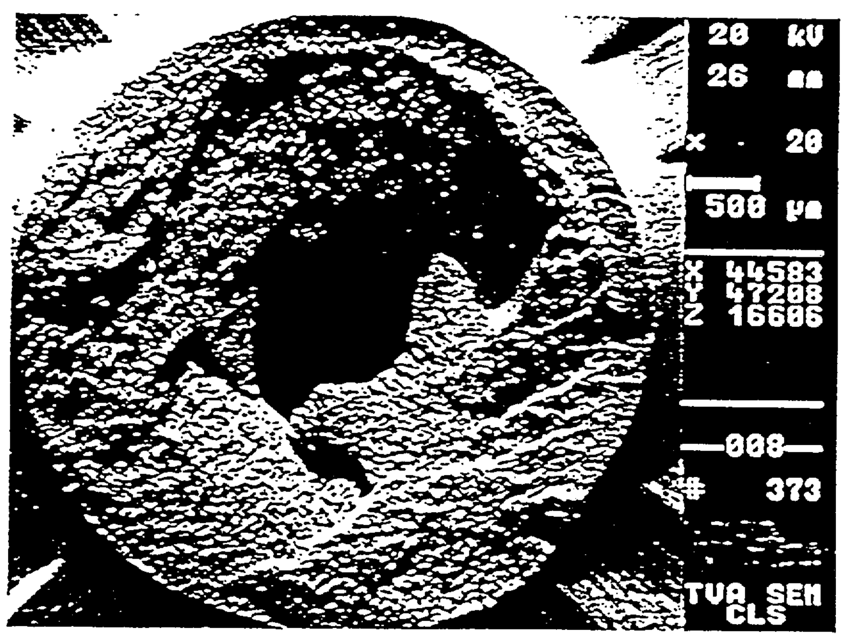
Figure 1: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.





SEM photographs of typical fracture surfaces taken from fractures screws (set "A"). Note that all fractured screws received in set "A" failed in a brittle manner (except for the small final fracture area near the center which failed in a ductile manner). 20X.

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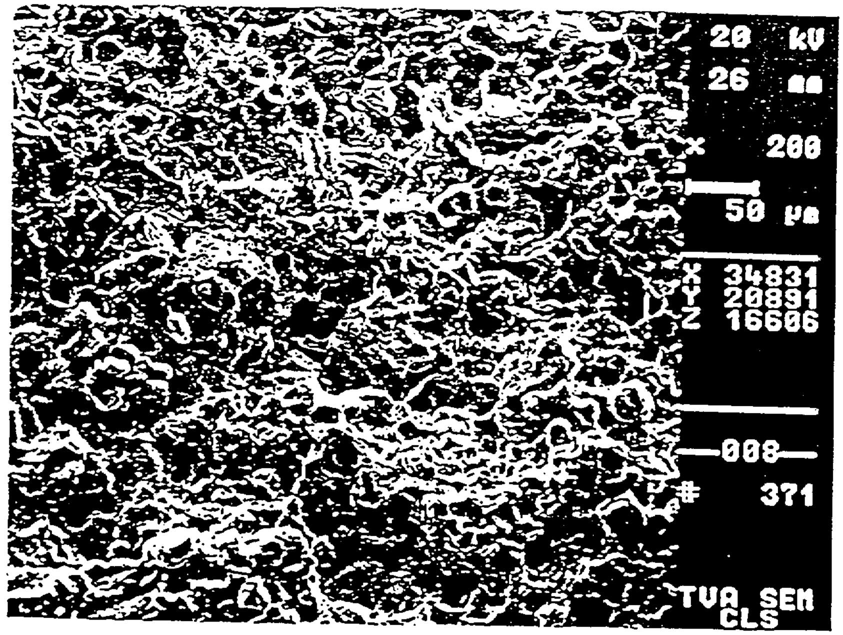
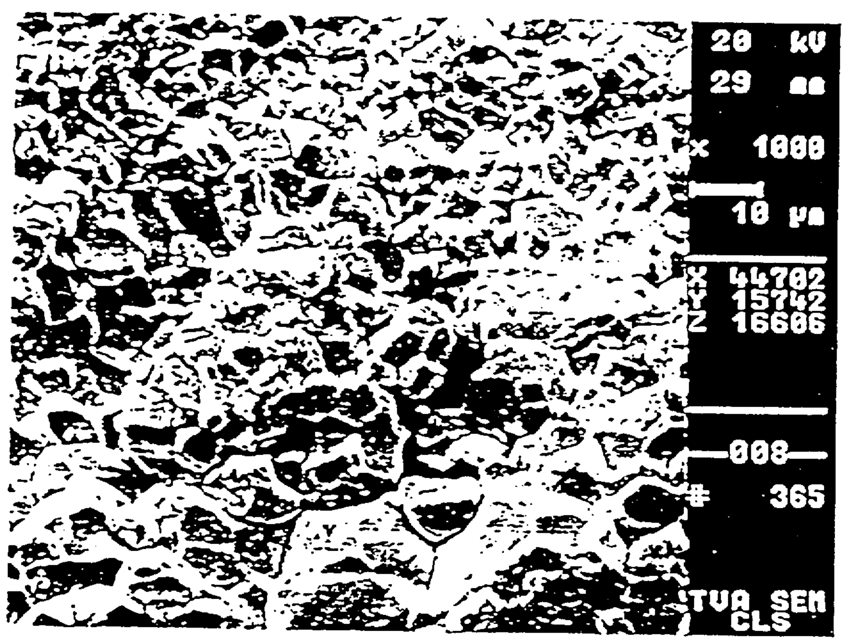
Figure 2: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.





SEM photographs of typical fracture topography seen on failed screws in set "A." The "rock-candy" appearance indicates that these screws failed in a brittle, intergranular manner. Top: 200X; Bottom: 1000X.

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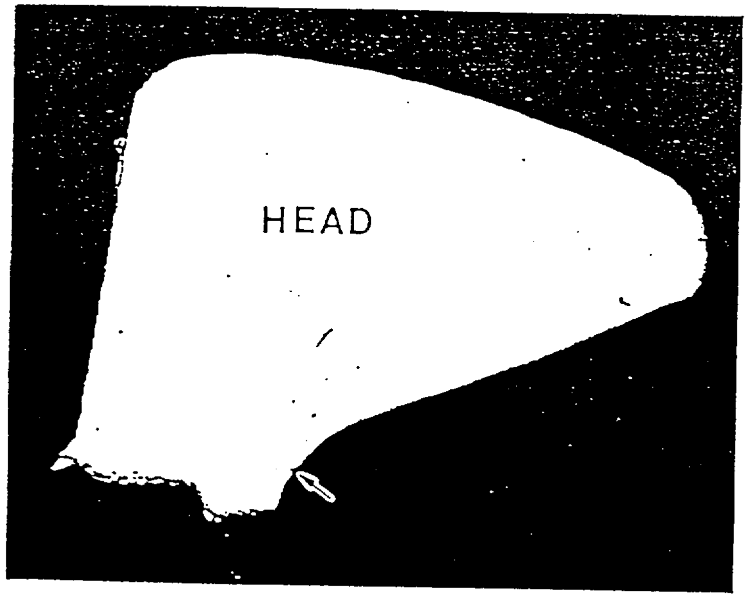
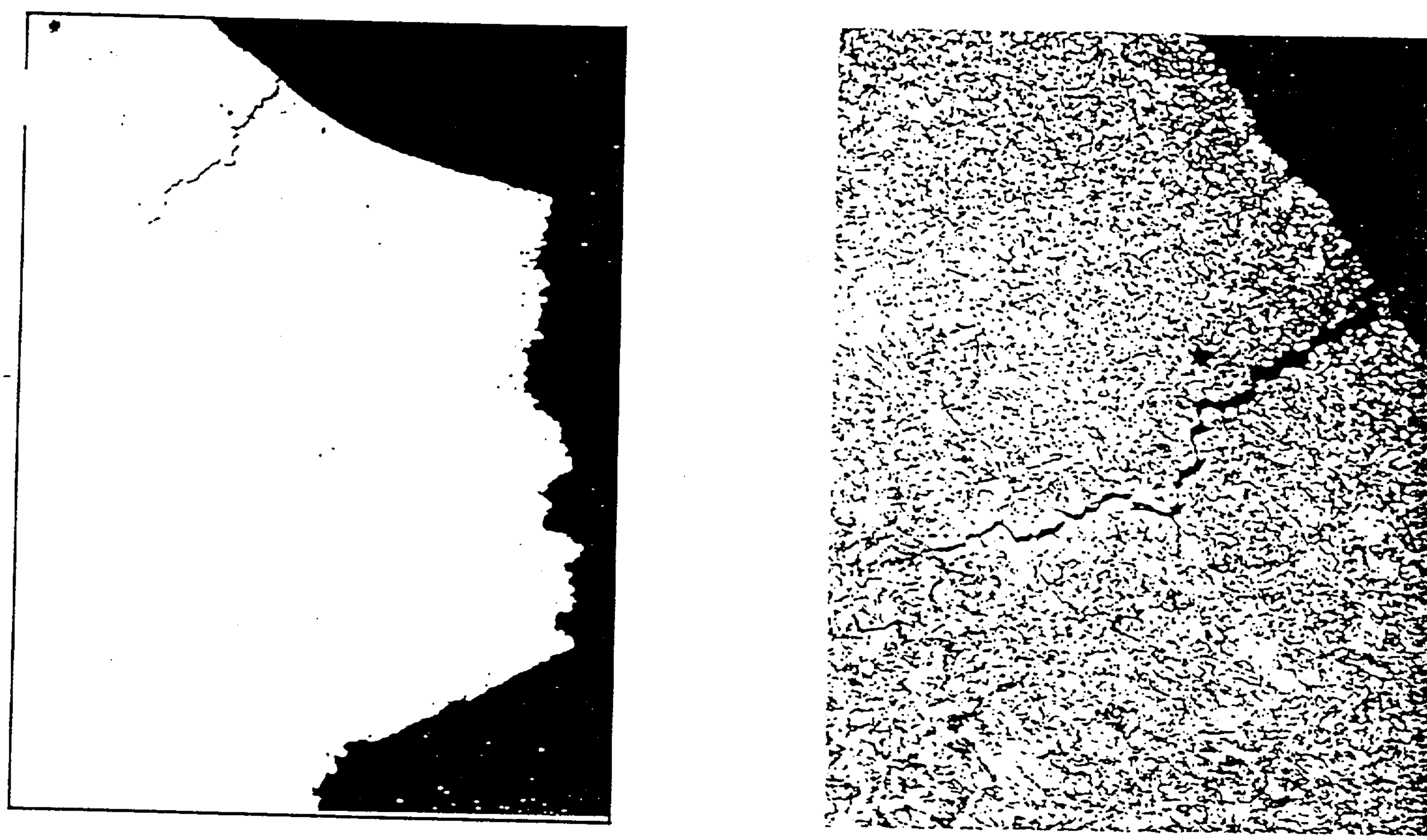
Figure 3: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.



Longitudinal cross section through a fractured screw. The arrow points to a secondary crack above the fracture surface. 20X. As-polished.



Close-up views of secondary crack seen in the upper view of this Figure. Left: As-polished, 125X; Right: Vilella's etch, 400X.

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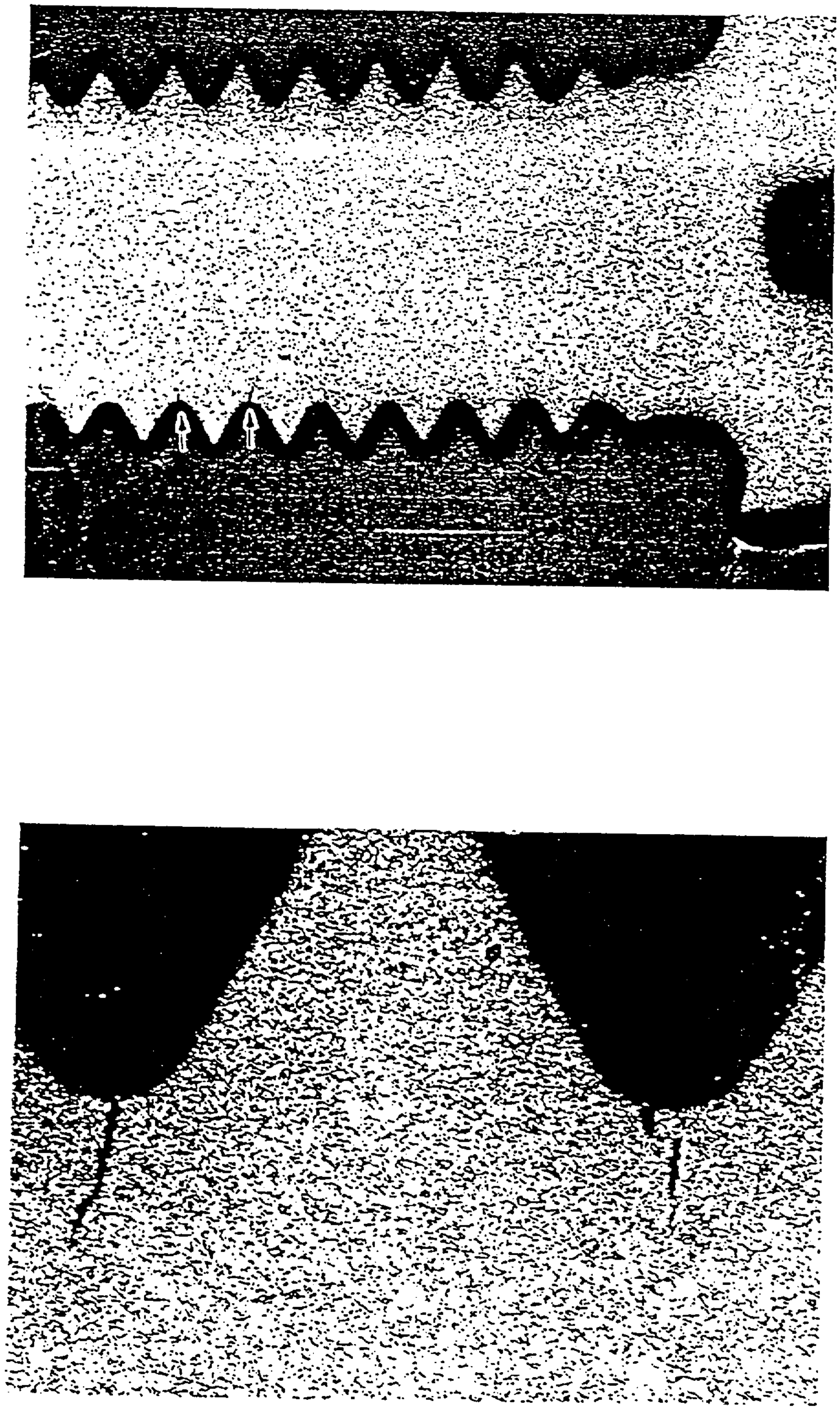
Figure 4: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification: BE(95-07, Laboratory Report No. 95-1021.



Longitudinal view of cracks present in one of the screws that were removed from service in set "G". Top: 12X; Bottom: 100X.

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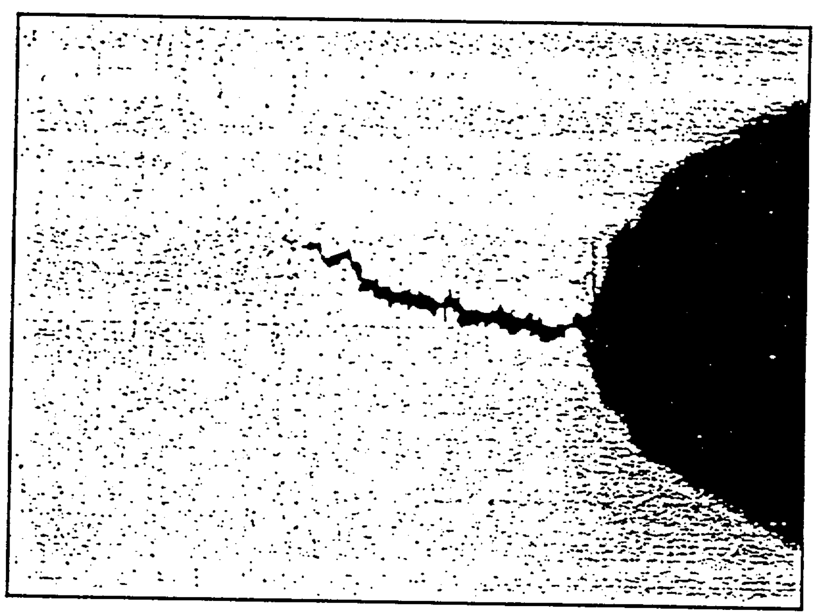
Figure 5: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.

As-polished, longitudinal view of lapping present at tooth root of a screw that was removed from service in set "G". 200X.



As-polished, longitudinal view of crack present at tooth root of a screw that was removed from service in set "G". 200X.

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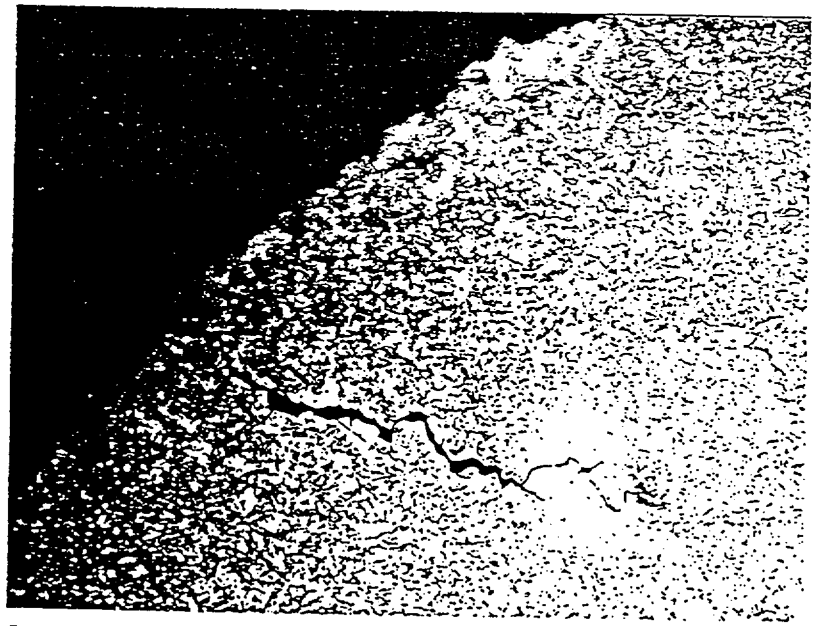
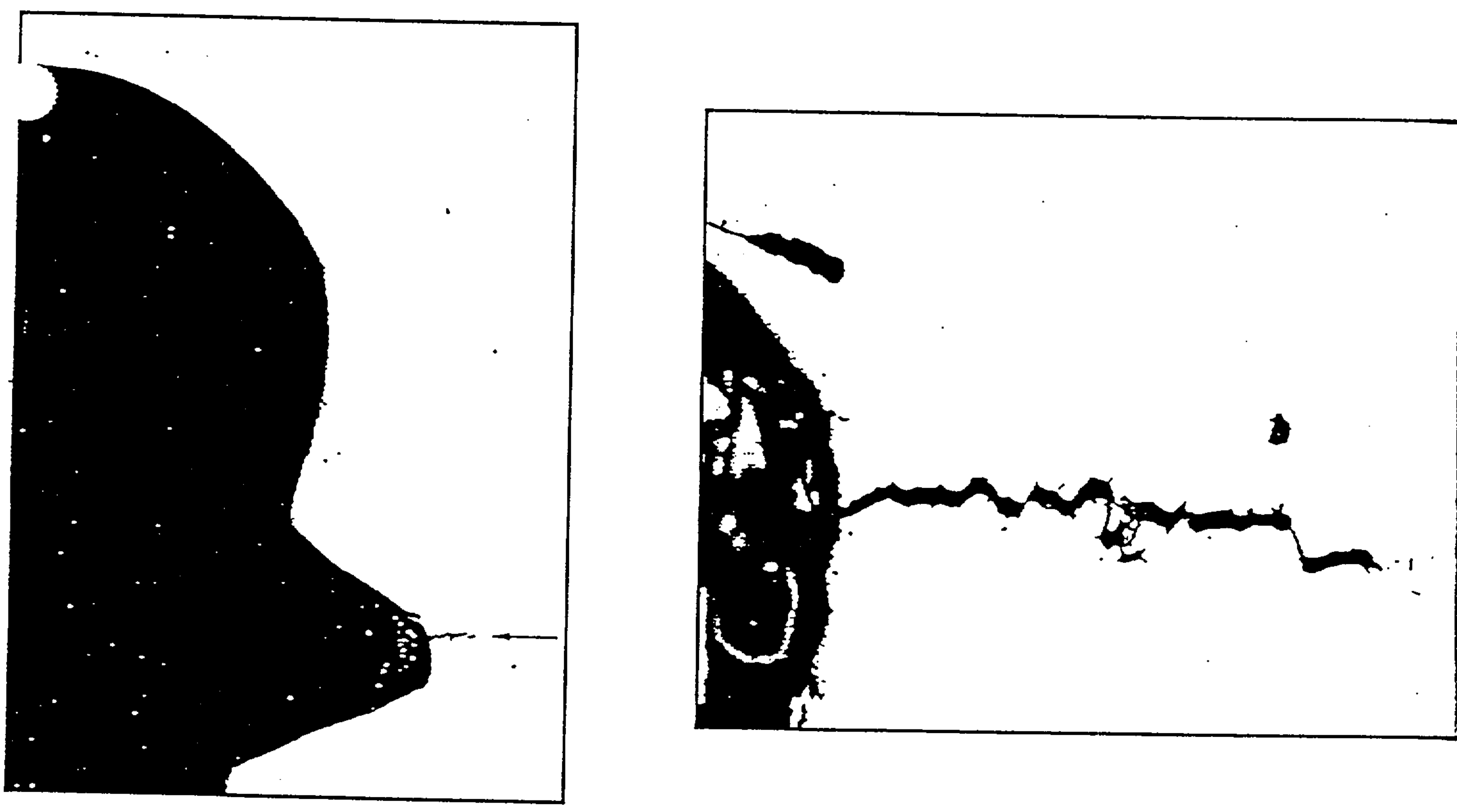
Figure 6: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.



Transverse cross-sectional view of a crack present in the screw that was not in service from set "A". 400X. Vilella's etch.



Intergranular crack found at thread root of first thread below head in a longitudinal cross section of a screw that was removed from service in set "H". Left: 50X; Right: 500X. As-polished condition.

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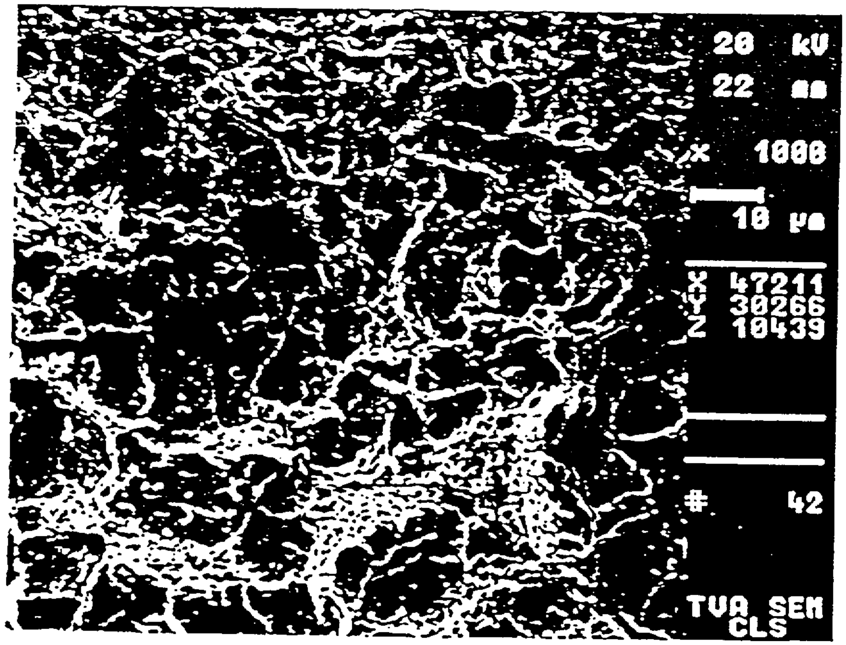
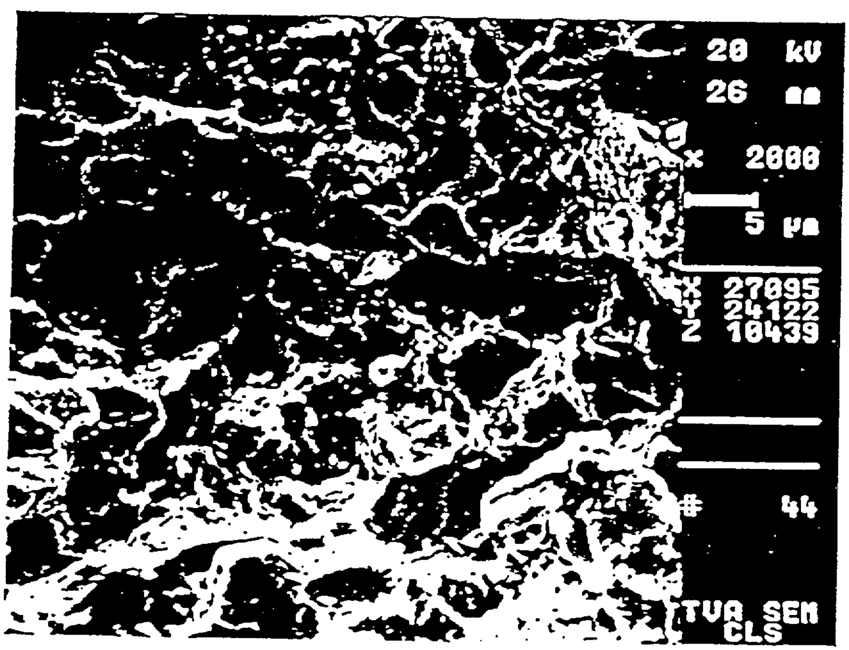
Figure 7: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.



SEM photograph of fresh fracture surface showing quasi-cleavage in the case of a new screw. 1000X.



SEM photograph of fresh fracture surface showing intergranular separation (with some void coalescence) in the case of a screw that was removed from service in set "D". 2000X.

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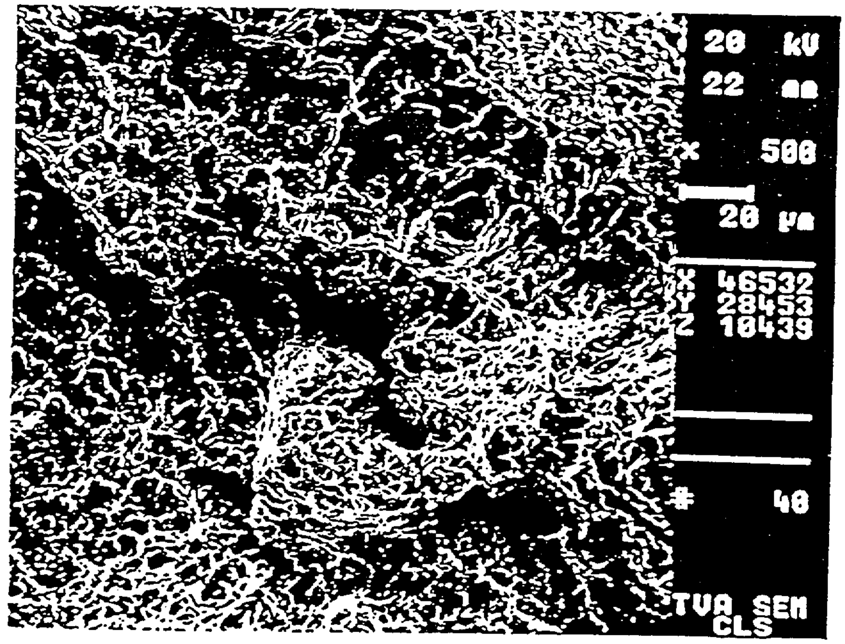
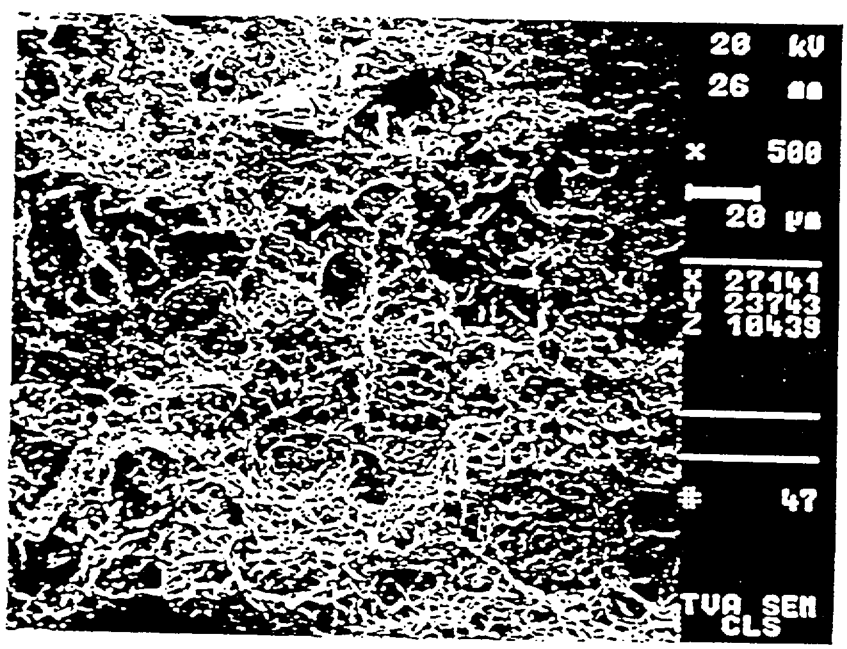
Figure 8: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.



SEM photograph of fresh fracture surface showing void coalescence in the core of a new screw. 500X.



SEM photograph of fresh fracture surface showing mixed-mode separation (cleavage and void coalescence) in the core of a screw that was removed from service in set "D". 500X.

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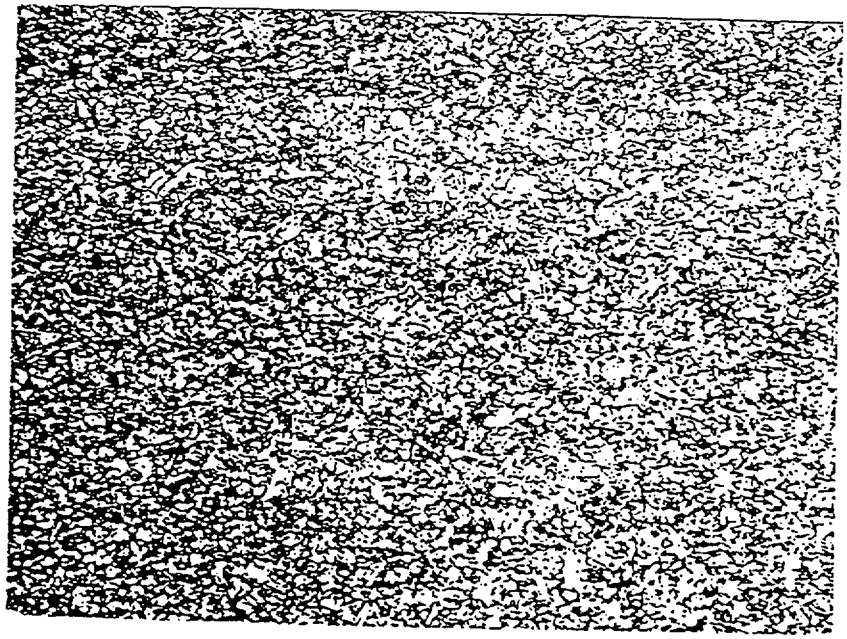
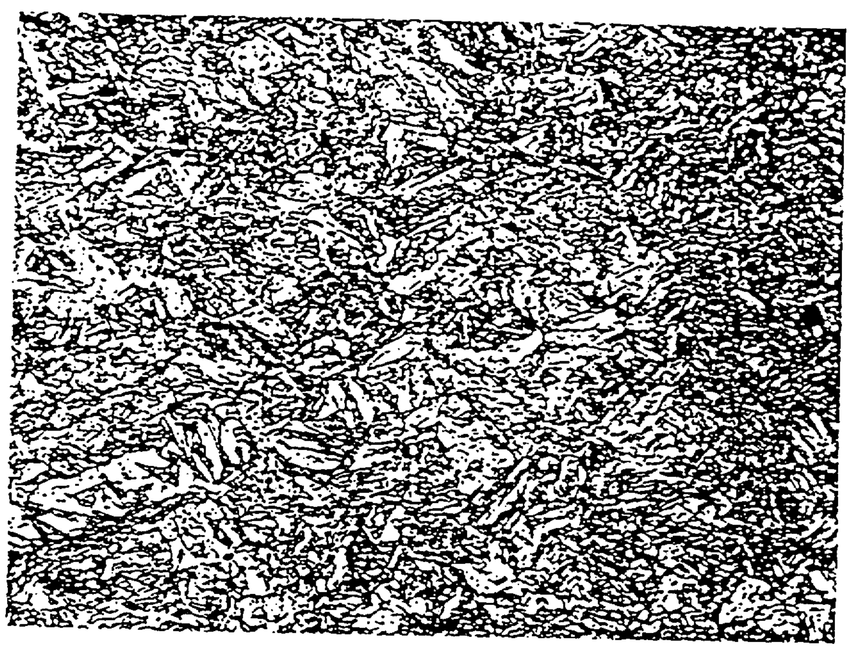
Figure 9: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.





General microstructure of a typical new screw: tempered martensite. Top: 100X; Bottom: 500X.

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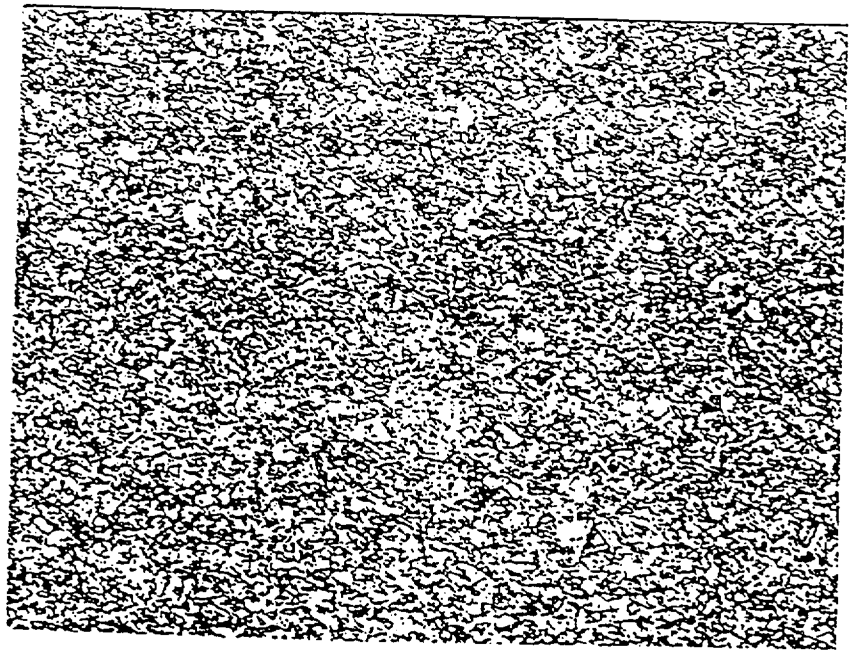
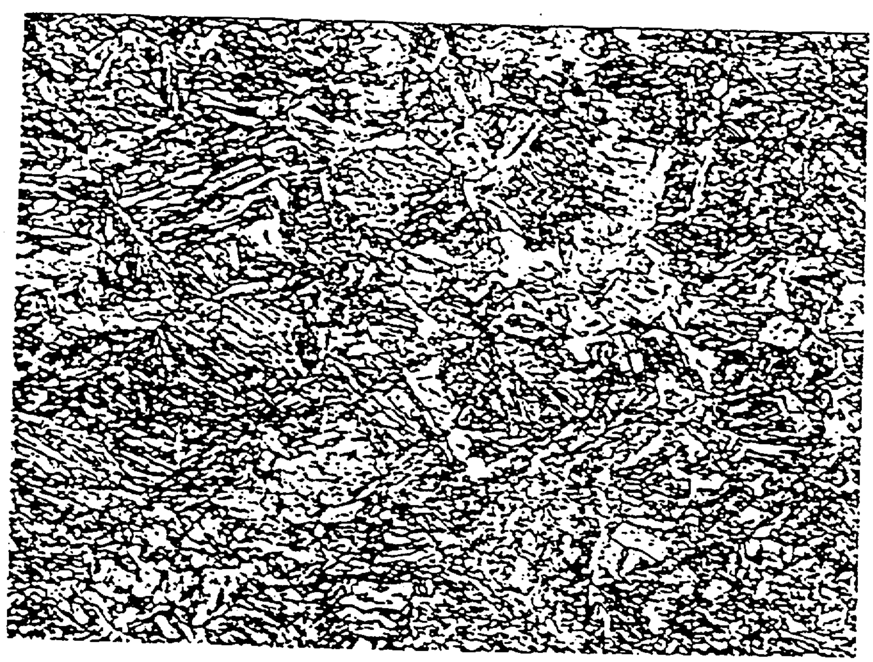
Figure 10: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.





General microstructure of a typical screw that was remived from service in set "G": tempered martensite. Note microstructure was similar for screws in each set that was removed from service. Top: 100X; Bottom: 500X.

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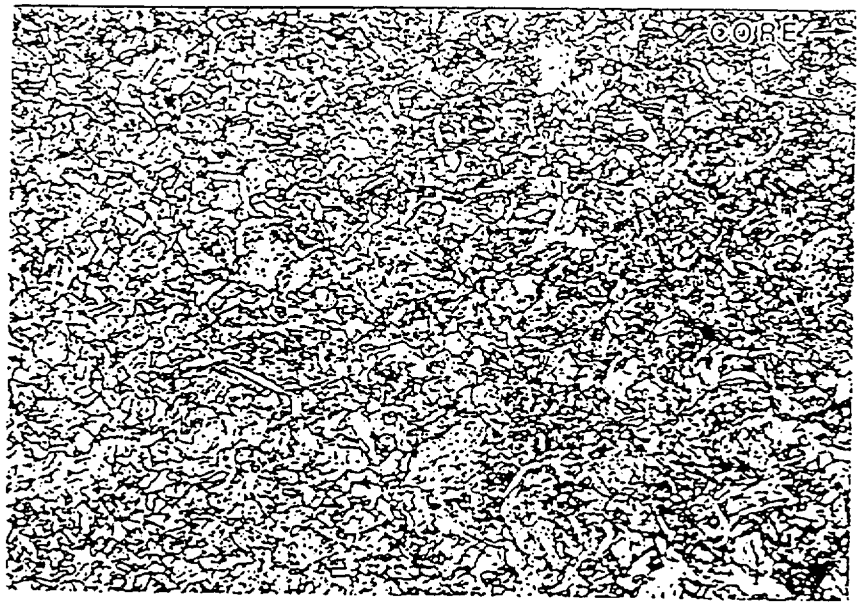
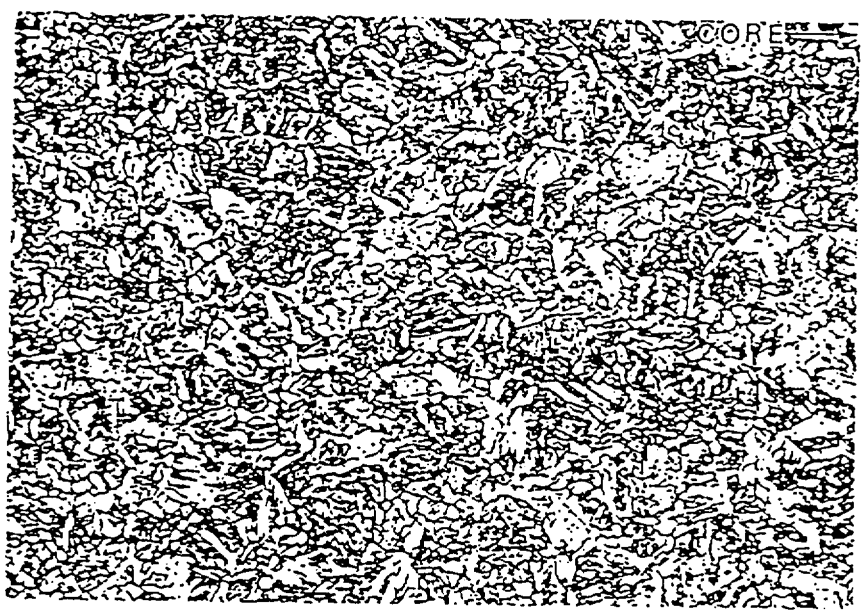
Figure 11: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.





Slack-quenched areas near thread roots consisting of pro-eutectoid ferrite on prior-austenite grain boundaries in a matrix of intermediate transformation products. Top: Longitudinal cross section of a new screw from set "B". Bottom: Longitudinal cross section of a screw removed from service in set "H". 500X. 2% nital etch.

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Figure 12: Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07, Laboratory Report No. 95-1021.

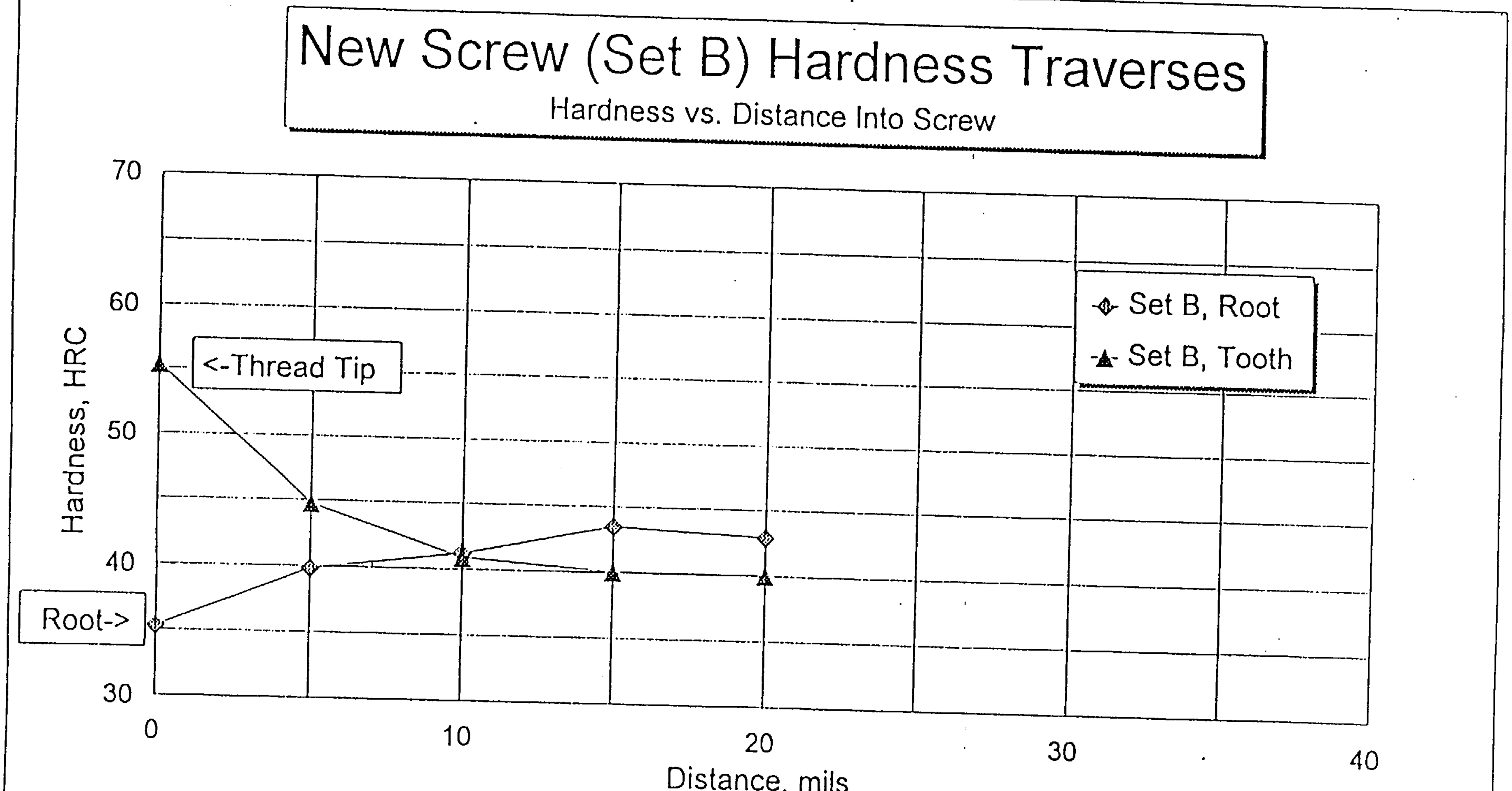

Figure 13 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

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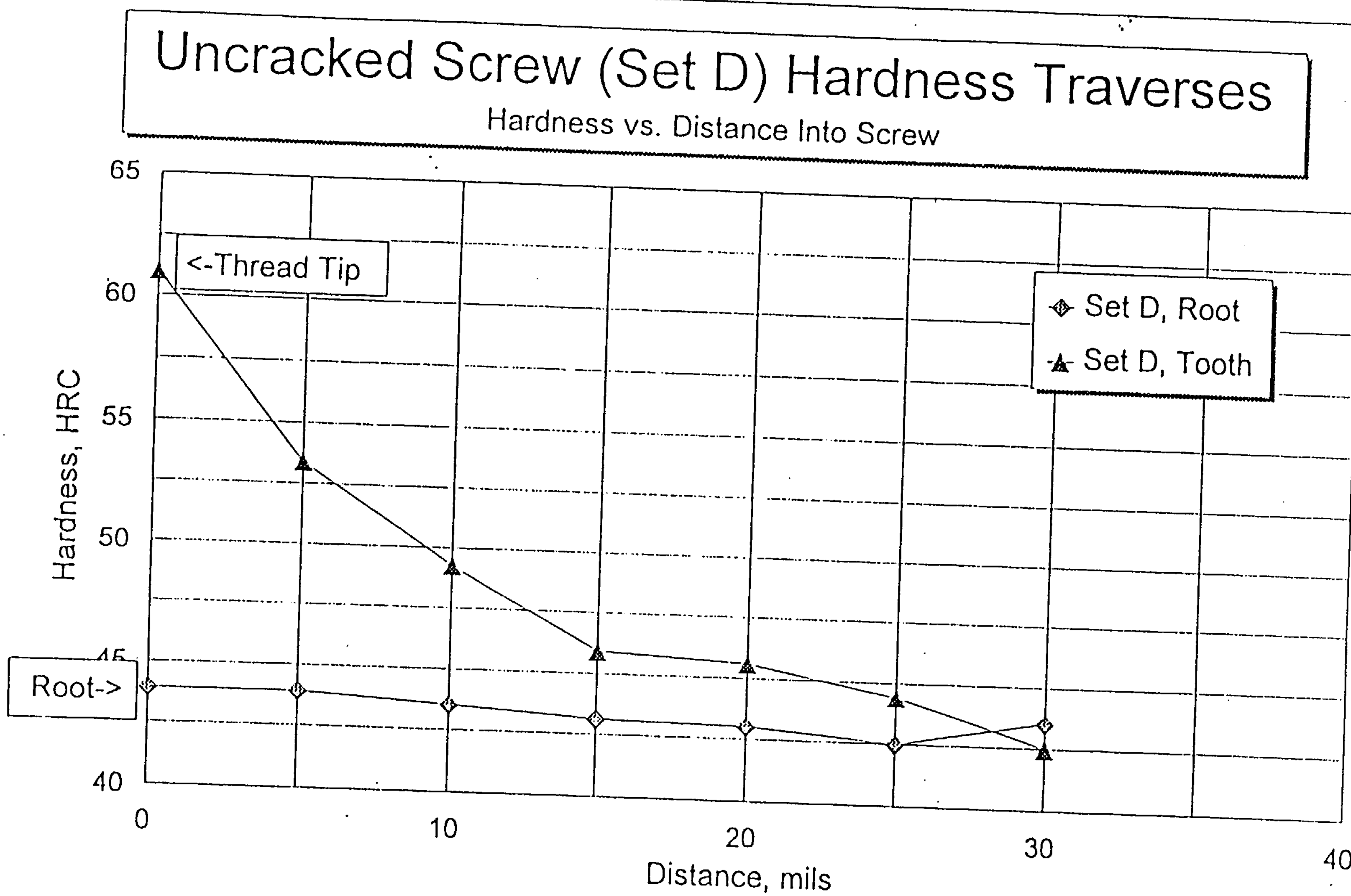

Figure 14 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

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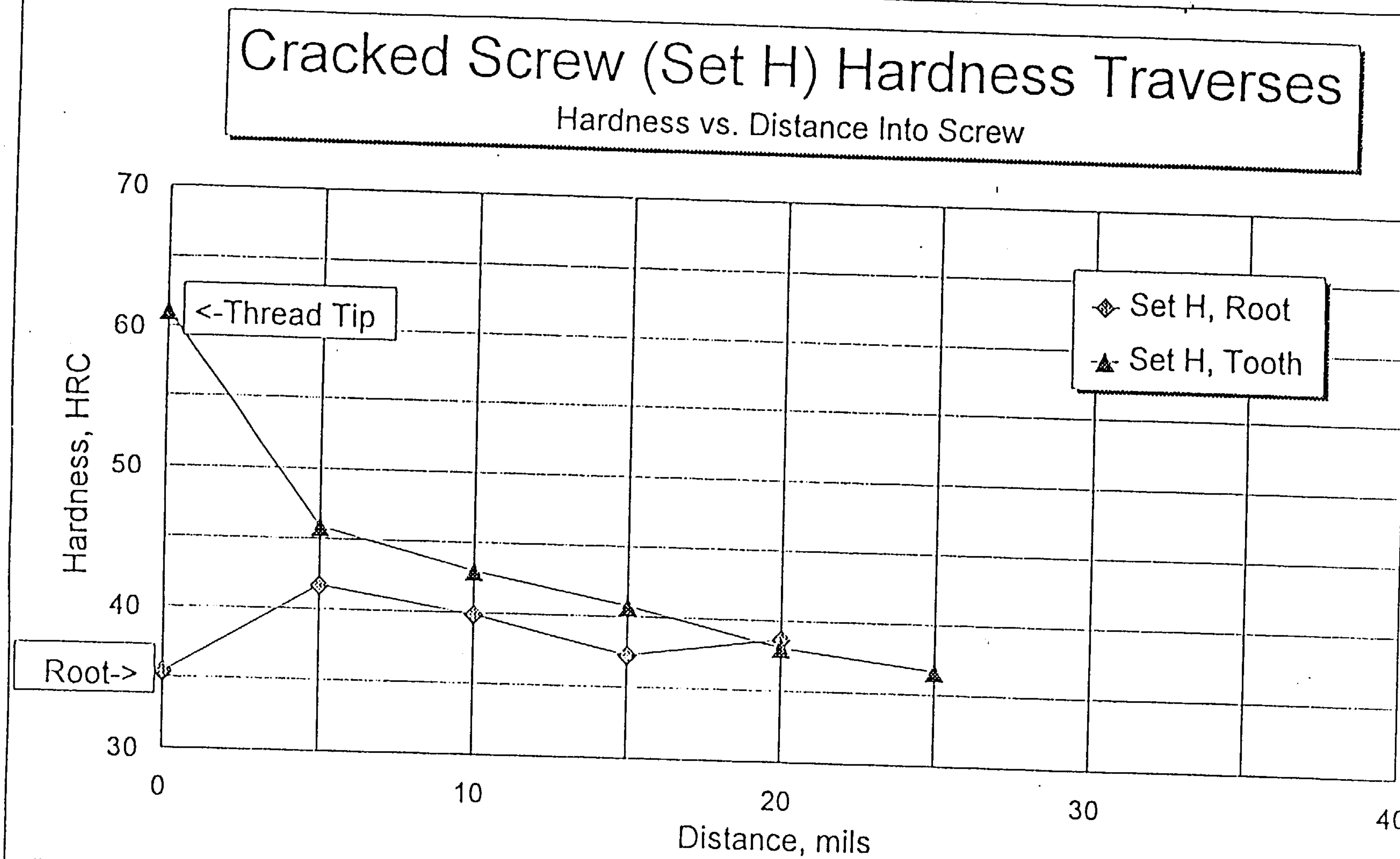

Figure 15 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

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EQUIPMENT SPECIFIC ON COVER SHEET
WESTINGHOUSE FORM 54064C

Westinghouse Electric ...
Nuclear Energy Systems
P.O. Box 355
Pittsburgh, Pennsylvania 15230

EQUIPMENT SPECIFICATION	DATED	REVISION NO.	DATED	ORIGINAL ISSUE	SUPERSEDES PREVIOUS REVISIONS
678956	2/26/73	4	6/11/74	☐	☒

PROJECT: GENERAL

EQUIPMENT: ICE CONDENSER ICE BASKET (GALVANIZED)

SHOP ORDER: 902

SYSTEM: ICE CONDENSER

SPIN NO. CNHDIB

ANS SAFETY CLASS 2

ATTACHMENTS

W Administrative Spec.
W QCS-1

FOR SUPPLIER'S CONVENIENCE

REV. NO.	REVISION ENTERED BY & DATE

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APPROVALS

		REV. 1	REV. 2	REV. 3	REV. 4
AUTHOR	A. F. Satterlee/A. V. Pradhan [signatures]			A.V.P. 2-11-74	[signature]
SHOP ORDER HOLDER	D. I. Frelin [signature]			DIF 2/11/74	DIF 6/12
MANAGER	J. A. George [signature]			JAG 2/11/74	JAG 6/12
PROJECT MANAGER					

EXHIBIT 4

3.0 DESIGN REQUIREMENTS

The equipment is designed by W NES and the supplier is not to make design changes unless approved in writing by W NES.

4.0 MATERIALS

Materials listed in Paragraph 4.1 below are acceptable for this application.

4.1 Acceptable Materials

4.1.1 Sheet steel (couplings, stiffeners and basket end) shall be ASTM A-622, Hot rolled DQ-SK steel sheets with 32,000 psi specified minimum yield.

4.1.2 Bolts and clevis pins shall be SAE J429 Grade 8 steel.

4.1.3 Sheet metal screws shall be ASTM C-1022 heat treated to surface hardness minimum C-52 and a core hardness C-32-40.

4.1.4 Nuts shall be heat treated carbon steel (quench and temper).

4.1.5 The plate shall be ASTM A-36.

4.1.6 Lug, mounting bracket rest and mounting bracket shall be ASTM A-588 steel.

4.1.7 Cadmium plating, zinc plating and zinc phosphate coatings are acceptable for bolts, nuts, pins, washers and screws.

4.1.8 Wire screen and trap door shall be ASTM A-641 zinc coated carbon steel wire.

4.1.9 Sheet steel (perforated metal) shall be either ASTM A-569 commercial quality hot rolled steel with 32,000 psi specified minimum yield or sheet steel per Section 4.1.1.

4.1.10 Grid bars shall be ASTM A-570 Grade B steel.

4.1.11 Ice Support insert shall be ASTM A-366 steel.

4.2 Unacceptable Materials

Only those materials listed in 4.1 of this specification are acceptable.

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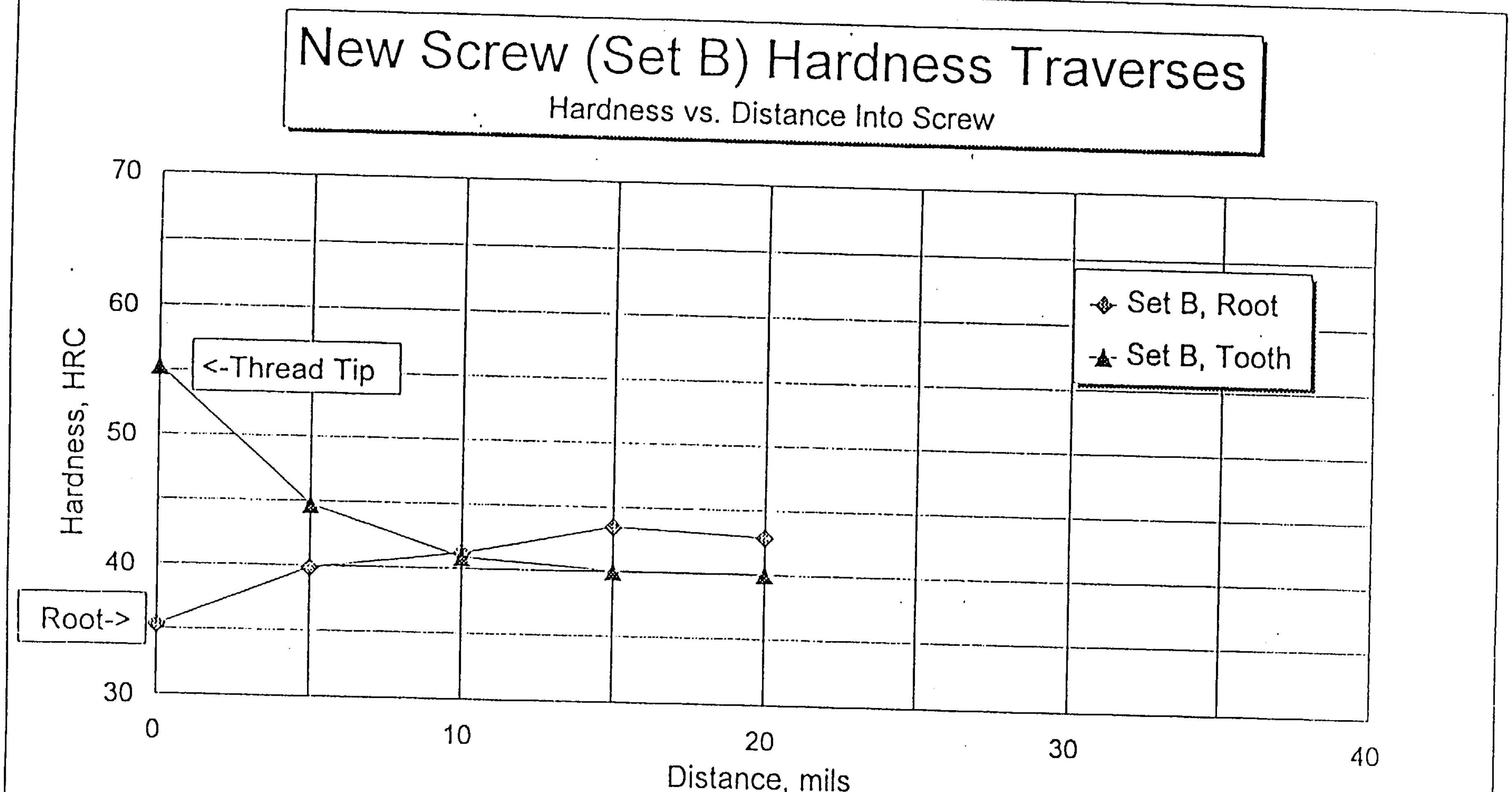

Figure 13 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

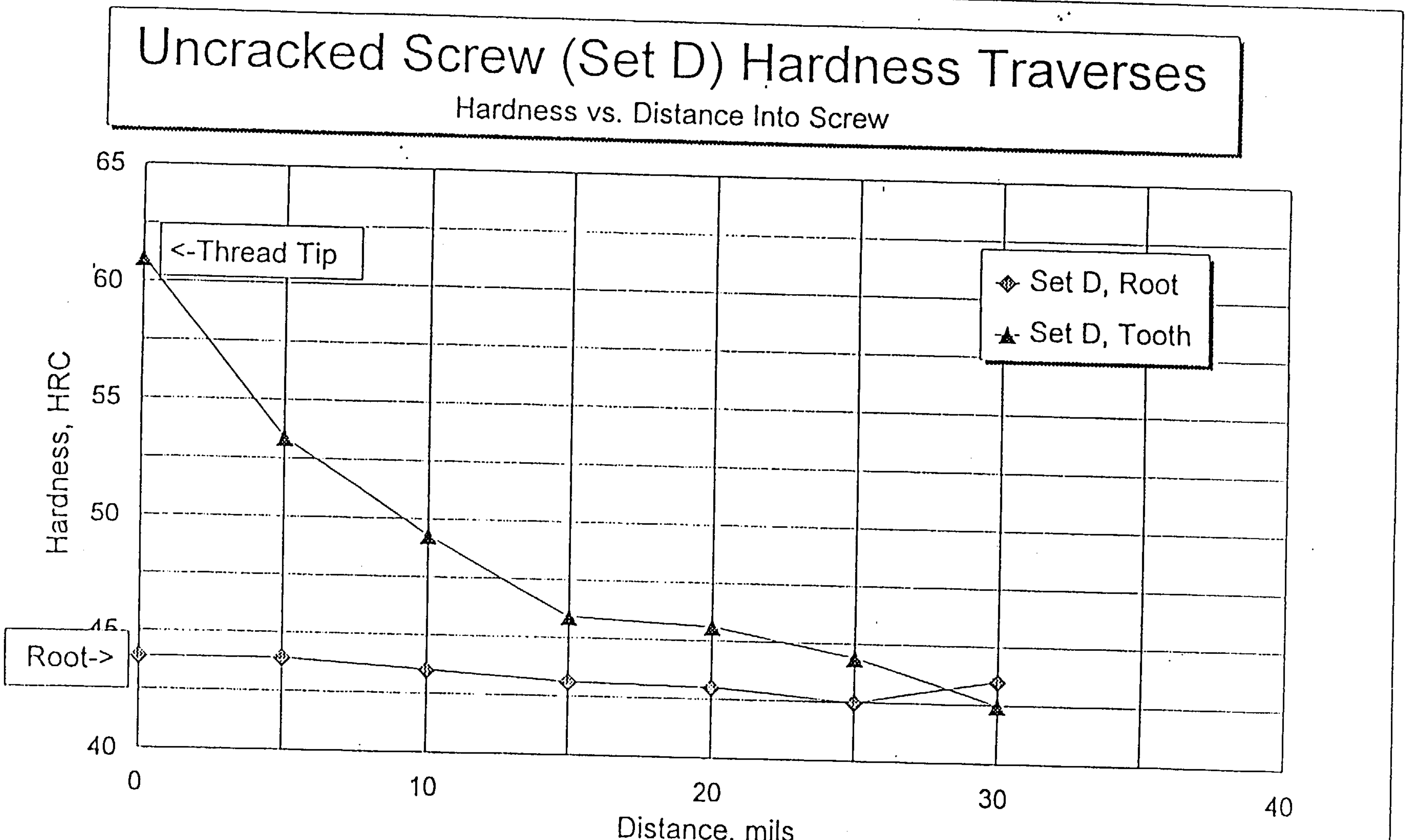

Figure 14 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

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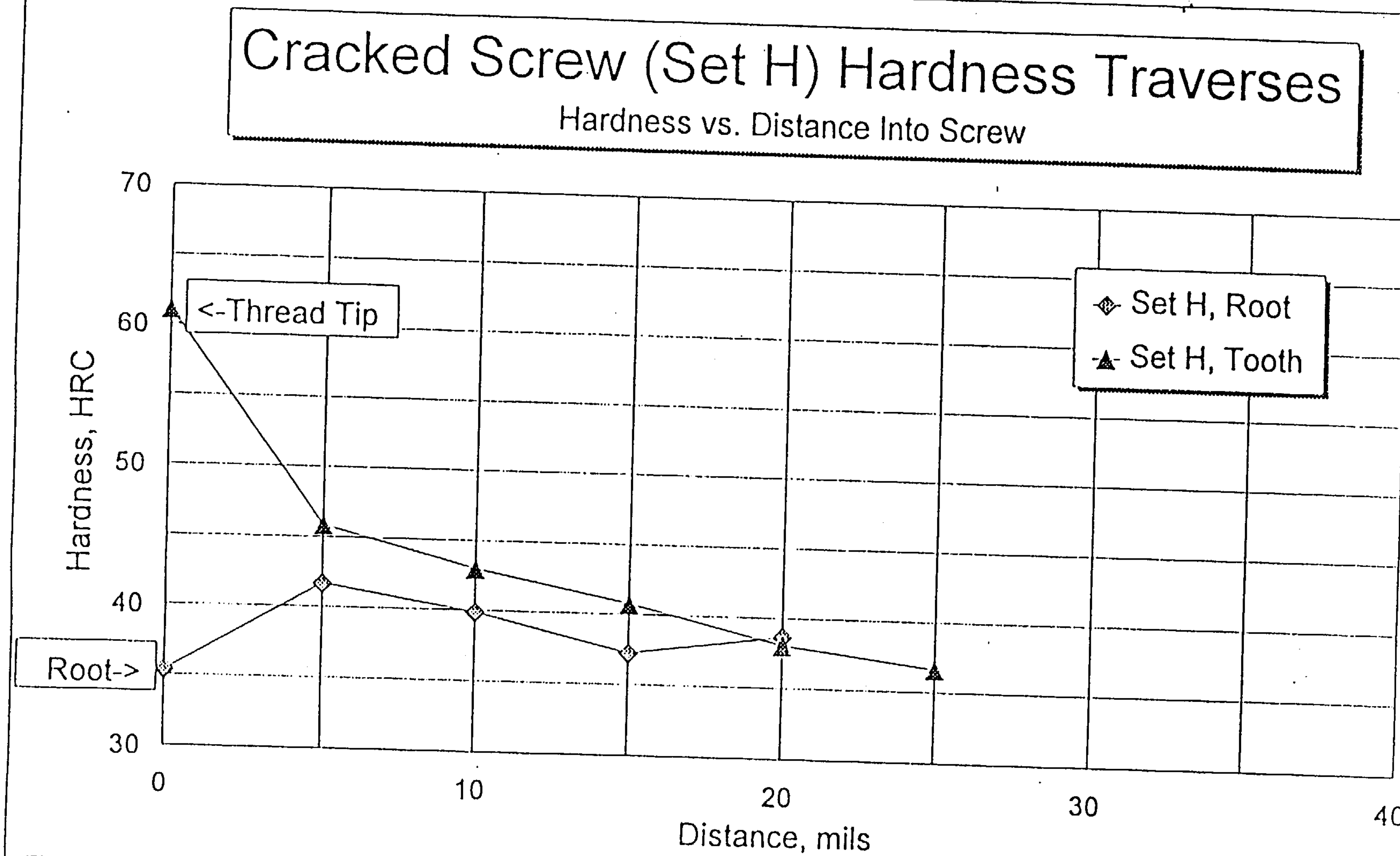

Figure 15 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

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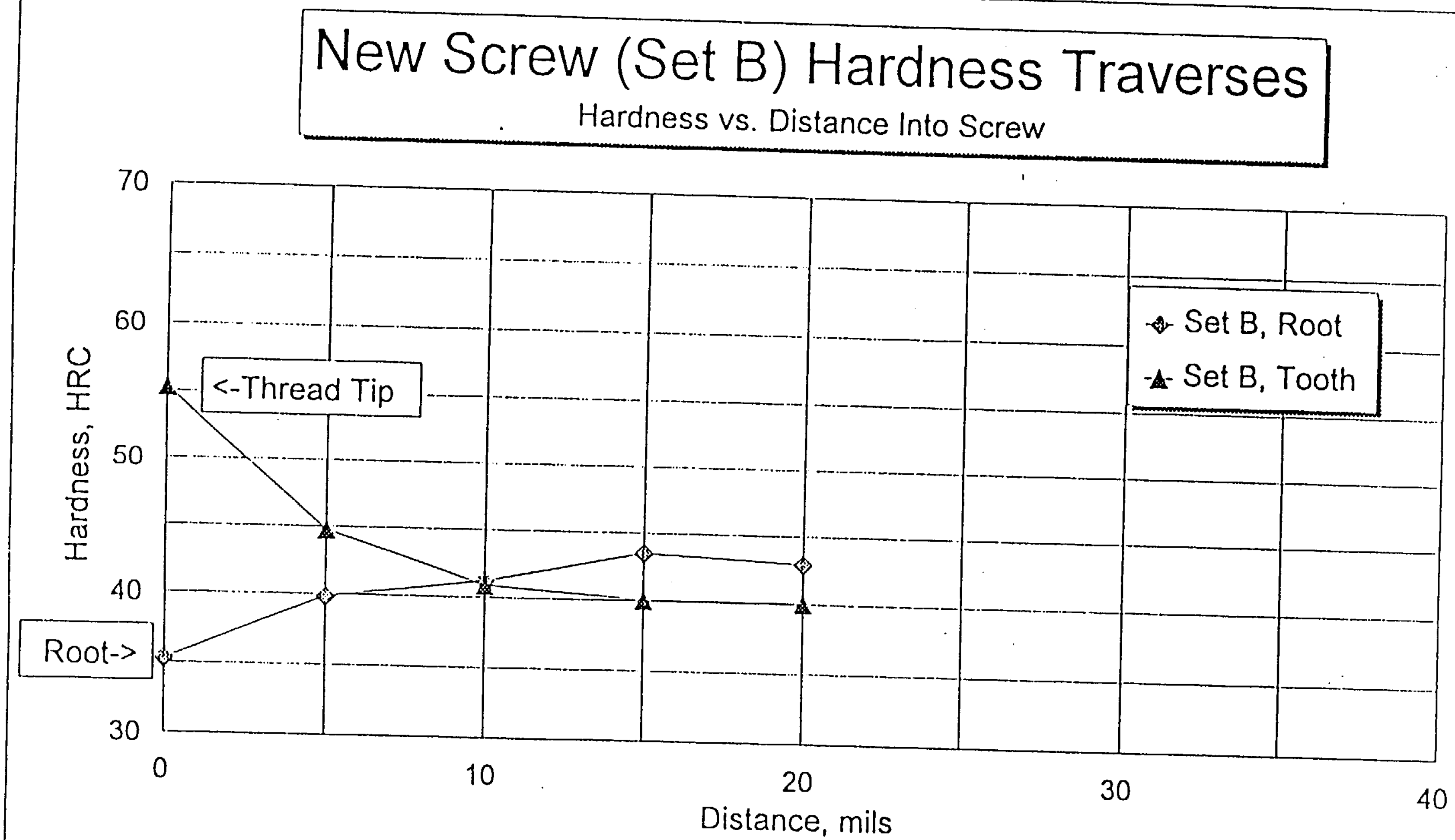

Figure 13 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

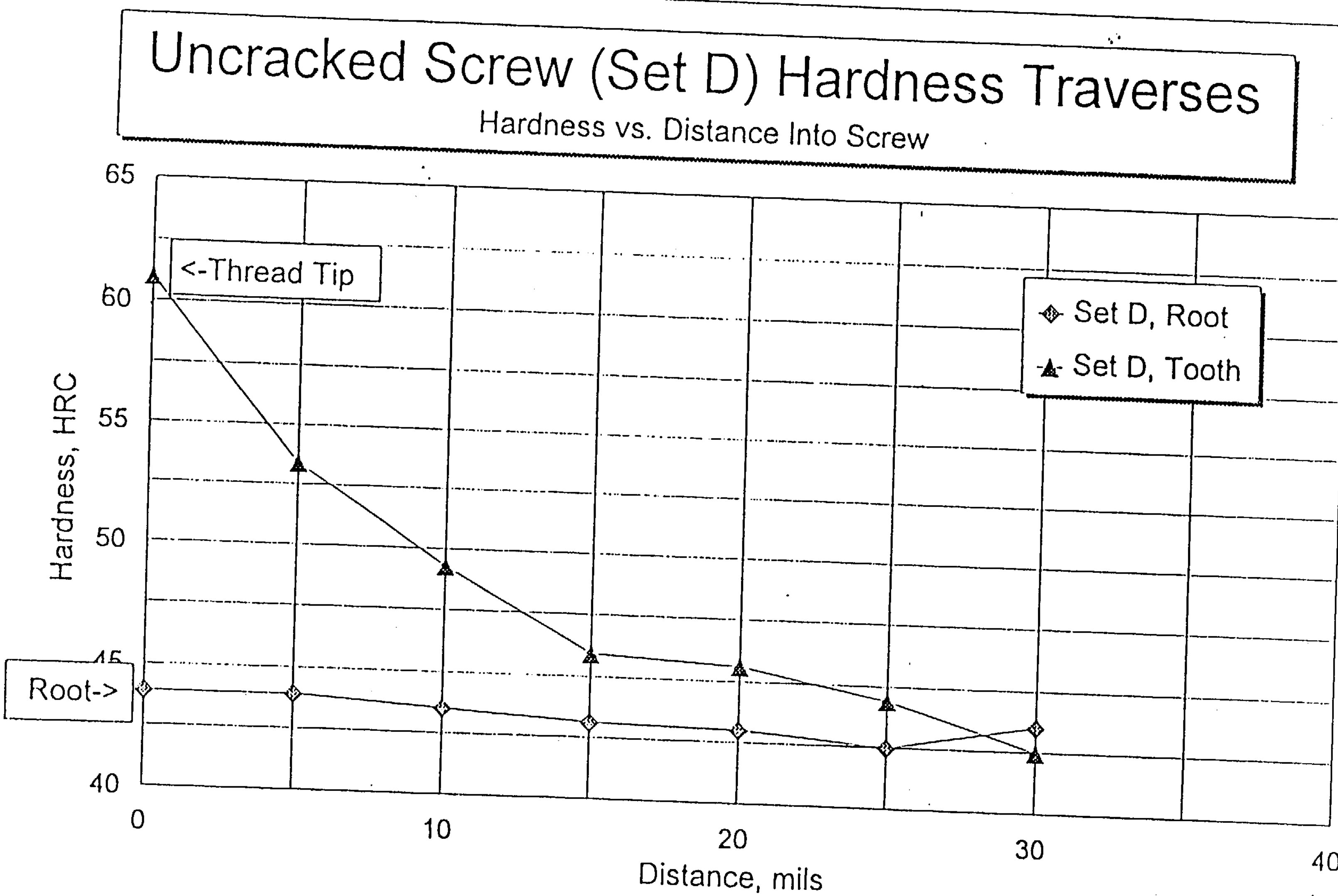

Figure 14 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

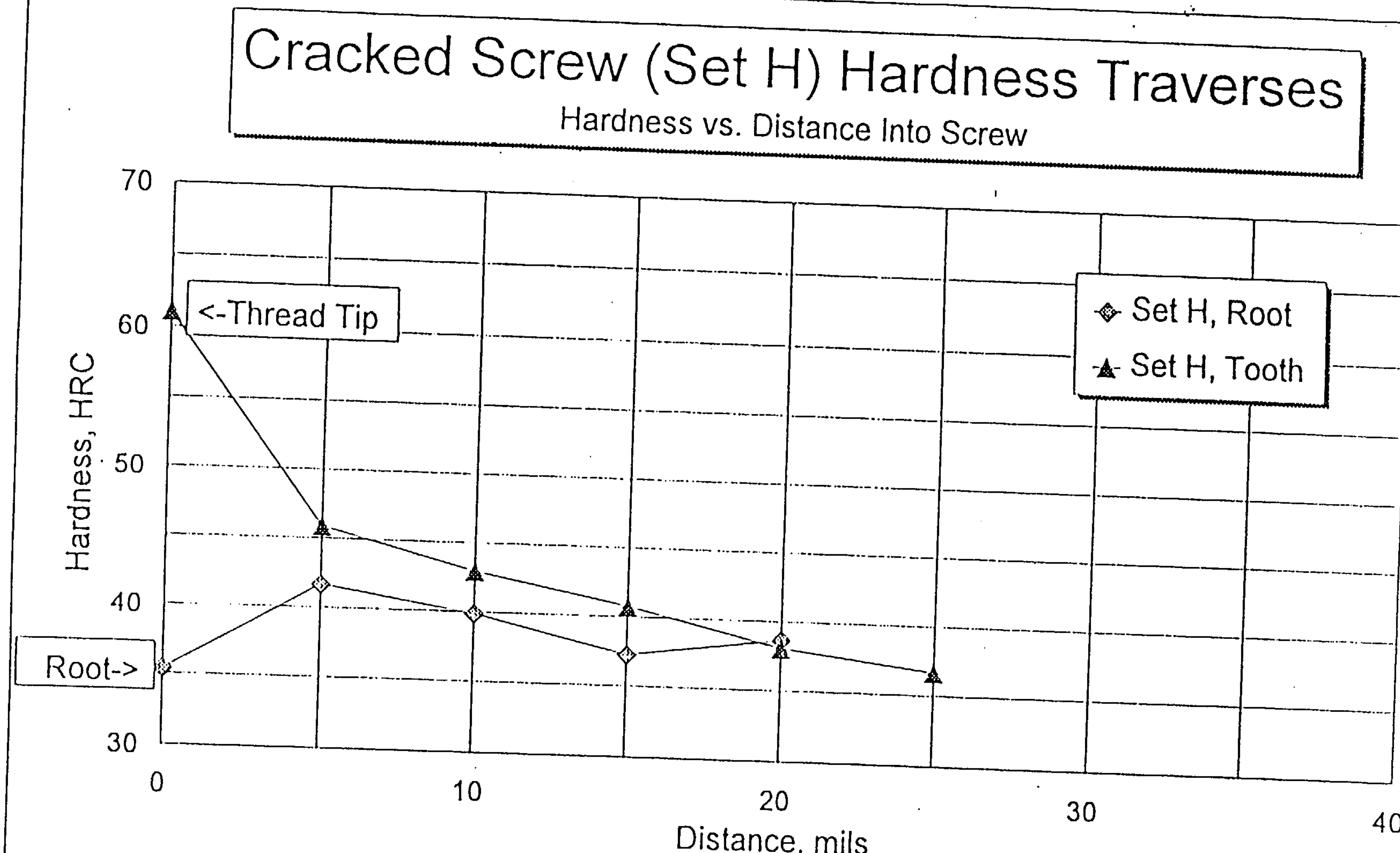

Figure 15 - Ice Condenser Basket Screws, Watts Bar Nuclear Plant, Unit No. 1. Customer Identification No. 95-07. Laboratory Report No. 95-1021.

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