FIELD PERFORMANCE OF EROSION RESISTANT MATERIALS ON BOILER INDUCED DRAFT FAN BLADES

TENNESSEE VALLEY AUTHORITY KINGSTON FOSSIL PLANT

May 1993

Prepared by
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DISCLAIMER

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INTRODUCTION

The TVA Kingston Fossil Power Plant has nine units and is located near Kingston, Tennessee. Units 1 through 4 have a rating of 148 MW and units 5 through 9 have a rating of 197 MW. Each unit has two induced draft fans manufactured by Westinghouse Electric Corp., Sturtevant Division. A table showing design data for the induced draft fans is located on page 16 of this report. The fan blade design details for units 5 through 9 are shown on pages 11 through 14. There is a mechanical fly ash collector and a small electrostatic precipitator preceding the induced draft fans in the boiler flue gas stream and a large, efficient electrostatic precipitator downstream of these fans. The steam generators and pulverizers were supplied by Combustion Engineering. The average temperature of the flue gas is about 340 degrees Fahrenheit for units 5 through 9.

All induced draft fans in the boiler flue gas stream experience erosion from fly ash. When the precipitators and fly ash collectors were new the fan blades would last about three years before they were eroded severely and had to be replaced. Kingston Plant personnel say the fly ash collectors are presently in need of major repairs; therefore, the fan blades are not expected to last as long as they did when the plant was new.

Between February 8, 1987 and August 25, 1989, Research and Development and Kingston performed a field test on twelve different erosion resistant materials. The results of this test were published in the TVA report Number TVA/PBO/R&D-90/5 titled "Erosion Resistant Material Field Test Report, Kingston Fossil Plant Unit 9 "B" Induced Draft Fan Blades", dated August 1989. In the above test, chrome carbide weld overlays, vacuum bonded ceramic tiles, mechanically bonded coatings, and fused coatings were tested. The fused metallic coatings offered the greatest protection from fly ash erosion and the mechanically bonded coatings offered the least amount of protection. Many of the ceramic tiles came off early in the test and permitted the blades to erode severely. The chromium carbide and vanadium tungsten weld overlays eroded severely on the inlet edges of the blades. Stress cracks that were in the weld overlays were also deepened and widened by fly ash erosion. The material that performed best was the Conforma Clad WC200 fused coating. This coating was made up of 69 to 73% tungsten carbide, 15% chromium, 3.5% boron, less than .1% carbon and the balance nickel. The WC200 coating performed better than the other coatings but it was also more expensive than weld overlays.

In the the spring of 1990 it was decided to install the WC200 coating on a full set of blades in one fan (120 blades total). In an effort to minimize cost it was decided to install the coating only on the area of the blades which experience severe erosion (see the photographs on page 5). The total cost of this coating was $12,000 for 120 blades ($100 per blade).

Kinton Carbide installed tungsten carbide platelets on four test blades in another induced draft fan in the summer of 1990. The tungsten carbide platelets were silver soldered to the blades only in the area where the maximum amount of erosion was expected. Kinton Carbide estimated it would cost $16,680 ($139 per blade) to install tungsten carbide platelets on 120 blades similar to the four test blades.

In February 1992 Applied Thermal Coatings, Inc. (ATC) installed a coating, Metadur III, consisting of 80% tungsten carbide, on 240 fan blades for a cost of $22,800 ($95 per blade). One set of blades (120) were installed in the unit 5 "A" induced draft fan in March 1992 and one set in the unit 7 "A" induced draft fan in May 1992. The ATC Metadur III coating covered the same area of the blades the Conforma Clad WC200 and Kinton Carbide cladding covered.

We learned from inspections of the Kinton Carbide and Conforma Clad test blades (see photographs on pages 5, 6, and 7) that we should, in the future, protect more area of the blades from erosion. Jim Weedman, District Manager of the Stoody/Thermadyne Welding Company, claimed the Stoody 130-0 MIG welding wire (60% tungsten carbide) would produce weld overlay that would be as resistant to solid particle erosion as the Conforma Clad and ATC coatings. The weld overlay could also be weld repaired in the field during a scheduled maintenance outage. After receiving a cost estimate from Consolidated which showed the Stoody 130-0 weld overlay would cost less than the Conforma Clad WC200 and the ATC Metadur III coatings, Kingston and R&D decided to install Stoody 130-0 weld overlay on a set of fan blades for a Kingston induced draft fan. These test blades were installed in a Kingston induced draft fan during the summer of 1992. During the fall of 1992, a set of fan blades with the Stoody 130-0 weld overlay was installed in a Widows Creed unit 7 induced draft fan.

RESULTS

In April 1992 the blades with the WC200 Conforma Clad were inspected after being in operation for 20 months (see photographs on page 5). Inspections of these blades indicated a need for cladding a greater area of the blade than was cladded. The area near the blade ear was eroded severely and was weld repaired with weld overlay. This fan was then placed in operation for about 10 more months before the blades were replaced. At the end of this operating period the blades were eroded so severely that two blades failed and were thrown from the fan rotor (see photographs on page 6). It appeared that during this 10 month operating period there was two or three times as much fly ash erosion of the blades as there was during the preceding 20 month operating period. This higher rate of erosion (4 to 6 times higher than normal) was caused by a decrease in the performance of the fly ash collectors preceding the induced draft fans.

The blades with the Kinton Carbide cladding were eroded near the ear and directly behind the Tungsten Carbide cladding (see photographs on page 7). An inspection of these test blades again indicated that there was a need to protect more area of the blade. If more area of the blade is protected it appears the life of the blade could be tripled or quadrupled. Kinton Carbide quoted $44,400 to clad a set of blades (120 blades at $370 per blade) for a Kingston fan. This quotation included covering a larger area of the blades with tungsten carbide platelets than was covered on the four test blades.

On February 8, 1993, after unit 5 at the Kingston Plant had been in operation for about 10 months, it was taken out of service. The test blades in the "A" induced draft fan with the ATC Metadur III coatings were replaced with blades made of conventional material. The test blades were severely eroded in the area near the blade ears where there was no coating (see photographs on page 8). It appeared the ATC Metadur III coating may have doubled the life of these blades. It may possibly tripled the life of the blades if more area of the blade is covered with this coating.

The Kinton Carbide and Conforma Clad WC200 cladding caused an accelerated rate of erosion in the base metal near the edges of the cladding (see the photographs on pages 6 and 7). This was probably due to the cladding thickness being a step change from the base metal which caused the fly ash to cut a path (channel) down the edge of the cladding. The Metadur coating thickness tapered off at its edges and did not cause this channeling effect (see the photographs on page 8).

RECOMMENDATIONS

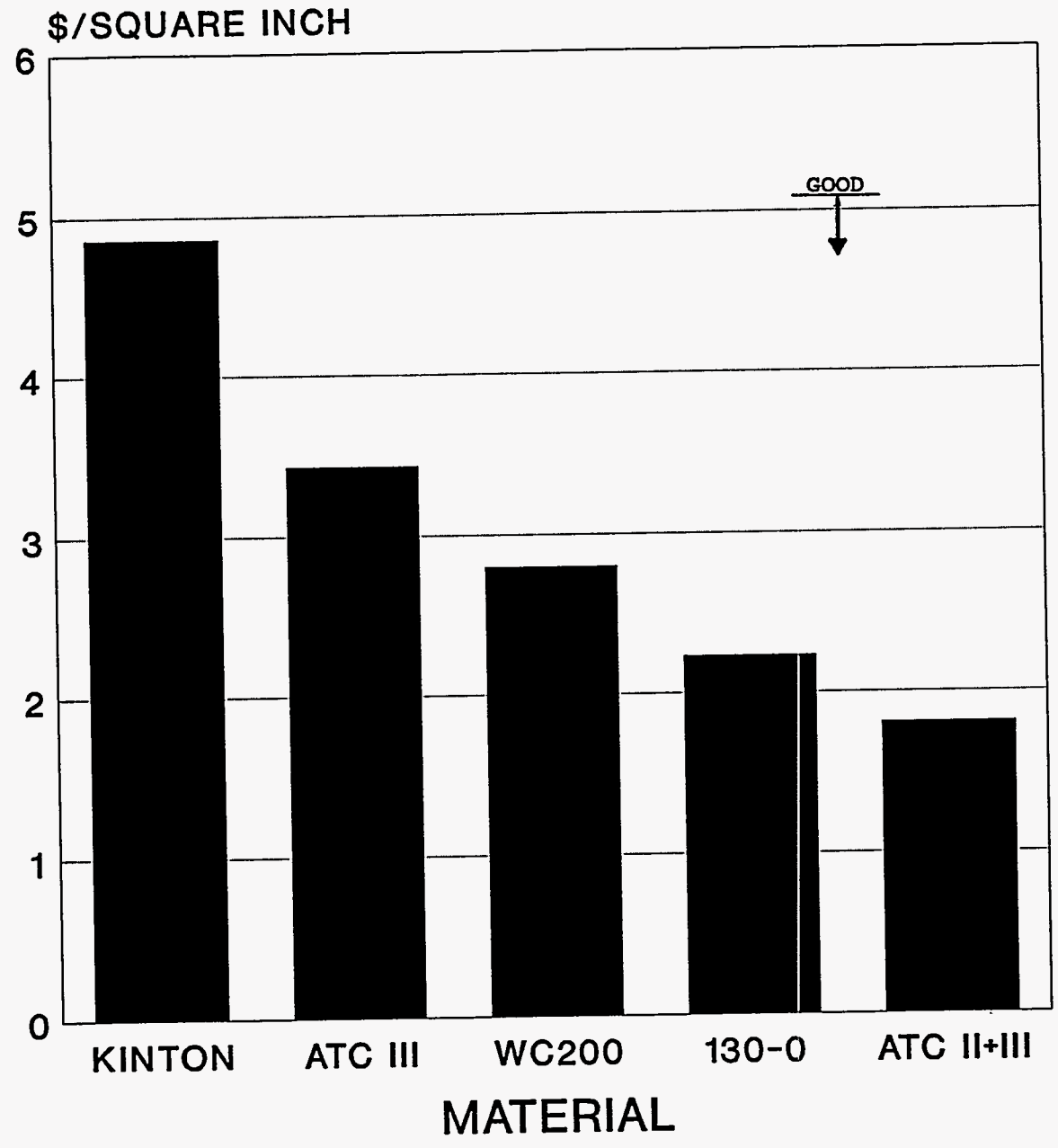
It is recommended that the ATC Metadur II (50% tungsten carbide) coating (0.040" thick) be installed over the area of the blades that experience severe erosion (about 20% of the blade's concave surface) and the Metadur III (80% tungsten carbide) coating (0.020" thick) be installed over the Metadur II coating in the area experiencing maximum erosion (about 6% of the blade's concave surface). This coating arrangement is shown on page 10 and cost about $12,000 to install on 120 blades of a Kingston fan ($100 per blade).

The Conforma Clad WC200 material is very erosion resistant and therefore should be retained in the future as an alternate method for erosion protection. The cost for installing the Conforma Clad WC200 coating over 120 blades of a Kingston fan is $18,480 ($154 per blade). The above cost is for installing a coating (0.030" thick) over the area of the blades shown on the sketch on page 10.

If the Stoody 130-0 weld overlay proves to be satisfactory it may be considered an alternate method of protecting the fan blades from fly ash erosion. At the time of this report, the test blades with the Stoody 130-0 weld overlay had not been inspected. The cost for installing the Stoody 130-0 on 120 blades of a Kingston fan was $13,024 ($108.53 per blade). It is expected that this price could be reduced in the future with lower cost MIG welding wire.

The Kinton Carbide tungsten carbide material is very resistant to fly ash erosion but it is the highest cost blade protection tested. Kinton Carbide estimates it would cost $370 per blade to provide satisfactory protection from fly ash erosion. This cost includes covering about 76 square inches of the blade with .0625 inch thick tungsten carbide platelets.

FAN BLADE
PROTECTION COST

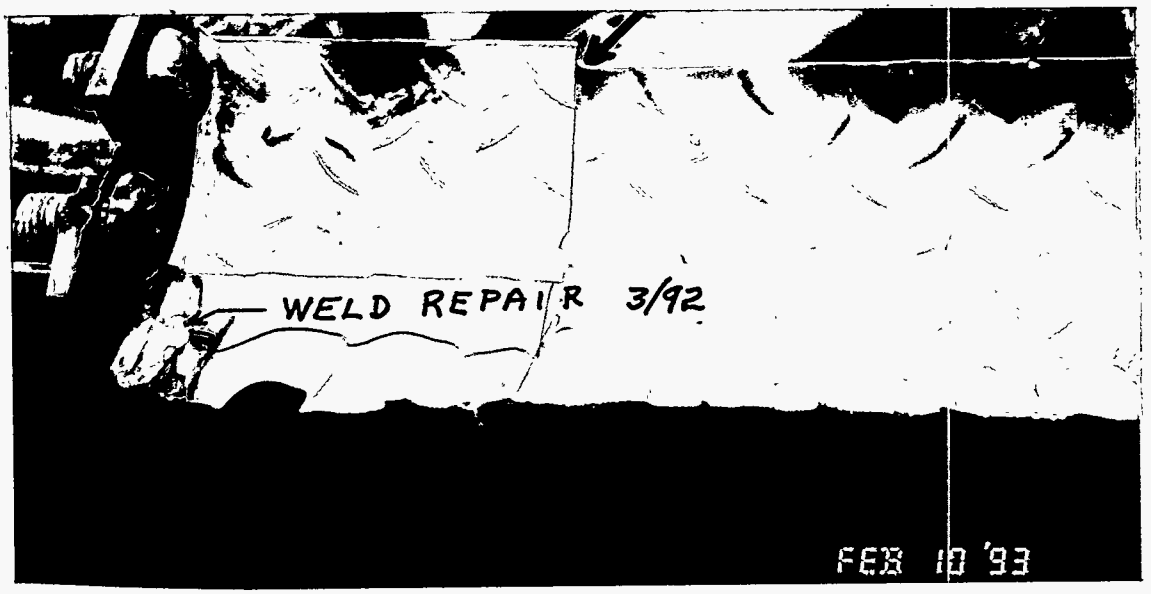


KIF-FAN

UNIT-5 "B" INDUCED DRAFT FAN BLADES

Test period: June 24, 1990 to February 15, 1992

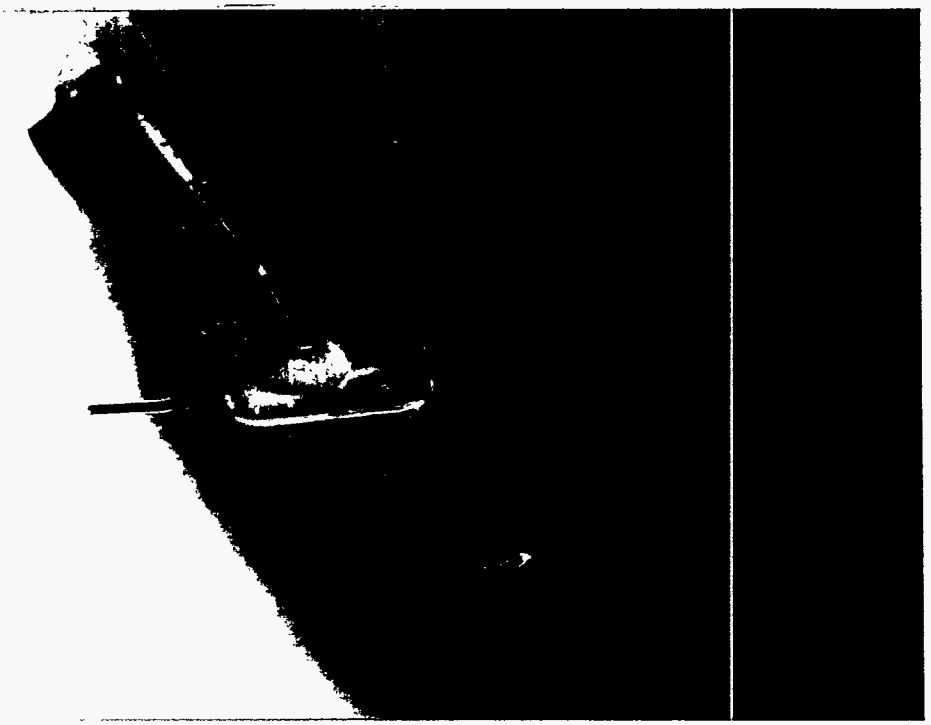
Condition of the Conforma Clad WC200 Tungsten Carbide coating after operating about 20 months. The coating protected the fan blades from erosion except for a small area at the edge of the blade where the coating is starting to come off. There is also an unprotected area at the side of the blade that eroded and was weld repaired. The cost of this coating was $12,000 for 120 Kingston fan blades ($100 per blade).



UNIT-5 "B" INDUCED DRAFT FAN BLADES

Test period: June 24, 1990 to February 8, 1993

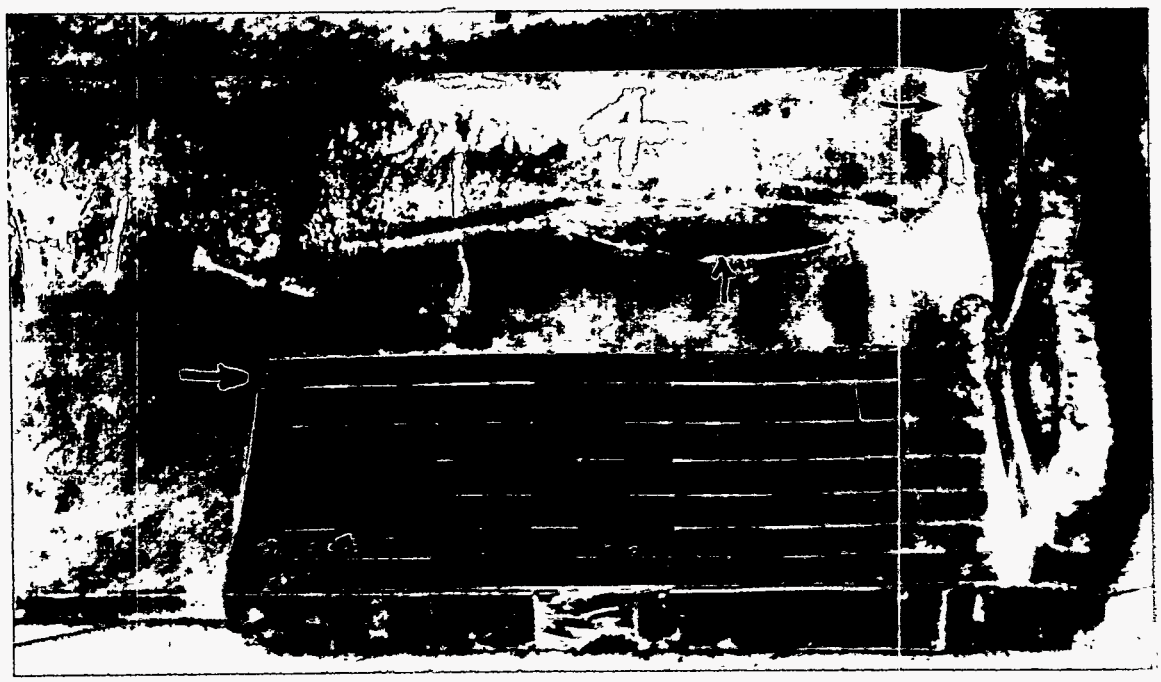
Condition of the Conforma Clad WC200 Tungsten Carbide coating and fan blade base metal after operating about 30 months. The coating protected the fan blades from erosion in the area it is installed except for an area of severe erosion near the inlet edge. The coating cost: $12,000 for 120 blades ($100 per blade).

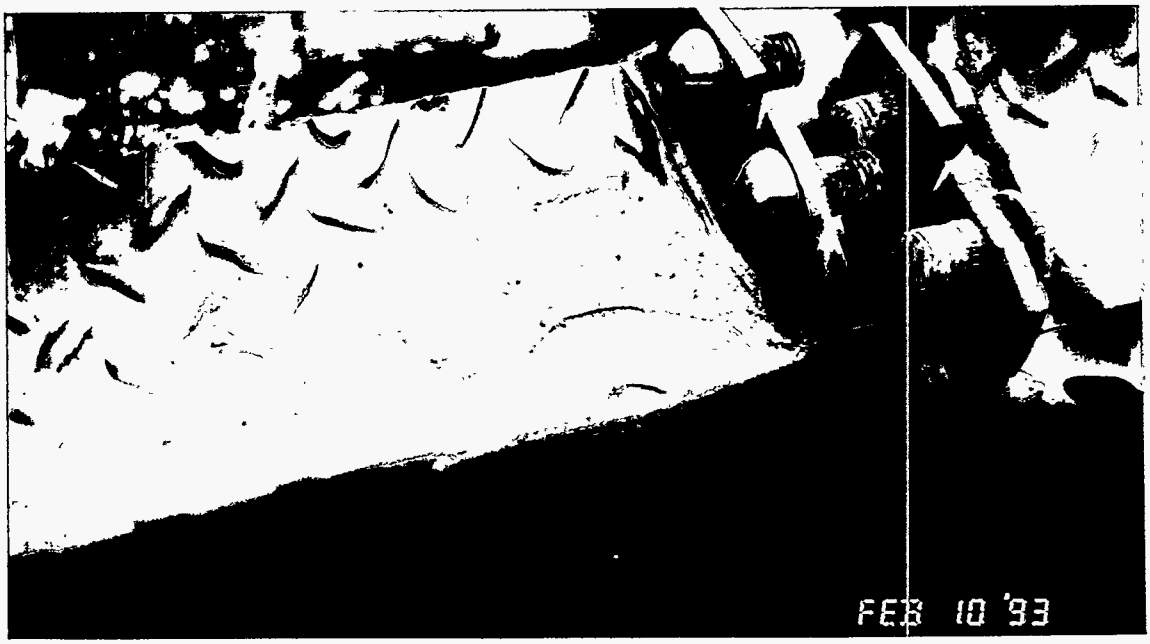


UNIT-7 "B" INDUCED DRAFT FAN BLADES

Test period: September 29, 1990 to April 24, 1992

Two fan blades with Kinton Carbide Tungsten Carbide platelets after operating about 19 months. The Tungsten Carbide protected the blades from erosion in the areas it was installed. Some Tungsten Carbide platelets came off the inlet edge of the four test blades. The unprotected area of the blade downstream from the Tungsten Carbide eroded severely (it eroded through the first layer of the 3/8" thick steel blade at the points shown by the arrows).
Cost: $16,680 for 120 blades ($139 per blade).

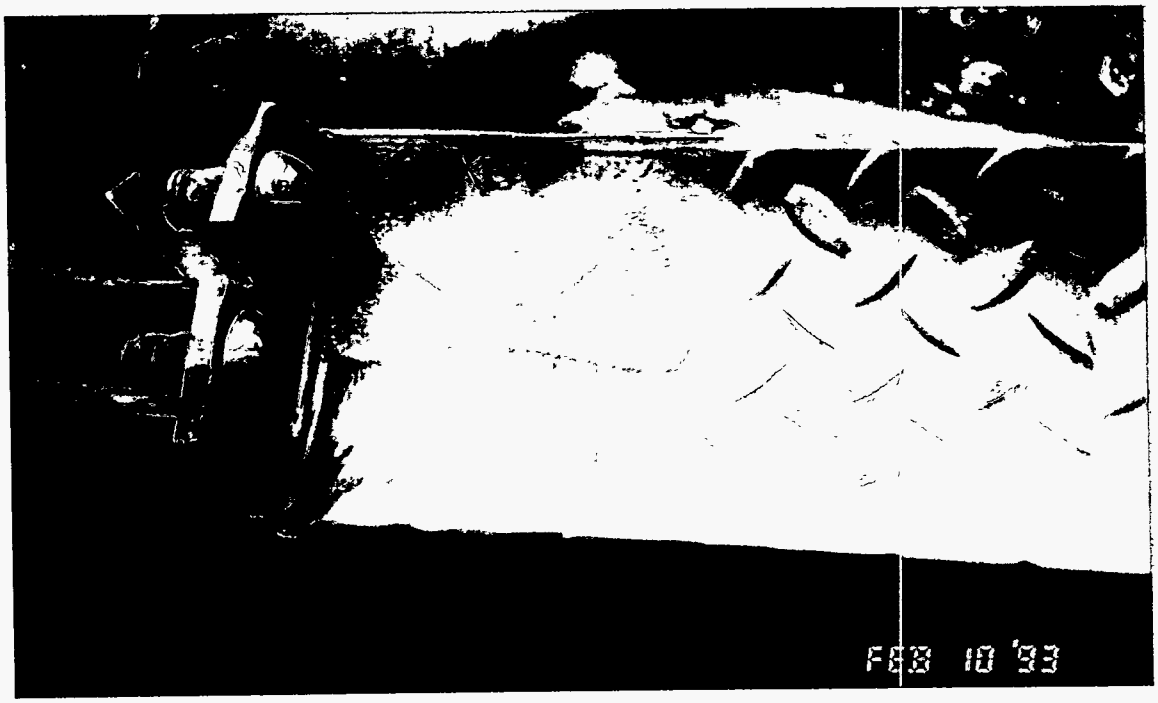




UNIT-5 "A" INDUCED DRAFT FAN BLADES

Test period: April 12, 1992 to February 8, 1993

Condition of the ATC Metadur III 80% Tungsten Carbide coating and fan blade base metal after operating about 10 months at 4 to 6 times the normal erosion rate. The coating reduced solid particle erosion and made the blade last about twice as long as it would have lasted without the coating. The coating cost: $11,400 for 120 blades ($95 per blade).

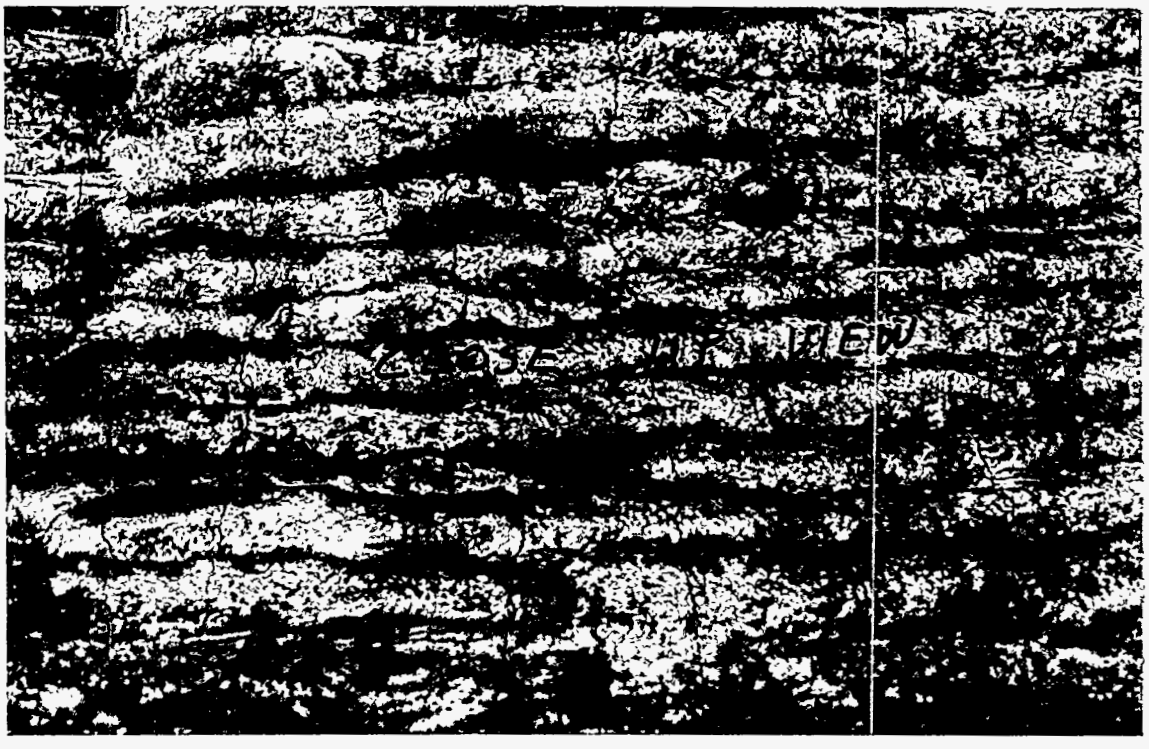


UNIT-7 "B" INDUCED DRAFT FAN

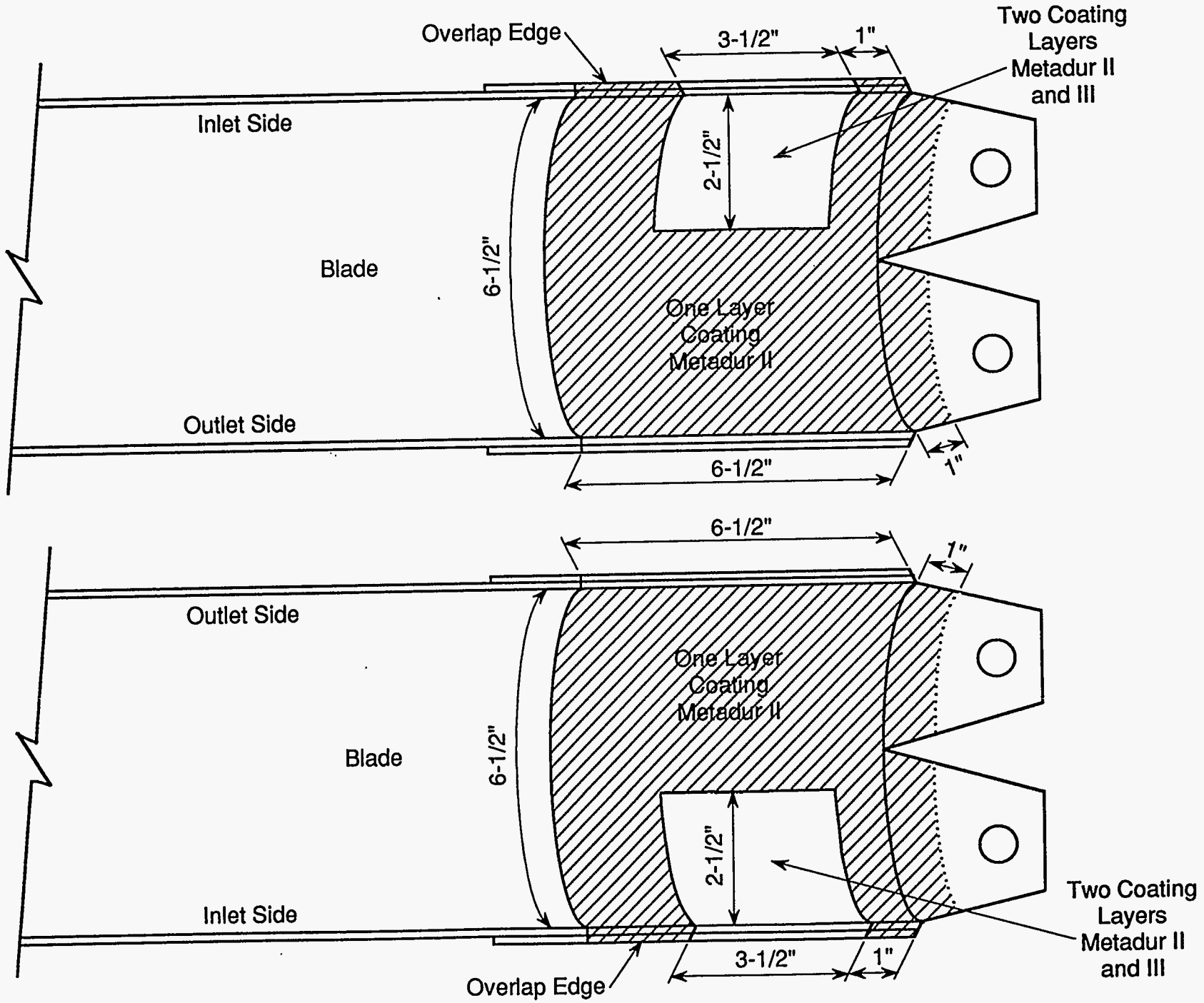
FAN BLADE EROSION PROBLEM

A fan blade before it was placed in service with a 60% Tungsten Carbide weld overlay on the area that experiences fly ash erosion. Two layers of weld overlay are installed on the area that experiences severe erosion. The weld overlay is made from 1/16 inch diameter Stoody 130-0 mig welding wire. The contractor was Consolidated Metal Services, Inc. The cost was $13,024 for 120 blades ($109 per blade) for a Kingston fan and $17,572 for 128 blades ($137 per blade) for a Widows Creek unit-7 fan.

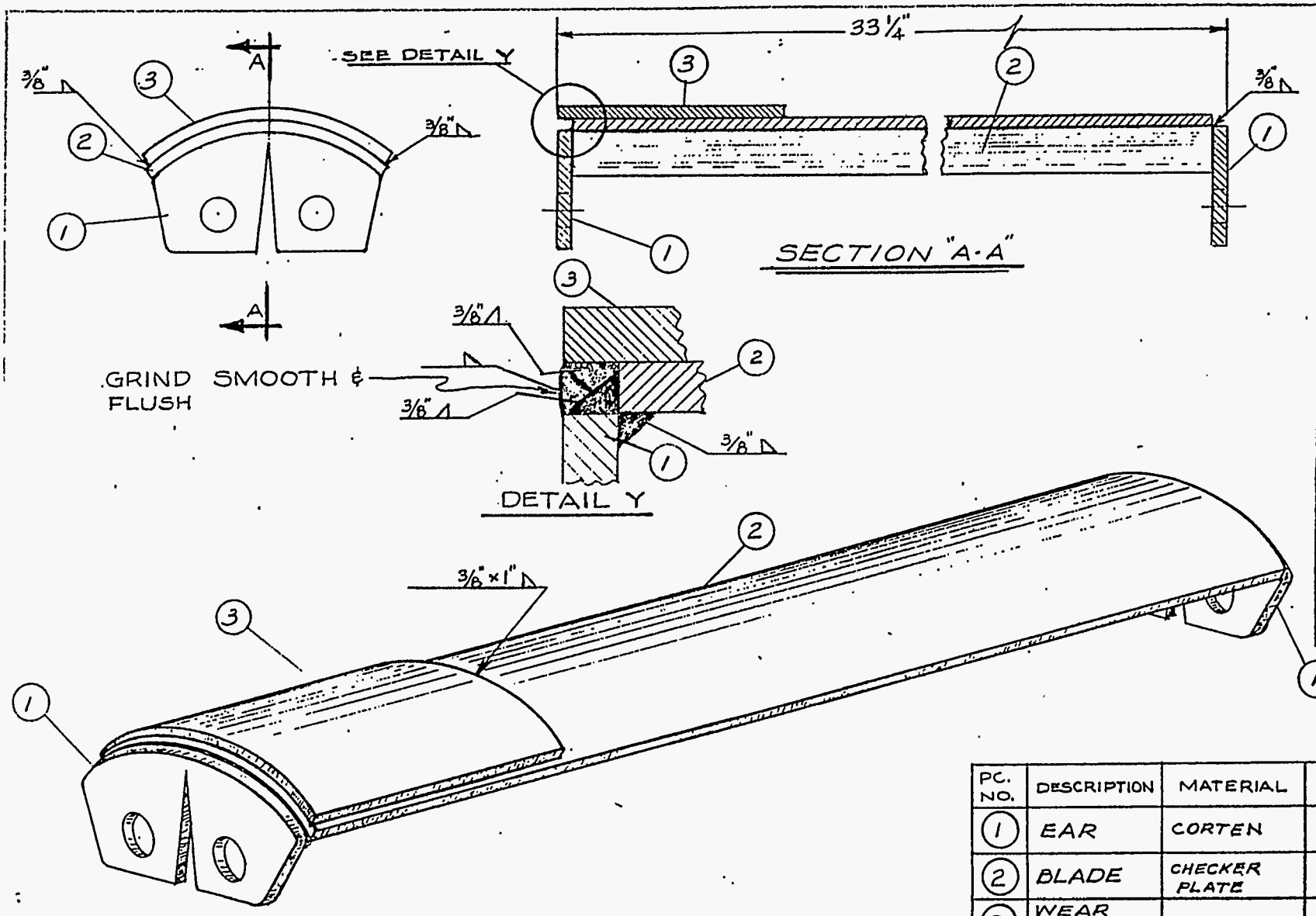
Test Start: June 19, 1992



TVA Kingston Fossil Plant I.D. Fan Blades



R&D:93/23



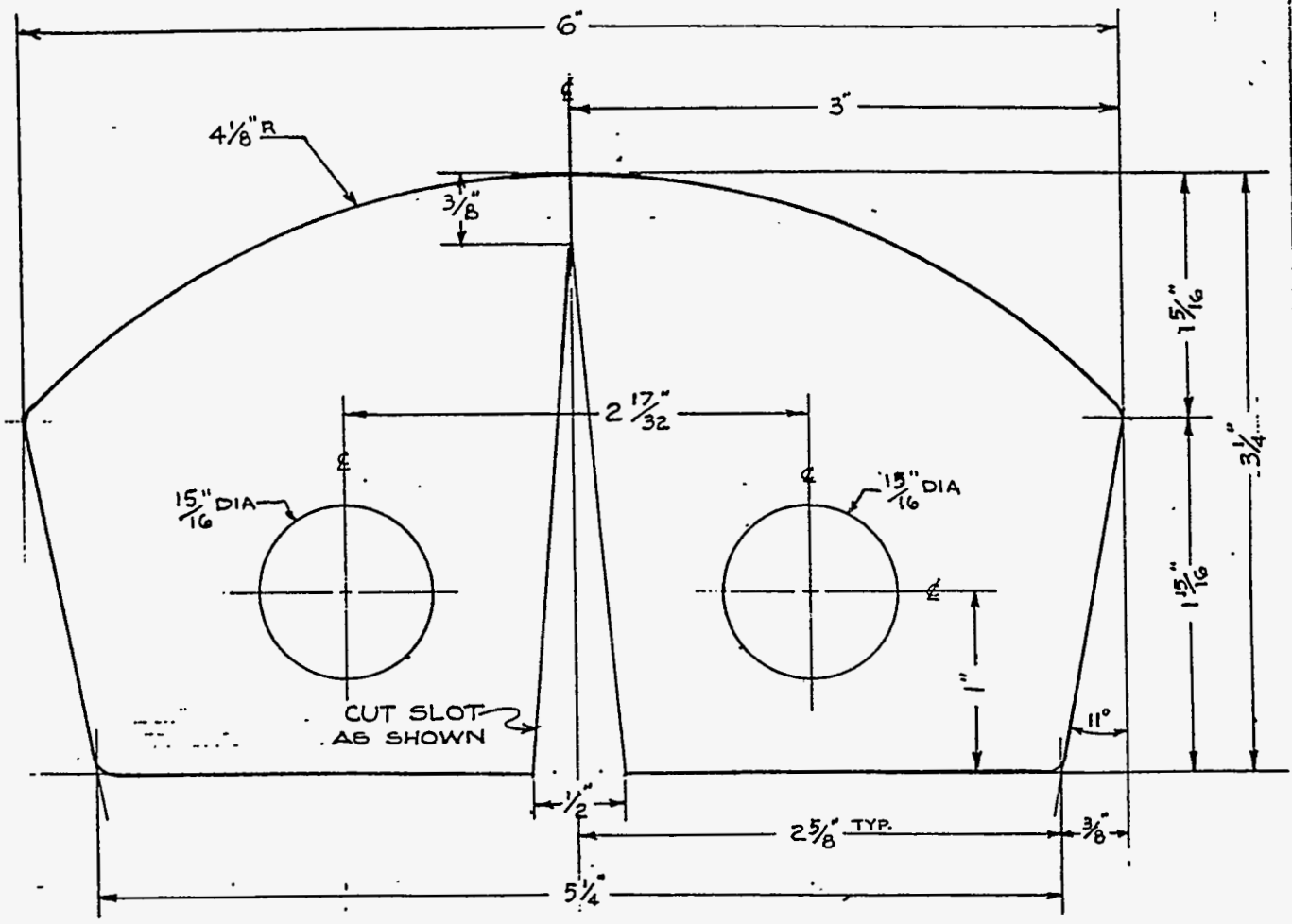
PC. NO.	DESCRIPTION	MATERIAL	REMARKS
1	EAR	CORTEN	SEE SHEET #2 FOR DETAILS
2	BLADE	CHECKER PLATE	SEE SHEET #3 FOR DETAILS
3	WEAR PAD	CORTEN	SEE SHEET #4 FOR DETAILS

TENNESSEE VALLEY AUTHORITY
DIVISION OF POWER PRODUCTION

I.D. FAN ASSEMBLEY & DETAILS UNIT 5 & 9 KINGSTON STEAM PLANT

SCALE: NONE | SUBMITTED | APPROVED | DATE 12/18/78
DRAWN J. RICHEY | SHEET 1 OF 4 SHEETS
TRACED | PSS2-M-A-66
-11-

TVA 6690 (PP-2-60)



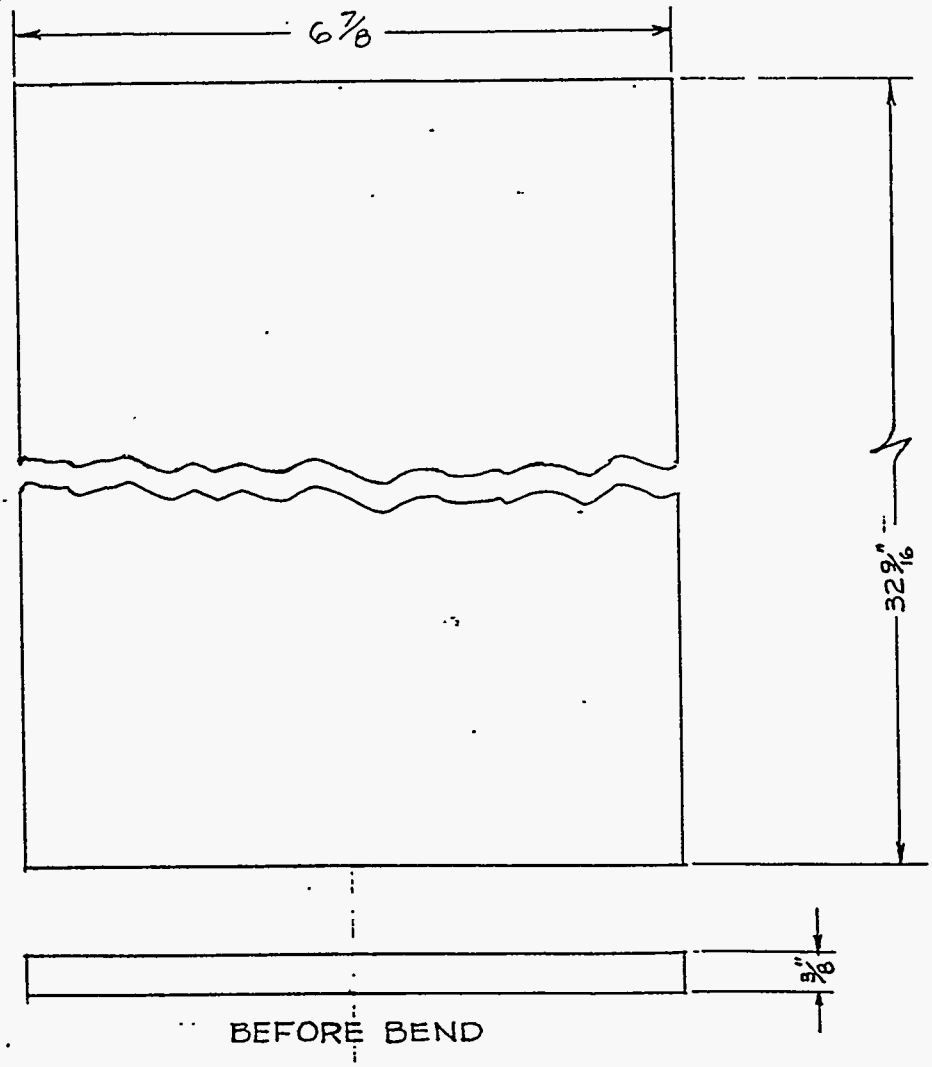
MATERIAL TO BE 3/8" CORTEN

TENNESSEE VALLEY AUTHORITY
DIVISION OF POWER PRODUCTION

I.D. FAN EAR
UNIT 5 & 9
KINGSTON STEAM PLANT

SCALE: FULL	SUBMITTED	APPROVED	DATE 12/15/78
DRAWN J. RICHEY			SHEET 2 OF 4 SHEETS
TRACED			PSS2-M-A-66

TVA 6690 (PP-2-60)



(2)

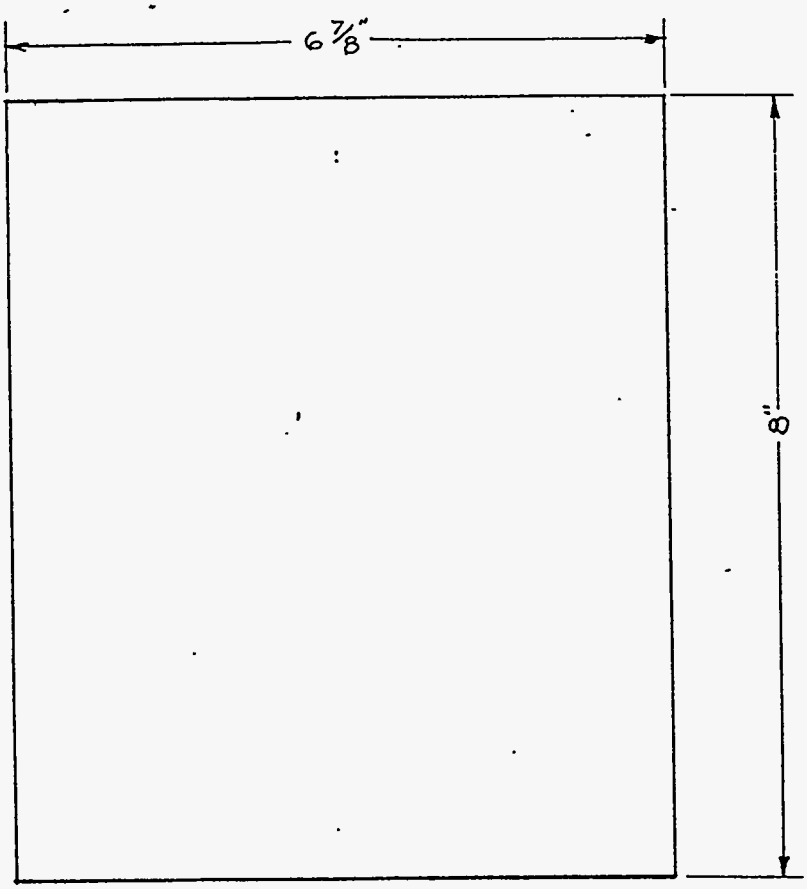
MATERIAL — 3/8" CHECKER PL

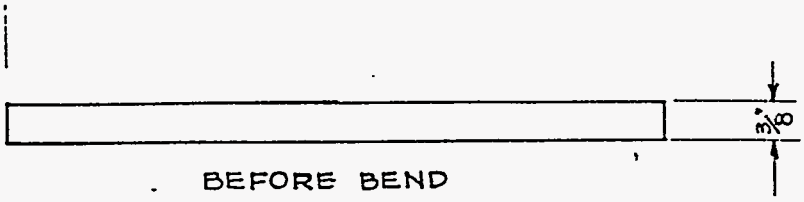
TENNESSEE VALLEY AUTHORITY
DIVISION OF POWER PRODUCTION

I.D. FAN BLADE
UNIT 5 & 9
KINGSTON STEAM PLANT

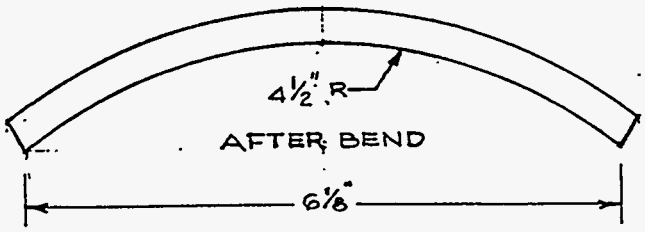
SCALE: 1/2" = 1"	SUBMITTED	APPROVED	DATE 12/15/78
DRAWN J. RICHEY			SHEET 3 OF 4 SHEETS
-13-			PSS2-M-A-66

TVA 6690 (PP-2-60)





BEFORE BEND



AFTER BEND

(3)

MATERIAL — 3/8" CORTEN

TENNESSEE VALLEY AUTHORITY
DIVISION OF POWER PRODUCTION

I.D. FAN PAD
UNIT 5 & 9
KINGSTON STEAM PLANT

SCALE: 1/2" = 1"	SUBMITTED	APPROVED	DATE 12/15/78
DRAWN J. RICHEY			SHEET 4 OF 4 SHEETS
TRACED			PSS2-M-A-66

TVA 6690 (PP-2-60)

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FAN DESIGN DATA

UNITS 5 - 9

Number of Induced Draft Fans	2
Induced Draft Fan type	16 MVID
Fan rated capacity (CFM)	400,000
Rated static pressure at test block (inches of water)	20.0
Fan Speed (RPM)	593