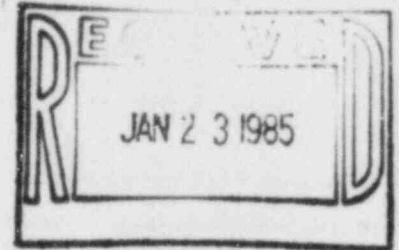




Public Service Company of Colorado

January 18, 1985
Fort St. Vrain
Unit No. 1
P-85017

Regional Administrator
Region IV
Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011



Attention: Mr. Eric H. Johnson

DOCKET No. 50-267

SUBJECT: Bearing Debris Analysis

REFERENCES: 1) G-84392, H. R. Denton to
R. F. Walker, dated 10/16/84
2) P-84290, O. R. Lee to
E. H. Johnson, dated 8/21/84

Dear Mr. Johnson:

This letter fulfills Public Service Company's commitment, as stated in Reference 2, to provide control rod drive orifice assembly (CRDOA) debris analysis information prior to restart. PSC has had chemical analysis performed by GA Technologies (Attachment 1) and Accu-Labs Research, (Attachment 2) on the CRDOA shim motor bearing ultrasonic cleaning solution and debris found on the CRDOA housing.

Bearing Debris

PSC analyzed several samples of the bearing cleaning solution only to discover that the samples were contaminated by the cleaning solution itself. The cleaning solution may have masked the results somewhat, but the analysis still indicates that all but two of the major constituents can be attributed to the bearing materials (Attachment 6). The two exceptions are lead and tin which were the major contaminants in the cleaning solution. Two noncontaminated samples, from CRDOA serial numbers 44 and 7, were also obtained. The results of this analysis verified that the major debris constituents could all be attributed to the materials of the bearing construction. Some of the minor constituents such as flourine, titanium, tungsten etc. were identified by the motor manufacturer as being constituents or contaminants which could be attributed to the motor.

PSC performed these tests in an attempt to prove or disprove the concept that the six CRDOAs which failed to scram resulted from moisture washing foreign particulate matter into the races of the

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RETURN ORIGINAL
TO RIV

CRDOA shim motor bearings. Since there is a high concentration of sodium and/or boron found on the housing adjacent to the shim motor, if a transport mechanism existed, these constituents should be found in the bearing debris analysis. Sodium is present on the housing due to the leaching of the black oxide coating on the CRDOA gear train. The boron is leached from the biological shield which is a component of the CRDOA. Since large quantities of sodium and/or boron were not found in the bearing debris samples the wash-in theory was not supported.

Due to the method of acquisition and the quantity of material available, PSC has determined that a meaningful bearing debris particulate size analysis can not be performed. However, we have obtained some idea of particle size by filtering the debris solution. A one-half micron filter successfully removed the particulate from solution, while this filter does not provide the exact measurement of the particulate involved, it does provide a general indication of size. Approximately one (1) gram of particulate is required for subsieve testing. Since only extremely small quantities ($\ll 1$ gram) are obtained from the cleaning solution, a meaningful particle size analysis test could not be performed. In an attempt to determine if there was any adhered particulate on the surface of the bearing race and the general condition of the race, PSC performed a scanning electron microscope (SEM) analysis. The SEM was performed on the inner race of CRDOA serial number 37 shim motor bearing. The scan (refer to Attachment 3) did not identify any particulate adhesion and only minor surface wear was detected.

General CRDOA Debris

7

In addition to the above, PSC has investigated the chemical composition and particle size of the general CRDOA housing debris. In most cases, any appreciable amount of debris that was obtained had to be scraped off the housing. The chemical analysis indicates that the scrapings and dust were essentially rust with a high content of sodium and boron (Attachment 4). The largest rust flakes, scraped off the ring gear pinion housing of CRDOA serial number 18, were approximately 0.0625 to 0.125 inches. However, the average particle size in this sample appears to be approximately .02 inches and the debris is relatively uniform in size. Although this sample has not been chemically analyzed it appears to consist of rust, molybdenum disulfide, and a few silicon particles.

Subsequent to chemical analysis, the remaining sample of CRDOA serial number 44 was examined utilizing a stereomicroscope at 165x. The largest particle found by this method was approximately 0.003 inches (Attachment 5; Figure 7). A SEM analysis was then performed on the same CRDOA 44 housing debris (Attachment 5). The average particle size was 0.003 inches. The largest particle found was approximately 0.009 inches.

In conclusion, transport of debris from the housing into the shim motor bearings has not been substantiated. Therefore, the CRDOA rust has been discounted as a potential cause of the June 23, 1984 failure to scram. However, the internally generated CRDOA bearing debris can not be discounted as the potential cause of the scram failures.

If you have any further questions, please contact Mr. M. H. Holmes at (303) 571-8409.

Very truly yours

D. W. Warembourg
D. W. Warembourg

DWW/MJF/ksc

Attachments

ATTACHMENT 1
G. A. BEARING DEBRIS
CHEMICAL ANALYSIS

SPECTROGRAPHIC ANALYSIS CRD MOTOR BEARING DEBRIS

ELEMENT	CRD SN44 8/16 PPM	CRD 44-1 8/17 PPM	CRD 44-2 8/17 PPM	BEARITE 8/21 PPM	OUTSIDE BEARING RESIDUE %
AG	N	N	300	50	
AL	600	1000	1000	300	1.1
B	N	30	30	N	
CA	N	N	>10000	N	1.1
CD	N	300	1000	N	
CO	N	N	N	N	0.5
CR	300	300	2000	3000	4
CU	2000	3000	>10000	>10000	22
FE	1000	1000	>10000	>10000	22
MG	10	30	3000	10	
MN	N	100	1000	100	1.5
MO	2000	1000	10000	>10000	.2
NA	N	N	N	N	
NI	N	N	1000	>10000	0.22
P	N	N	10000	N	
PB	>10000	>10000	>10000	300	1.5
SI	300	300	>10000	200	0.11
SN	>10000	>10000	>10000	>10000	1.5
W					0.02
ZN	N	N	>10000	N	

SPECTROGRAPHIC ANALYSIS CRD MOTOR BEARING DEBRIS (cont'd)

Element	Inside Bearing Residue 9089-18548-3-1	CRD 7 Residue Qualitative	New Solvent	Bearing 14 Residue PPM
AG				2400
AL	0.5	Minor		N.D.
B		Trace		N.D.
CA	2			
CD		Trace		
CO	2	Minor		>10000
CU	10	Minor		>10000
FE	15	Minor		>10000
HG	0.5			60
MN	1.5			2100
MO	2	Trace		>10000
NA		Major		N.D.
NI	0.3			1500
P		Minor		
PB	2		N.D. <1PPM	>10000
SI	0.4	Trace		900
SN	1.5	Trace	N.D. >5PPM	>10000
W				>10000
ZN				N.D.

SPECTROGRAPHIC ANALYSIS CRD MOTOR BEARING DEBRIS (cont'd)

Element	CRD 19-B002 PPM	CRD 19 Brake End Residue %	CRD 19 GT Evaporated Solvent Qual.	CRD 7 18,34,36 Residue Qual.
AG				
AL	5400	2		
B	N.D.			
CA	N.D.	2		
CD				
CO	3000	0.2		
CR	4800	1.5		Minor
CU	6000	5	Minor	Major
FE	>10000	15	Minor	Major
MG	1320	1		
Mn	1200	2		
MO	>10000	10	Minor	Minor
NA	N.D.			
NI	1800	0.5		
P				
PB	>10000	2	Major	Minor
SI	3000	2		
SN	>10000	1.5	Major	Minor
W	4800			
ZN	N.D.			

ATTACHMENT 2
ACCU-LABS BEARING DEBRIS
CHEMICAL ANALYSIS



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

To: Mr. Vic Lucero
 Public Service Co. of Colorado
 Fort St. Vrain
 Nuclear Power Station
 16805 County Rd. 19 1/2
 Platteville, CO 80651

Date: August 31, 1984
 ALR No.: 9098-18594-j-1
 Purchase Order No.:
 Concentration In: $\mu\text{g/ml}$

Sample Identification No.: Brake End
 Bearing 018

Uranium		Terbium		Ruthenium		Vanadium	
Thorium		Gadolinium		Molybdenum	0.13	Titanium	0.019
Bismuth		Europium		Niobium		Scandium	
Lead	NR	Samarium		Zirconium		Calcium	0.065
Thallium		Neodymium		Yttrium		Potassium	0.022
Mercury	NR	Praseodymium		Strontium		Chlorine	0.072
Gold		Cerium		Rubidium		Sulfur	0.25
Platinum		Lanthanum		Bromine	0.001	Phosphorus	0.081
Iridium		Barium	0.001	Selenium		Silicon	0.23
Osmium		Cesium		Arsenic		Aluminum	1.1
Rhenium Internal Standard		Iodine		Germanium		Magnesium	0.005
Tungsten	0.003	Tellurium		Gallium		Sodium	0.032
Tantalum	0.004	Antimony		Zinc	0.016	Fluorine	0.023
Hafnium		Tin	NR	Copper	0.14	Oxygen	NR
Lutetium		Indium Internal Standard		Nickel	0.010	Nitrogen	NR
Ytterbium		Cadmium		Cobalt	0.006	Carbon	NR
Thulium		Silver		Iron	0.63	Boron	
Erbium		Palladium		Manganese	0.003	Beryllium	
Holmium		Rhodium		Chromium	0.037	Lithium	

Dysprosium

NOTES: All elements for which values are not entered <0.001 $\mu\text{g/ml}$
 NR - Not reported.

This sample is scheduled to be disposed of four months after the date of this report.

db

David A. Jackson



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

To: Mr. Vic Lucero
 Public Service Co. of Colorado

Date: August 31, 1984
 ALR No.: 9098-185SA-5.2
 Purchase Order No.:
 Concentration In: µg/ml

Sample Identification No.: Inboard 034

Uranium		Terbium		Ruthenium		Vanadium	0.004
Thorium		Gadolinium		Molybdenum	0.22	Titanium	0.048
Bismuth		Europium		Niobium		Scandium	
Lead	NR	Samarium		Zirconium		Calcium	0.19
Thallium		Neodymium		Yttrium		Potassium	0.065
Mercury	NR	Praseodymium		Strontium	0.002	Chlorine	0.12
Gold		Cerium		Rubidium		Sulfur	0.69
Platinum		Lanthanum		Bromine	0.002	Phosphorus	0.041
Iridium		Barium		Selenium	0.003	Silicon	0.40
Osmium		Cesium		Arsenic	0.001	Aluminum	1.6
Rhenium	Internal Standard	Iodine		Germanium		Magnesium	0.014
Tungsten	0.071	Tellurium		Gallium		Sodium	0.033
Tantalum	0.004	Antimony		Zinc	0.026	Fluorine	0.046
Hafnium		Tin	NR	Copper	1.6	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	0.010	Nitrogen	NR
Ytterbium		Cadmium	0.003	Cobalt	0.026	Carbon	NR
Thulium		Silver	0.003	Iron	1.4	Boron	0.007
Erbium		Palladium		Manganese	0.017	Beryllium	
Holmium		Rhodium		Chromium	0.38	Lithium	
Dysprosium							

NOTES: All elements for which values are not entered <0.001 µg/ml

NR - Not reported.

This sample is scheduled to be disposed of four months after the date of this report.

JK

David A. Jackson



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

To: Mr. Vic Lucero
 Public Service Co. of Colorado

Date: August 31, 1984
 ALR No.: 9098-18594-5-3
 Purchase Order No.:
 Concentration In: $\mu\text{g/ml}$

Sample Identification No.: Outboard 036

Uranium		Terbium		Ruthenium		Vanadium	0.002
Thorium		Gadolinium		Molybdenum	0.17	Titanium	0.038
Bismuth	0.001	Europium		Niobium	0.002	Scandium	
Lead	NR	Samarium		Zirconium	0.002	Calcium	0.12
Thallium		Neodymium		Yttrium		Potassium	0.11
Mercury	NR	Praseodymium		Strontium		Chlorine	0.53
Gold		Cerium		Rubidium		Sulfur	0.69
Platinum		Lanthanum		Bromine	0.003	Phosphorus	0.083
Iridium		Barium		Selenium	0.003	Silicon	1.1
Osmium		Cesium		Arsenic		Aluminum	6.6
Rhenium	Internal Standard	Iodine		Germanium		Magnesium	0.014
Tungsten	0.10	Tellurium		Gallium		Sodium	0.094
Tantalum	0.009	Antimony		Zinc	0.022	Fluorine	0.10
Hafnium		Tin	NR	Copper	29	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	0.020	Nitrogen	NR
Ytterbium		Cadmium	0.004	Cobalt	0.026	Carbon	NR
Thulium		Silver		Iron	3.2	Boron	0.011
Erbium		Palladium		Manganese	0.021	Beryllium	
Holmium		Rhodium		Chromium	0.56	Lithium	
Dysprosium							

NOTES: All elements for which values are not entered $<0.001 \mu\text{g/ml}$

NR - Not reported.

This sample is scheduled to be disposed of four months after the date of this report.

dl

David A. Jackson



Accu-Labs Research, Inc.

11485 W. 48th Avenue Wheat Ridge, Colorado 80033
(303) 423-2766

P-85017
Attachment 2
CRD 29
Page 4 of 5

To: Ms. Mary Fischer
Public Service Co. of Colorado
Fort St. Vrain Nuclear
Power Station
16805 County Rd. 19 1/2
Platteville, CO 80651

Date: August 24, 1984
ALR No.: 9089-18548-3-1
Purchase Order No.: N-5608
Concentration In: $\mu\text{g/ml}$

Sample Identification No.:
Bearing No. 14-
Inside

Uranium		Terbium		Ruthenium		Vanadium	0.003
Thorium	<0.014	Gadolinium		Molybdenum	0.22	Titanium	0.091
Bismuth	0.17	Europium		Niobium	0.002	Scandium	
Lead	NR	Samarium	0.001	Zirconium	0.001	Calcium	0.49
Thallium	0.001	Neodymium	0.039	Yttrium		Potassium	0.072
Mercury	NR	Praseodymium	0.006	Strontium	0.057	Chlorine	0.31
Gold		Cerium	0.011	Rubidium		Sulfur	1.4
Platinum		Lanthanum		Bromine	0.003	Phosphorus	0.20
Iridium		Barium	0.005	Selenium		Silicon	0.26
Osmium		Cesium		Arsenic	0.10	Aluminum	0.91
Rhenium	Internal Standard	Iodine	0.001	Germanium		Magnesium	0.010
Tungsten	0.13	Tellurium		Gallium		Sodium	0.037
Tantalum	0.010	Antimony	0.085	Zinc	0.40	Fluorine	0.26
Hafnium	0.007	Tin	NR	Copper	1.8	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	0.11	Nitrogen	NR
Ytterbium		Cadmium		Cobalt	0.029	Carbon	NR
Thulium		Silver	0.011	Iron	1.7	Boron	0.005
Erbium		Palladium		Manganese	0.022	Beryllium	
Holmium		Rhodium		Chromium	0.64	Lithium	
Dysprosium							

NOTES: All elements for which values are not entered <0.001 $\mu\text{g/ml}$.
NR - Not reported.
This sample is scheduled to be disposed of four months after the date of this report.

dh

David A. Jackson



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

P-85017
 Attachment 2
 CRD 29
 Page 5 of 5

To: Ms. Mary Fischer
 Public Service Co. of Colorado

Date: August 24, 1984
 ALR No.: 9089-18548-3-2
 Purchase Order No.: N-5608
 Concentration In: $\mu\text{g/ml}$

Bearing No. 022-

Sample Identification No.: Outside Liquid

Uranium		Terbium		Ruthenium		Vanadium	0.002
Thorium	<0.008	Gadolinium		Molybdenum	0.015	Titanium	0.016
Bismuth	0.050	Europium		Niobium		Scandium	
Lead	NR	Samarium		Zirconium		Calcium	0.099
Thallium		Neodymium	0.039	Yttrium		Potassium	0.051
Mercury	NR	Praseodymium	0.008	Strontium	0.001	Chlorine	0.59
Gold		Cerium	0.017	Rubidium		Sulfur	0.38
Platinum		Lanthanum	0.001	Bromine	0.003	Phosphorus	0.046
Iridium		Barium	0.005	Selenium		Silicon	0.26
Osmium		Cesium		Arsenic	0.070	Aluminum	0.18
Rhenium	Internal Standard	Iodine	0.002	Germanium		Magnesium	0.044
Tungsten	0.011	Tellurium		Gallium		Sodium	0.074
Tantalum	0.002	Antimony	0.085	Zinc	0.29	Fluorine	0.78
Hafnium		Tin	NR	Copper	3.5	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	0.048	Nitrogen	NR
Ytterbium		Cadmium		Cobalt	0.006	Carbon	NR
Thulium		Silver	0.001	Iron	0.44	Boron	0.003
Erbium		Palladium		Manganese	0.007	Beryllium	
Holmium		Rhodium		Chromium	0.043	Lithium	

Dysprosium

NOTES: All elements for which values are not entered <0.1 $\mu\text{g/ml}$.
 NR - Not reported.
 This sample is scheduled to be disposed of four months after the date of this report.

dh

David A. Jackson

ATTACHMENT 3
SCANNING ELECTRON
MICROSCOPE ANALYSIS
ON THE INNER RACE OF
CRDOA SERIAL NUMBER 37

QAC-84-0826

DATE: December 19, 1984
TO: Mr. R. L. Craun, Supervisor, Nuclear Site Engineering, FSV
FROM: R. L. Hellner, Sr. QA Engineer, FSV
SUBJ: SEM ANALYSIS OF CRD BEARING

The shim motor bearing from CRD serial #37 was submitted for scanning electron microscopic examination. The bearing was cut into sections for examination. The sections were decontaminated by ultrasonic cleaning in a solution of aalconox soap.

The bearing contact surface of the outer race was examined and shallow defects were observed as shown in Figures 1, 2, and 3. These defects had the appearance of pits, but are not thought to have been caused by corrosion since they are smooth rather than rough. For comparison a new bearing was examined, the bearing contact surface of the other race is shown in Figure 4.

RL Hellner by R. L. Hellner
R. L. Hellner

RLH:dm

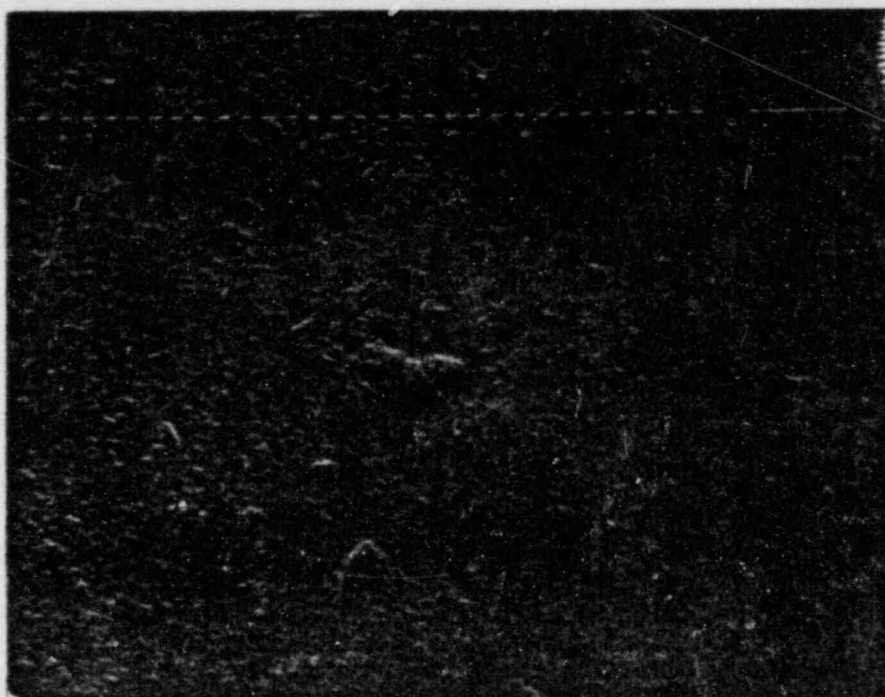


FIGURE 1 160 X



FIGURE 2 80 X

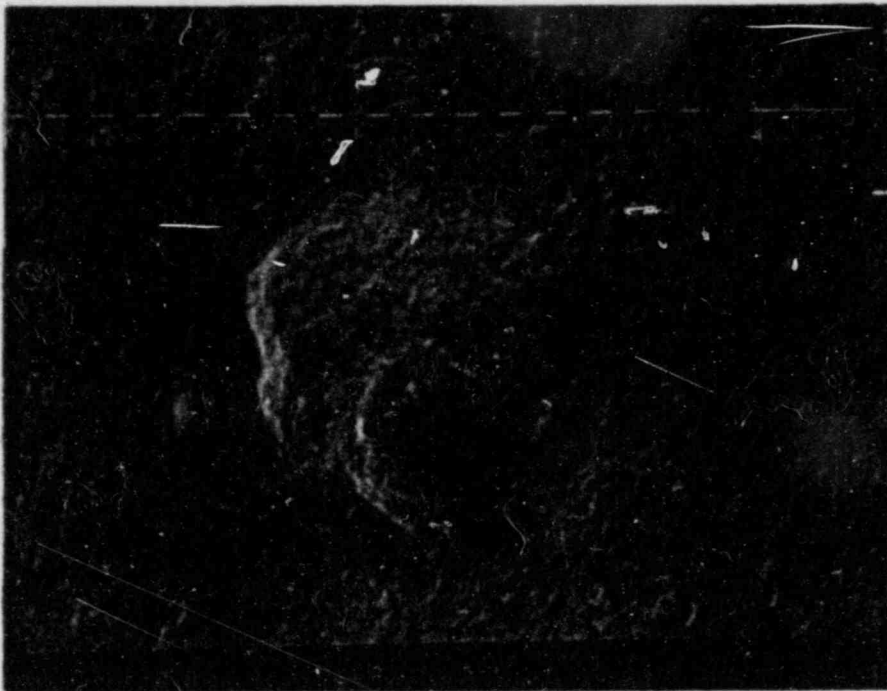


FIGURE 3 320 X

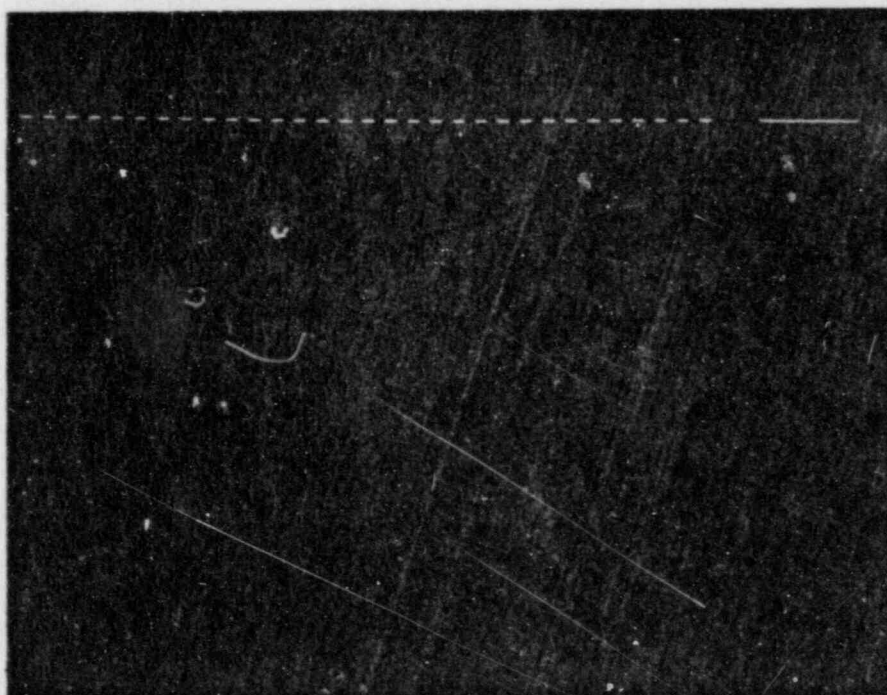


FIGURE 4 160 X

ATTACHMENT 4
GENERAL CRDOA
DEBRIS CHEMICAL ANALYSIS
(G.A. and Accu-Labs)



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

To: Mr. Vic Lucero
 Public Service Co. of Colorado

Date: August 31, 1984
 ALR No.: 9098-18594-5-5
 Purchase Order No.:
 Concentration In: ppm wt.

Sample Identification No.: Debris from
 CRD No. 7

Uranium	<0.20	Terbium		Ruthenium		Vanadium	21
Thorium	<0.24	Gadolinium	<0.20	Molybdenum	110	Titanium	25
Bismuth	<0.25	Europium		Niobium	0.80	Scandium	0.20
Lead	0.70	Samarium	<0.23	Zirconium	0.53	Calcium	36
Thallium	<0.24	Neodymium	<0.16	Yttrium	<5.7	Potassium	≈ 2400
Mercury	NR	Praseodymium		Strontium	390	Chlorine	≈ 1400
Gold		Cerium		Rubidium	0.30	Sulfur	>1%
Platinum		Lanthanum	0.23	Bromine	12	Phosphorus	>1%
Iridium		Barium	5.2	Selenium	13	Silicon	700
Osmium		Cesium		Arsenic	8.5	Aluminum	≈ 1%
Rhenium	Internal Standard	Iodine	0.68	Germanium	0.26	Magnesium	42
Tungsten	22	Tellurium		Gallium	0.54	Sodium	>1%
Tantalum	3.0	Antimony	1.5	Zinc	17	Fluorine	>1%
Hafnium	<0.56	Tin	34	Copper	≈ 0.5%	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	120	Nitrogen	NR
Ytterbium	<0.28	Cadmium	1.1	Cobalt	2.2	Carbon	NR
Thulium		Silver	1.5	Iron	510	Boron	≈ 1000
Erbium	<0.18	Palladium		Manganese	2.5	Beryllium	<0.18
Holmium		Rhodium		Chromium	≈ 1900	Lithium	0.22
Dysprosium							

NOTES: All elements for which values are not entered <0.1 ppm wt.

NR - Not reported.

This sample is scheduled to be disposed of four months after the date of this report.

dh

David A. Jackson



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

P-85017
 Attachment 4
 CRD 44
 Page 2 of 6

To: Ms. Mary Fisher
 Fort St. Vrain
 Public Service Co. of Colorado

Date: November 21, 1984
 ALR No.: 9098-19044-2-2
 Purchase Order No.: N-5733
 Concentration In: ppm wt.

Sample Identification No.: CRD No. 44

Uranium	0.44	Terbium		Ruthenium		Vanadium	8.5
Thorium	<0.60	Gadolinium	<0.24	Molybdenum	>1%	Titanium	INT
Bismuth	21	Europium		Niobium	1.6	Scandium	0.10
Lead	70	Samarium	<0.25	Zirconium	30	Calcium	110
Thallium	0.35	Neodymium	0.26	Yttrium	0.43	Potassium	270
Mercury	NR	Praseodymium	0.22	Strontium	3.7	Chlorine	720
Gold		Cerium	0.80	Rubidium	0.26	Sulfur	≈ 1400
Platinum		Lanthanum	0.35	Bromine	22	Phosphorus	190
Iridium		Barium	46	Selenium	9.4	Silicon	≈ 0.5%
Osmium		Cesium		Arsenic	37	Aluminum	≈ 0.5%
Rhenium	Internal Standard	Iodine	0.77	Germanium	1.4	Magnesium	≈ 1200
Tungsten	12	Tellurium	0.26	Gallium	1.8	Sodium	≈ 1600
Tantalum	0.72	Antimony	8.3	Zinc	140	Fluorine	83
Hafnium	1.1	Tin	460	Copper	400	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	270	Nitrogen	NR
Ytterbium	<0.28	Cadmium	<17	Cobalt	38	Carbon	NR
Thulium		Silver	<4.5	Iron	>1%	Boron	≈ 1800
Erbium	<0.30	Palladium		Manganese	≈ 0.5%	Beryllium	
Holmium		Rhodium		Chromium	≈ 1300	Lithium	55
Dysprosium							

NOTES: All elements for which values are not entered <0.1 ppm wt.
 NR - Not reported.
 INT - Interference by a major component spectrum.

dh

David A. Jackson



Accu-Labs Research, Inc.
 11485 W. 48th Avenue Wheat Ridge, Colorado 80033
 (303) 423-2766

P-85017
 Attachment 4
 CRD 5
 Page 3 of 6

To: Ms. Mary Fisher
 Fort St. Vrain
 Public Service Co. of Colorado
 16805 W. County Rd. 19 1/2
 Platteville, CO 80651

Date: November 21, 1984
 ALR No.: 9098-19044-2-1
 Purchase Order No.: N-5733
 Concentration In: ppm wt.
 CRD No. 5
 Sample Identification No.: Bag 2

Uranium	0.44	Terbium		Ruthenium		Vanadium	8.5
Thorium	1.6	Gadolinium	<0.24	Molybdenum	120	Titanium	250
Bismuth	0.60	Europium		Niobium	3.2	Scandium	0.45
Lead	35	Samarium	0.35	Zirconium	30	Calcium	≈ 1100
Thallium	<0.28	Neodymium	0.51	Yttrium	0.57	Potassium	140
Mercury	NR	Praseodymium	1.1	Strontium	14	Chlorine	480
Gold		Cerium	5.4	Rubidium	0.13	Sulfur	240
Platinum		Lanthanum	2.3	Bromine	7.2	Phosphorus	≈ 3100
Iridium		Barium	590	Selenium	9.4	Silicon	>0.5%
Osmium		Cesium		Arsenic	37	Aluminum	>1%
Rhenium	Internal Standard	Iodine	0.39	Germanium	1.2	Magnesium	≈ 1200
Tungsten	3.7	Tellurium	0.11	Gallium	1.3	Sodium	800
Tantalum	1.5	Antimony	3.3	Zinc	210	Fluorine	290
Hafnium	2.6	Tin	22	Copper	400	Oxygen	NR
Lutetium		Indium	Internal Standard	Nickel	180	Nitrogen	NR
Ytterbium	<0.28	Cadmium	3.9	Cobalt	38	Carbon	NR
Thulium		Silver	0.64	Iron	>1%	Boron	≈ 1800
Erbium	<0.30	Palladium		Manganese	≈ 0.5%	Beryllium	
Holmium		Rhodium		Chromium	150	Lithium	35
Dysprosium							

NOTES: All elements for which values are not entered <0.1 ppm wt.
 NR - Not reported.

dh

David O. Jackson

CONTROL ROD DRIVE

GA TECHNOLOGIES
P.O. BOX 85608
SAN DIEGO, CA 92138
619-455-3000

SPECTROGRAPHIC REPORT

LAB. NUMBER: 58160
SAMPLE: MUST FSU
PLATE NO.: 181
DATE: 8/3/84
REPORT TO: D. THURGOOD

ELEMENT	PPM	ELEMENT	PPM	ELEMENT	PPM
AG	N 10.0	HF	N 500.0	RH	N 1000.0
AL	3000.0	HG	N 50.0	RU	N 500.0
AS	N 1000.0	IH	N 50.0	SB	N 50.0
AU	N 10.0	IR	N 250.0	SI	3000.0
B	300.0	LI	N 1000.0	SN	N 50.0
BA	N 100.0	HG	1000.0	SR	N 2500.0
BE	N 10.0	MN	2000.0	TA	N 250.0
BI	N 50.0	MO	1000.0	TE	N 500.0
CA	2000.0	NA	N 500.0	TH	N 500.0
CD	N 10.0	NB	N 50.0	TI	100.0
CO	N 500.0	NI	1000.0	TL	N 500.0
CR	2000.0	P	N 500.0	V	N 50.0
CU	1000.0	PB	N 50.0	U	N 500.0
FE	>10000.0	PD	N 50.0	ZN	N 1000.0
GE	N 50.0	PT	N 50.0	ZR	N 50.0

S 2200 ppm

=====

CONCENTRATION BASED ON ORIGINAL SAMPLE
> MEANS GREATER THAN THE CONCENTRATION SHOWN
N MEANS NOT DETECTED AT THE SENSITIVITY LEVEL SHOWN
RESULTS ARE CORRECT WITHIN A FACTOR OF TWO OF THE AMOUNT PRESENT
METHOD USED 50-1
PPM = PART PER MILLION OR 1000 PPM = .1%

*Ledges underneath the shim motor

GA TECHNOLOGIES
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619-455-3900

SPECTROGRAPHIC REPORT

LAB. NUMBER: 50160 PLATE NO.: 182 DATE: 8/7/84
SAMPLE: WIPE #2 ASHED REPORT TO: B. THURGOOD

ELEMENT	PPM	ELEMENT	PPM	ELEMENT	PPM
AG	N 20.0	HF	N 1000.0	KH	N 2000.0
AL	>20000.0	HG	N 100.0	KU	N 1000.0
AS	N 2000.0	IH	N 100.0	SB	N 100.0
AU	N 20.0	IK	N 500.0	SI	20000.0
B	600.0	LI	N 2000.0	SM	N 100.0
BA	N 200.0	HG	600.0	SR	N 5000.0
BE	N 20.0	MN	2000.0	TA	N 500.0
BI	N 100.0	MO	>20000.0	TE	N 1000.0
CA	6000.0	NA	N 1000.0	TH	N 1000.0
CB	N 20.0	NB	N 100.0	TI	2000.0
CO	2000.0	NI	2000.0	TL	N 1000.0
CK	20000.0	P	N 1000.0	V	N 100.0
CU	20000.0	PB	N 100.0	W	N 1000.0
FE	>20000.0	PD	N 100.0	ZN	N 2000.0
GE	N 100.0	PI	N 100.0	ZR	N 100.0

=====

CONCENTRATION BASED ON ORIGINAL SAMPLE
> MEANS GREATER THAN THE CONCENTRATION SHOWN
N MEANS NOT DETECTED AT THE SENSITIVITY LEVEL SHOWN
RESULTS ARE CORRECT WITHIN A FACTOR OF TWO OF THE AMOUNT PRESENT
METHOD USED 50-1
PPM = PART PER MILLION OR 1000 PPM = .1%

*Dust from shim motor

GA TECHNOLOGIES
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619-455-3000

SPECTROGRAPHIC REPORT

LAB. NUMBER: 58160 PLATE NO.: 102 DATE: 8/7/84
SAMPLE: WIPE #14 ASHED REPORT TO: G. THURGOOD

ELEMENT	PPM	ELEMENT	PPM	ELEMENT	PPM
AG	N 20.0	HF	N 1000.0	RN	N 2000.0
AL	20000.0	HG	N 100.0	KU	N 1000.0
AS	N 2000.0	IR	N 100.0	SB	N 100.0
AU	N 20.0	IK	N 500.0	SI	20000.0
B	6000.0	LI	N 2000.0	SM	N 100.0
BA	N 200.0	MG	600.0	SK	N 5000.0
BE	N 20.0	MN	600.0	TA	N 500.0
BI	N 100.0	MO	>20000.0	TE	N 1000.0
CA	4000.0	NA	N 1000.0	TH	N 1000.0
CB	N 20.0	NB	N 100.0	TI	N 100.0
CO	2000.0	NI	2000.0	IL	N 1000.0
CR	6000.0	P	N 1000.0	V	N 100.0
CU	2000.0	PB	N 100.0	W	N 1000.0
FE	>20000.0	PD	N 100.0	ZN	N 2000.0
GE	N 100.0	PT	N 100.0	IR	N 100.0

CONCENTRATION BASED ON ORIGINAL SAMPLE
 > MEANS GREATER THAN THE CONCENTRATION SHOWN
 N MEANS NOT DETECTED AT THE SENSITIVITY LEVEL SHOWN
 RESULTS ARE CORRECT WITHIN A FACTOR OF TWO OF THE AMOUNT PRESENT
 METHOD USED 50-1
 PPM = PART PER MILLION OR 1000 PPM = 1%

*Wipe of white debris upper housing

ATTACHMENT 5
SCANNING ELECTRON
MICROSCOPE ANALYSIS
ON CRDOA SERIAL NUMBER 44
(Debris from gear pinion housing)

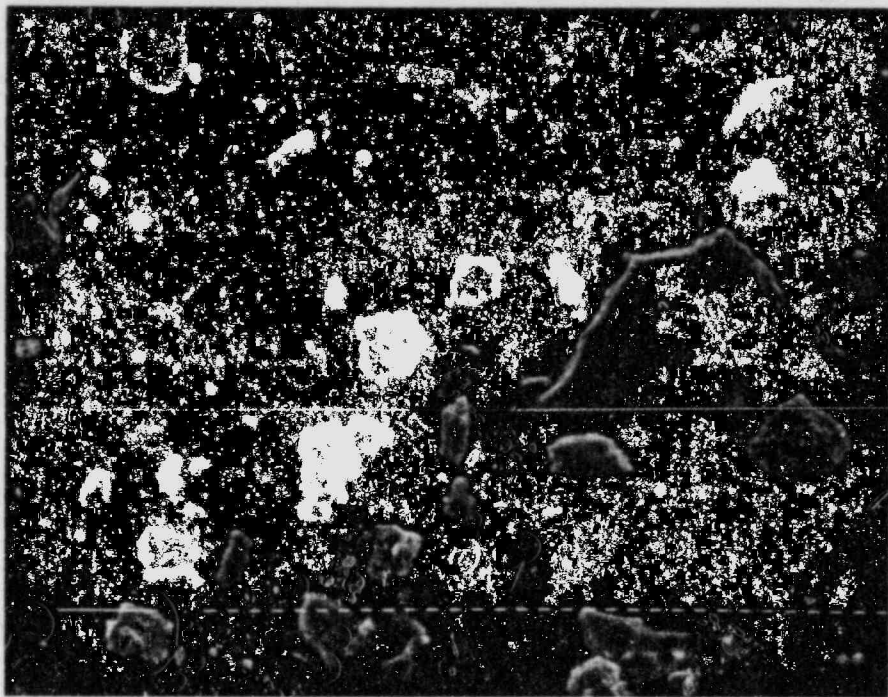


FIGURE 1 160X

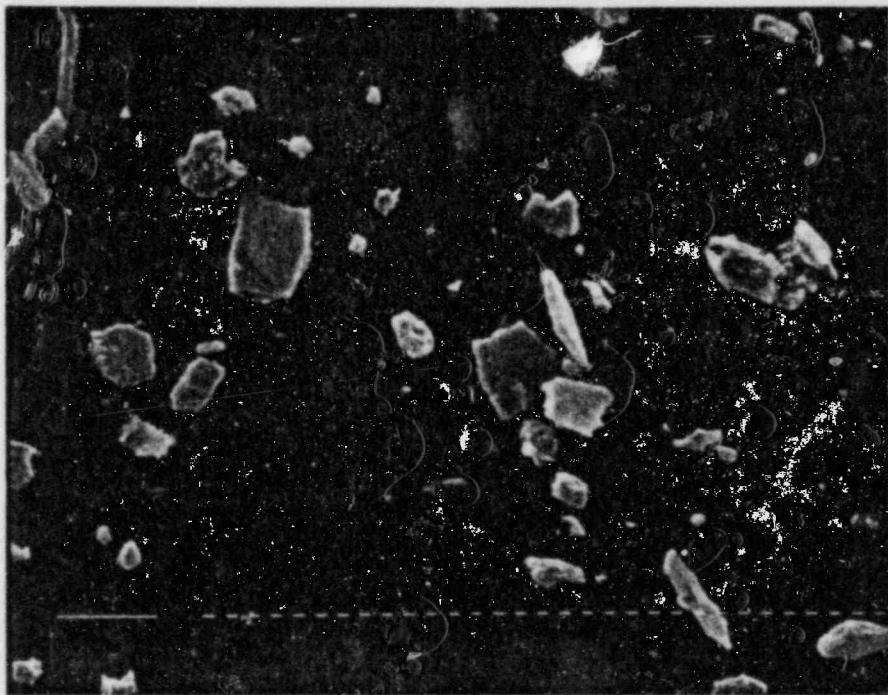


FIGURE 2 160X

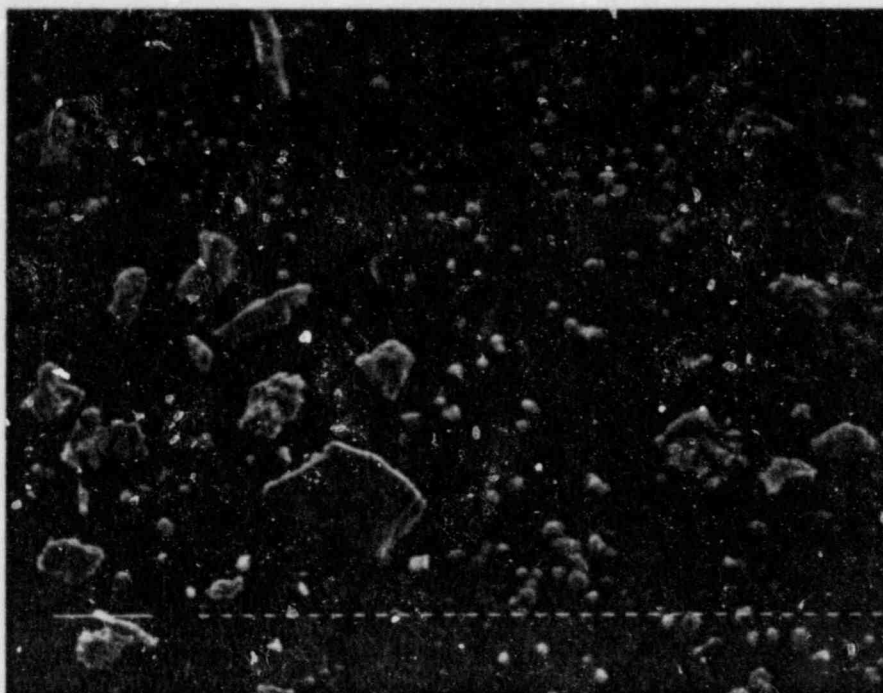


FIGURE 3 160 X

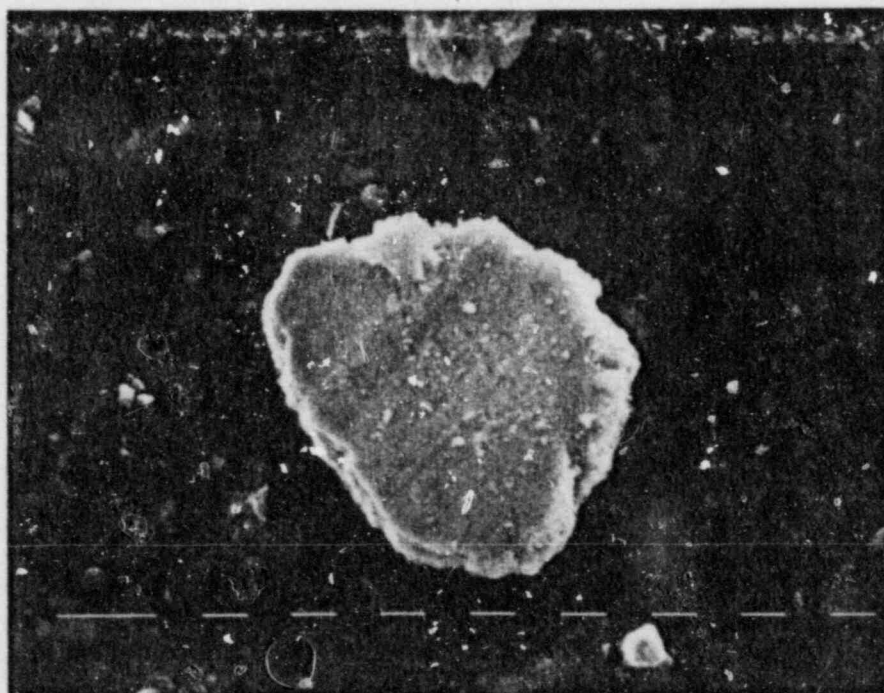


FIGURE 4 640X

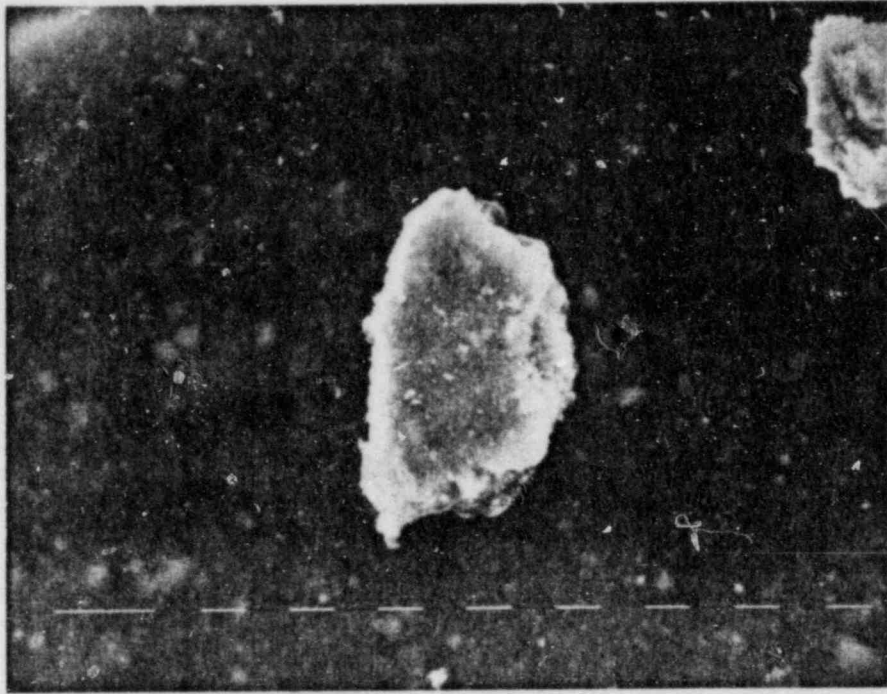


FIGURE 5 640 X

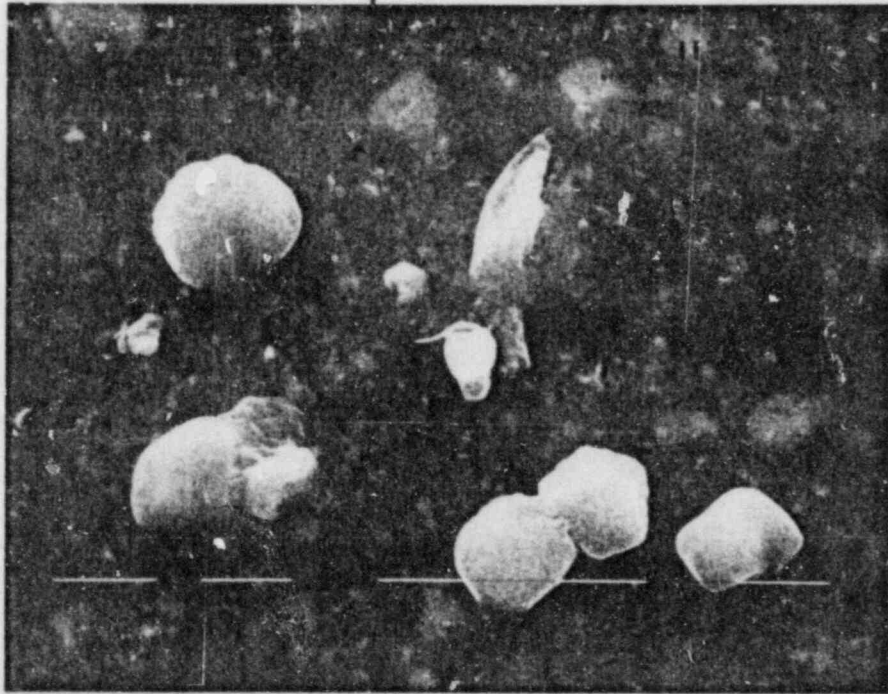
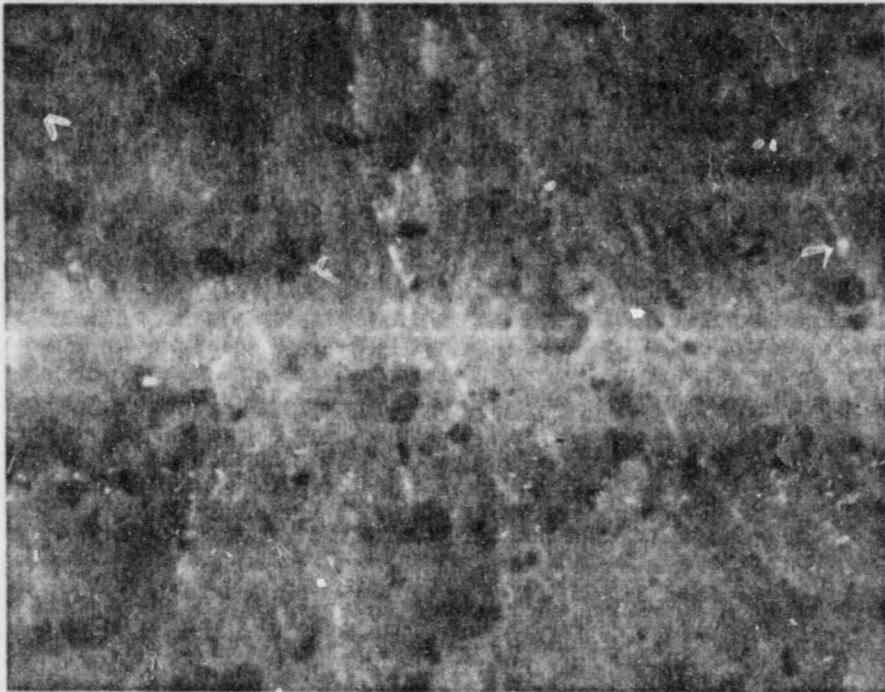


FIGURE 6 1250 X



:

FIGURE 7 160X

16-JAN-85 15:04:42
RATE: CPS TIME 61LSEC
00-20KEV: 10EV/CH PRST: OFF
A: "SPHERES" B: TAPE
FS= 773 MEM: A/B FS= 356

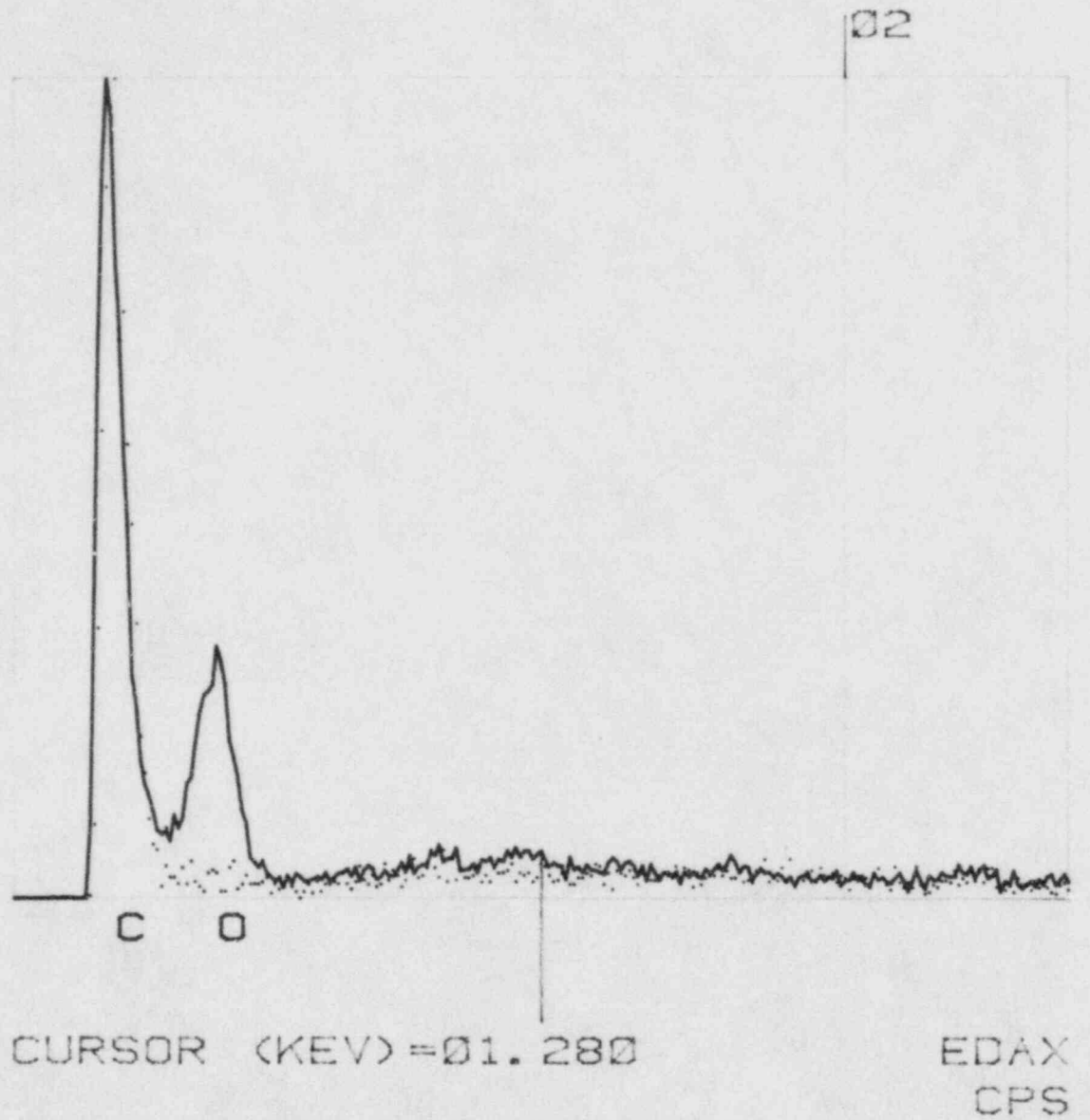


FIGURE 8

16-JAN-85 15:20:02
RATE: CPS TIME 26LSEC
00-20KEV: 10EV/CH PRST: OFF
A: STEEL B: 30KV WLESS
FS= 1467 MEM: A FS= 178

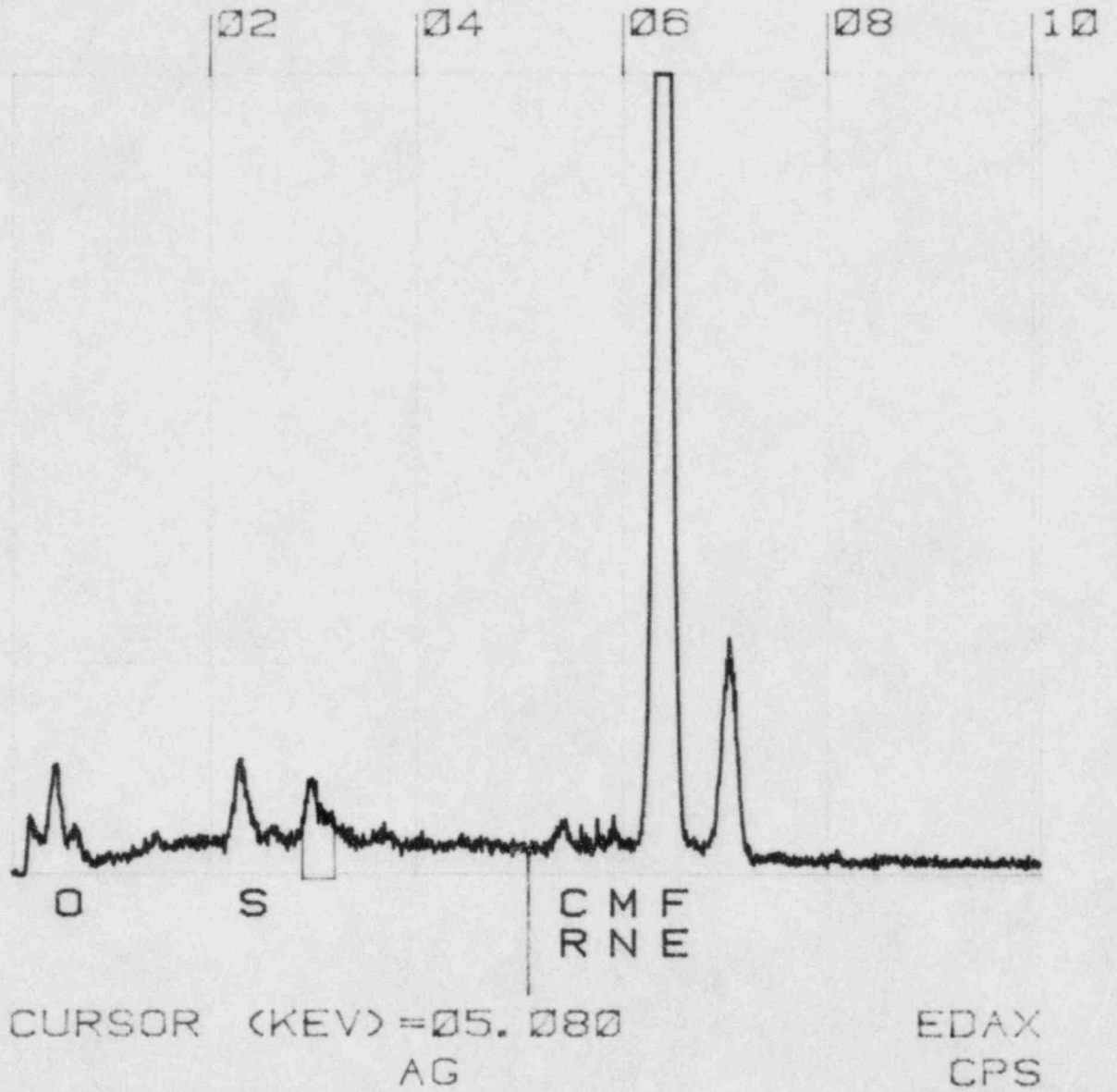


FIGURE 9

16-JAN-85 15:26:20
RATE: CPS TIME 27LSEC
00-20KEV: 10EV/CH PRST: OFF
A: MOLY SULFIDE B: 30KV WLESS
FS= 1908 MEM: A FS= 178

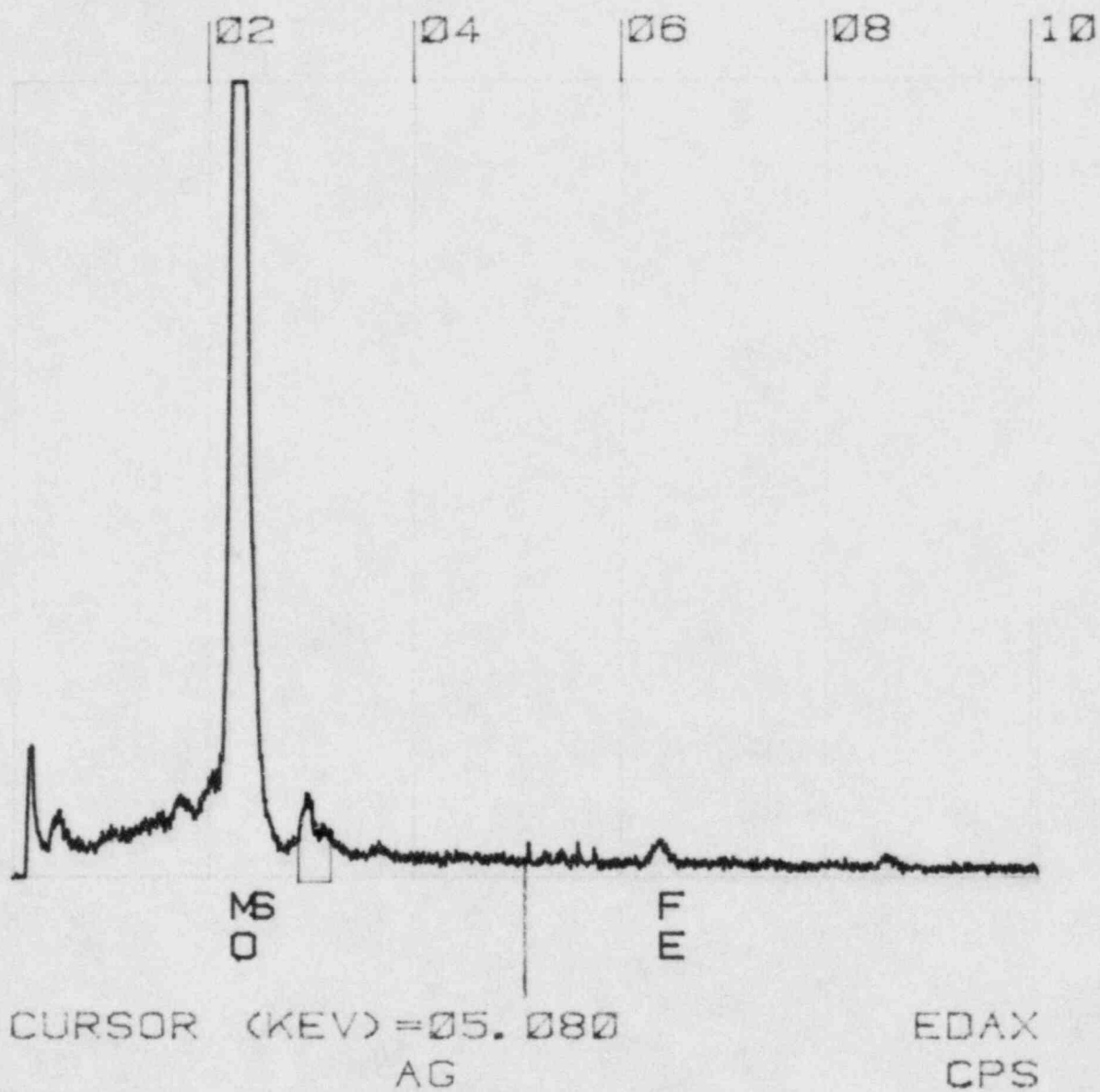


FIGURE 10

16-JAN-85 15:11:11
RATE: CPS TIME 41LSEC
00-20KEV: 10EV/CH PRST: OFF
A: OXIDE B: 30KV WLESS
FS= 2060 MEM: A FS= 178

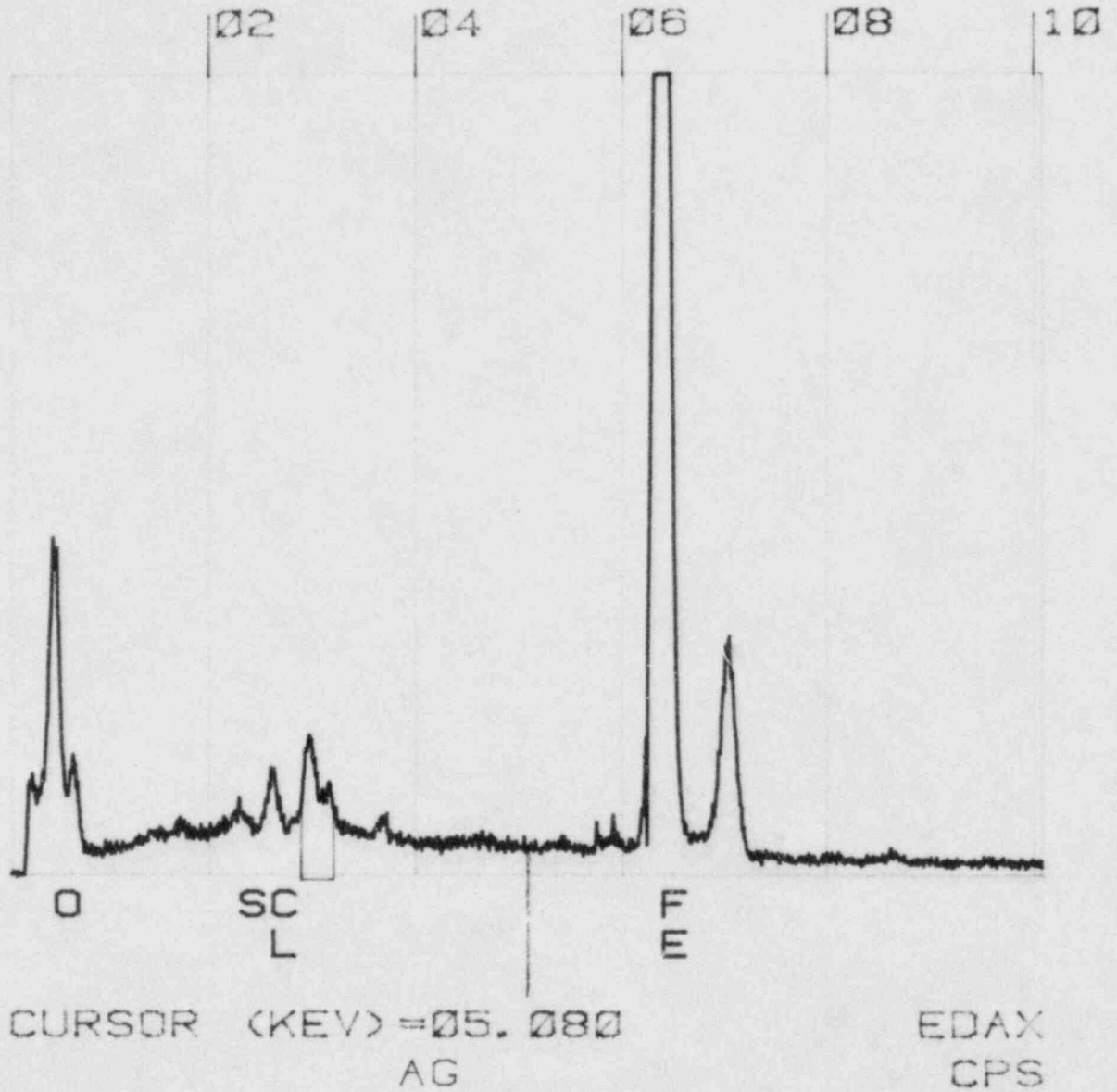


FIGURE 11

ATTACHMENT 6
MATERIALS OF BEARING
CONSTRUCTION

Materials of Bearing Construction

Ball	<u>Tungsten Carbide Gr. 25</u>
	93.5-94.5 Tungsten Carbide 6.5-5.5 Cobalt
Outer Race/Inner Race	<u>AISI 440C</u>
	0.95-1.20 Carbon 1.0 (max) Manganese 1.0 (max) Silicon 16.0-18.0 Chromium 0.0 Nickel 0.04 (max) Phosphorus 0.03 (max) Sulfur 0.75 (max) Molybdenum
Retainer Ring	<u>AISI 430</u>
	0.12 (max) Carbon 1.0 (max) Manganese 1.0 (max) Silicon 16.0-18.0 Chromium 0.04 (max) Phosphorus 0.03 (max) Sulfur
Retainer	<u>Nitralloy 135 Mod AMS 6472</u>
	0.38-0.43 Carbon 1.6 Chromium 0.35 Molybdenum 1.13 Aluminum
Ring	<u>Bearite (Spectrographic Analysis)</u>
	50ppm Silver 300ppm Aluminum 3000ppm Chromium 10,000ppm Copper 10,000ppm Iron 10ppm Magnesium 100ppm Manganese 10,000ppm Molybdenum 10,000ppm Nickel 300ppm Lead 200ppm Silicon 10,000ppm Tin