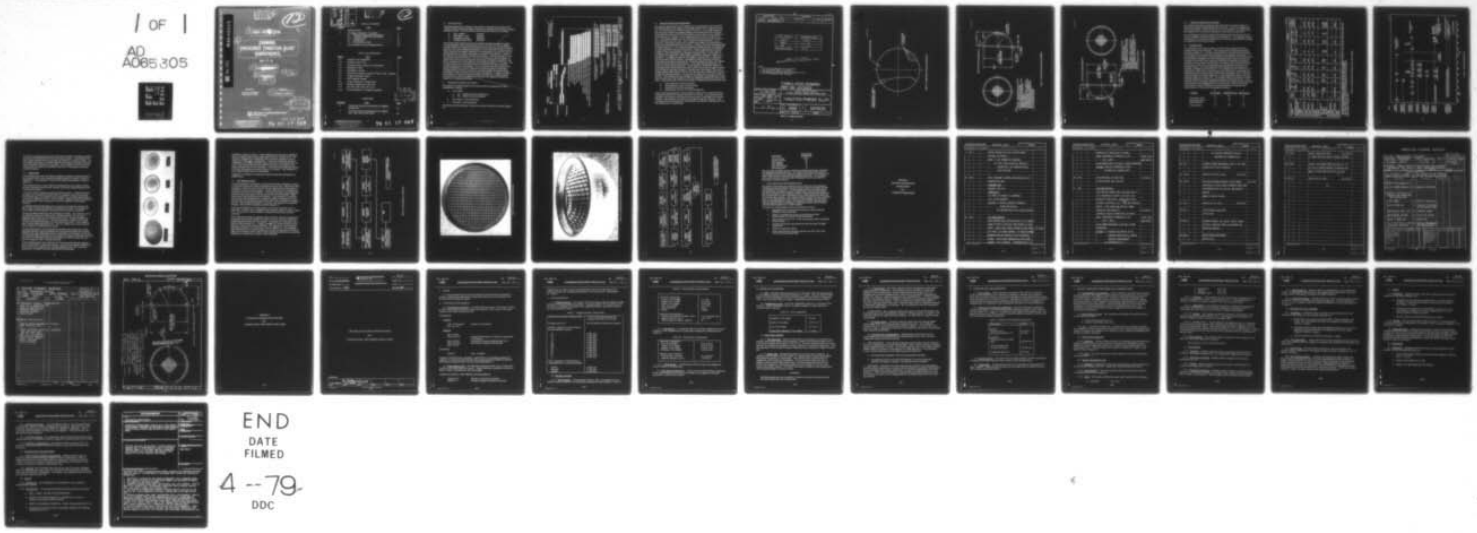
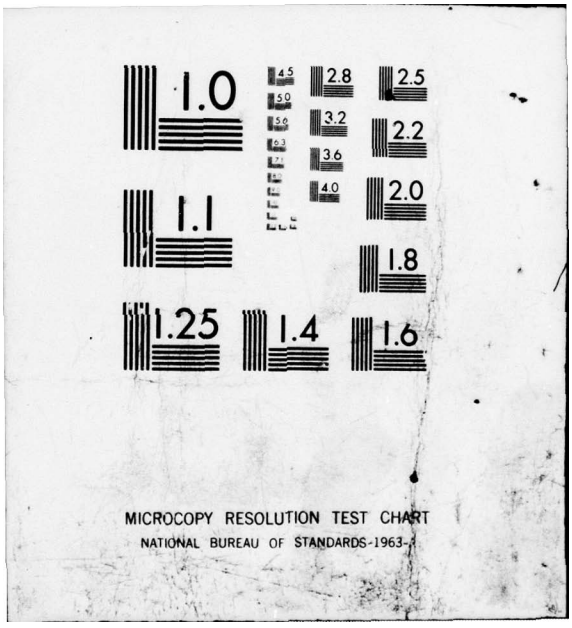
AD-A065 305 VOUGHT CORP STERLING HEIGHTS MICH MICHIGAN DIV F/G 11/6
FORMING PRESCORED TUNGSTEN ALLOY HEMISPHERES.(U)
SEP 78 DAAK10-77-C-0221
UNCLASSIFIED 7-34000/78R-8 NL

1 OF 1
AD A065 305



END
DATE FILMED
4-79
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LEVEL II

(12)

(9) FINAL REPORT FOR

(6)

FORMING PRESCORED TUNGSTEN ALLOY HEMISPHERES,

MDV-77-35

(11) SEP[redacted]78

(12) 42 P.

(14) [redacted]
7-34[redacted]/78R-8
MDV-77-35

Submitted to:

Commander, ARRADCOM
Dover, New Jersey 07801

(15) In response to:

DAAK1[redacted]-77-C-[redacted]221

Submitted by:

VOUGHT CORPORATION
michigan plant
an LTV company

409 730 RLH

LEVEL II

12

TABLE OF CONTENTS

Section	Title	Page
1	INTRODUCTION	1
2	PROGRAM SCHEDULE OF EVENTS	1
	2.1 Material Selection and Requirements	3
	2.1.1 Material Certification and Analysis	8
	2.2 Production Plan	8
	2.3 Process Plan	11
	2.4 Cost Reduction Events	13
3	CONCLUSIONS AND RECOMMENDATIONS	18

LIST OF ILLUSTRATIONS

Figure	Title	Page
2-1	Tungsten Alloy Hemispheres	2
2-2	Tungsten Powder Alloy	4
2-3	Typical Porosity Location and Concentration	5
2-4	Hemisphere, Male	6
2-5	Hemisphere, Female	7
2-6	Chemical and Physical Properties Tests of Disc, Tungsten	9
2-7	Tungsten Hemisphere Status	10
2-8	XM74 Tungsten Grenade	12
2-9	Process Diagram for Tungsten Disc	14
2-10	Modified Tungsten Disc with Collar	15
2-11	Disc with Collar After Fist Form	16
2-12	Process Diagram for Tungsten Hemisphere	17

ADDENDUMS

Addendum	Title	Page
A	Process and Inspection Instructions for Tungsten Hemispheres	A-1
B	Process and Material Specification for Tungsten Base, High Density Metal Discs	B-1

1. IN TRODUCTION

This report presents the summary of the program contracted under DAAK-10-77-C-0221 to further develop and effect economies for producing 2400 prescored tungsten hemisphere liners. The documentation used during this contract is as follows:

a.	Disc, tungsten	T9313567
b.	Hemisphere, male	T9298785
c.	Hemisphere, female	T9298784
d.	Tungsten powder alloy	T9313626

The process used to produce the male and female hemispheres from the tungsten disc was developed under contract number DAAA-21-76-C-0105. It was planned to further develop the manufacturing process by eliminating certain time consuming functions such as grit blasting and cleaning by a more rapid and economical means. Other economies were planned especially in the inspections of the part but were not implemented due to problems experienced in forming the hemispheres. Based on the experience of the program conducted during 1976, a 3-percent overage of discs was initially ordered (2472 discs). In order to complete the contract quantity, an additional 358 discs were purchased for processing, completing certifications and doing evaluation tests which brought the total purchased quantity to 2830 discs. The forming processes were carefully monitored to determine the most successful forming temperature and die strokes. It is felt that the successful forming of the tungsten hemispheres is directly dependent on material quality and uniformity. Varying amounts of porosity were found in the discs during this program which contributed to about 97 percent of the rejected hemispheres. A follow-on development program to improve the material quality and reduce the scrappage during forming has been proposed. About three months will be required to qualify the hardware to a preproduction status.

2. PROGRAM SCHEDULE OF EVENTS

The program was planned based on the contract delivery requirements of 2400 hemispheres as follows:

a. Four months

   1) 450 T9298784 Female hemispheres
   2) 450 T9298785 Male hemispheres

b. Five months: 1000 hemispheres

c. Six months: 500 hemispheres.

The initial production program to support the contract deliveries is shown in figure 2-1.

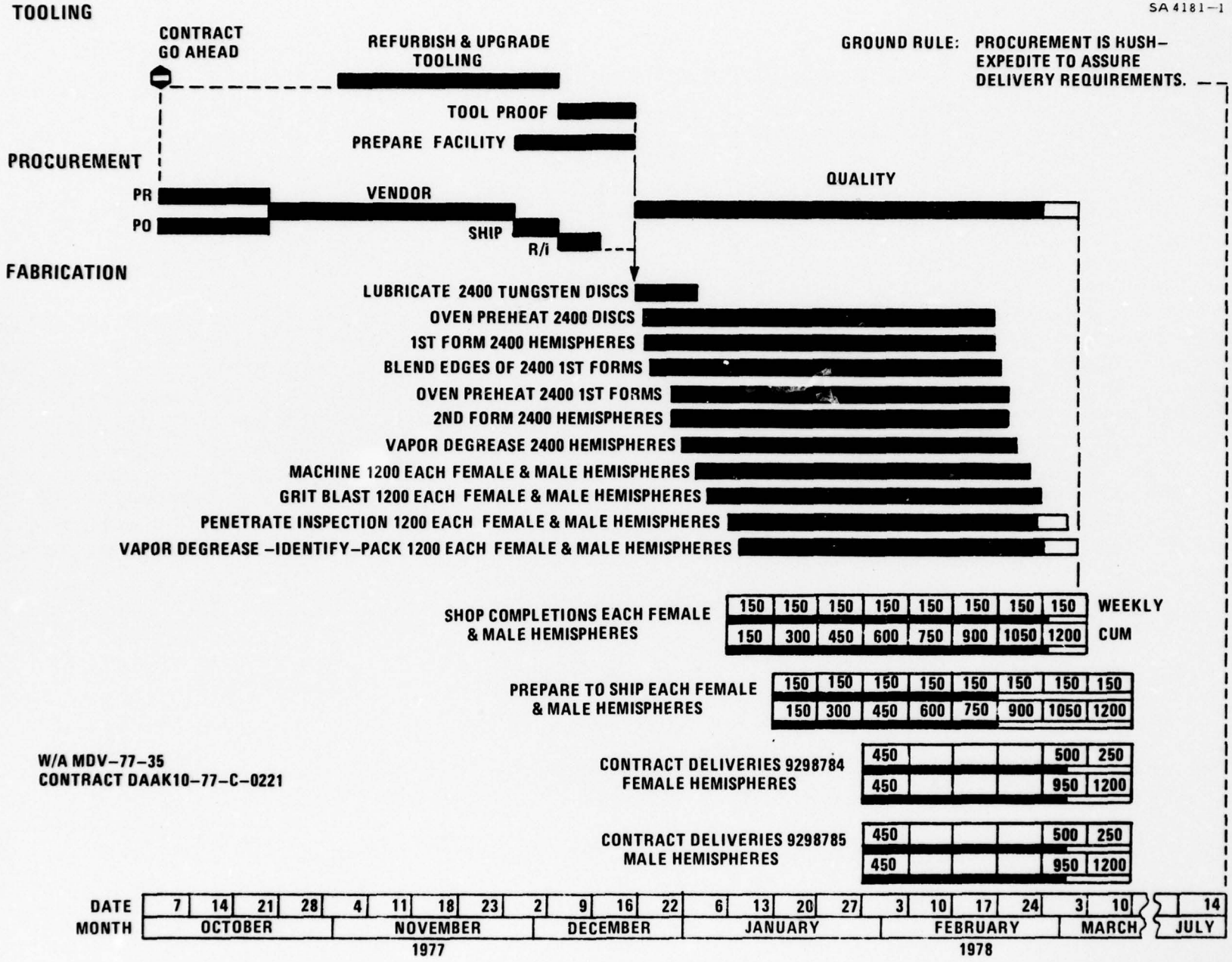


Figure 2–1. Tungsten Alloy Hemispheres

2.1 Material Selection and Requirements

The material requirements for the tungsten disc are controlled by the formulation drawing T9313626 and the tungsten disc drawing 9313567 shown in figures 2-2 and 2-3. The formed parts are shown in figures 2-4 and 2-5. The initial shipment of 495 discs were received and inspected against the formulation and disc drawings. It was found that about one third of the hardware did not conform to the drawing requirements due to a "wash-in" of the alloying metals into the vee notches of the disc. This problem affected several dimensional requirements but only occurred over 25 percent of the disc area. Also, during the forming operations, it was found that a higher than normal rate of cracking was evident in the formed hemispheres due to concentrated areas of porosity. A sketch of the discs showing porosity is shown in figure 2-3. The material formulation drawing and the disc drawing did not control porosity in the part and therefore, a letter of agreement was initiated to allow for the out-of-tolerance "wash-in" over 25 percent of the disc area and acceptance of the hemispheres that exhibited surface porosity. The porosity in the sintered part appeared to cause surface separations resulting in a high rate of rejections. A meeting was held with the supplier in January 1978, to determine how the porosity could be reduced. Subsequent hardware deliveries showed improvements in the levels of porosity but, during the program duration, the supplier could not eliminate the porosity problem. In the initial forming operations, the scrap rate was as high as 40 percent. It was decided to 100-percent inspect the incoming hardware to determine the porosity levels and process the higher porosity parts through an additional operation. The discs were run through a "time saver" (surface sander) where about 0.001 inch was removed from the thickness of the part during this polishing operation. The time saver reduced the scrap rate to about 20 percent. This operation was later stopped as the porosity of incoming discs showed some decrease and it didn't appear to offer any additional benefits of the less porous discs. Other factors that were directly related to obtaining successful hardware are:

a. Stroke depth in the first forming die
b. Disc temperature prior to first forming
c. Lubrication in the first forming die
d. Impact stroke (load) in the second (coining) die.

Each of these operations were varied during the initial setup to repeat the process developed during the 1976 contract (DAAA-21-76-C-0105). It was found that each parameter was critical to the process and did not have a wide range for successful forming. Approximately 150 discs were processed during this evaluation. The remaining discs were processed as received after the optimum forming strokes and disc temperature was determined.

SA 4181–2

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	SYM	DESCRIPTION	DATE	APPROVAL
9313567	XM74GRENADE	—			

ALLOY INGREDIENTS	PERCENTAGE BY WEIGHT
TUNGSTEN	91% MAX
NICKEL	4.5 - 7.5%
IRON	2.5 - 5.5%
TOTAL OTHER ELEMENTS	1.5% MAX

NOTES:-
1- SPEC MIL-A-2550 AND ANSI Y14.5-1973 APPLY.
2- THE ALLOY DENSITY SHALL BE 17.0 MIN.
3- THE HARDNESS OF THE ALLOY SHALL BE ROCKWELL Rc 32 MAX.
4- THE ALLOY ELONGATION SHALL BE 22% MIN.

FORMULATION DRAWING
PART NO. 9313626

ORIGINAL DATE OF DRAWING 27 APR 1976	US ARMY MUNITIONS COMMAND PICATINNY ARSENAL. DOVER. NEW JERSEY 07801
DRAFTSMAN DC / CHECKER RSA	TUNGSTEN POWDER ALLOY
ENGR 07 / ENGR	
ENGR / ENGR	
A. King	SIZE A · CODE IDENT NO. 19203 · T · 9313626
	SCALE ~ · UNIT WT · SHEET

Figure 2–2. Tungsten Powder Alloy

SA 3834—3A.1

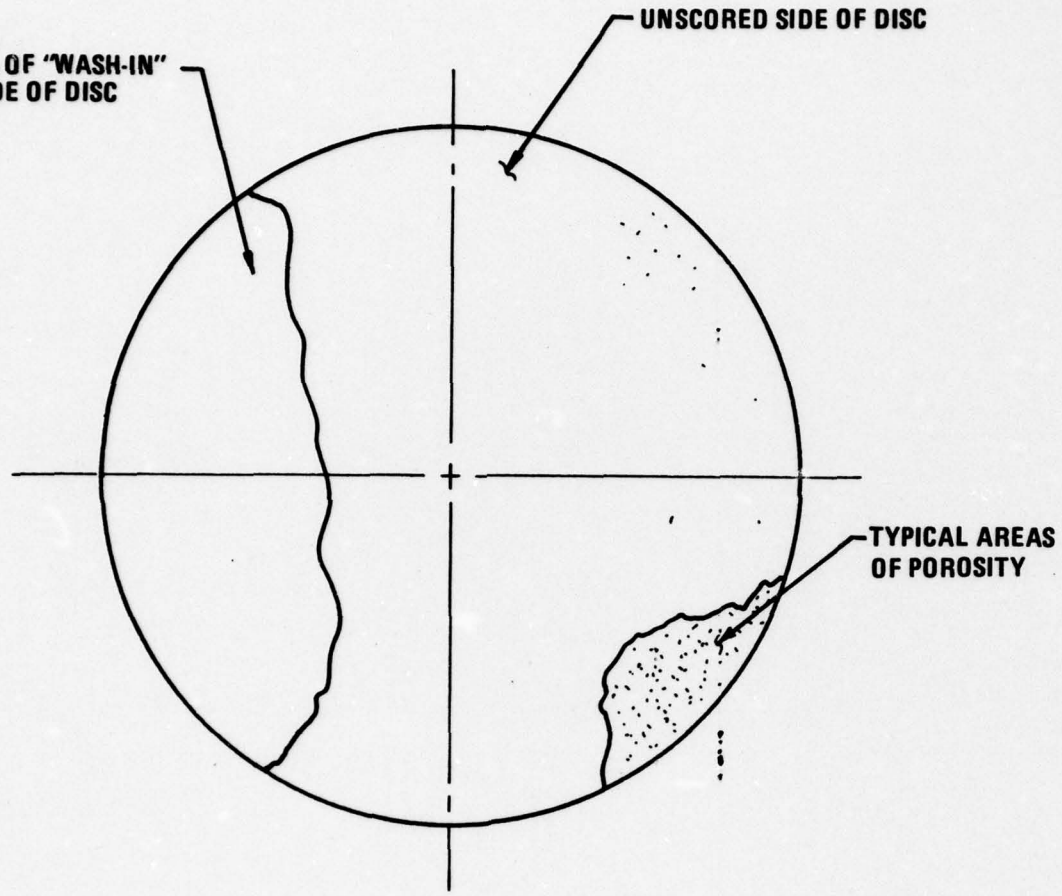
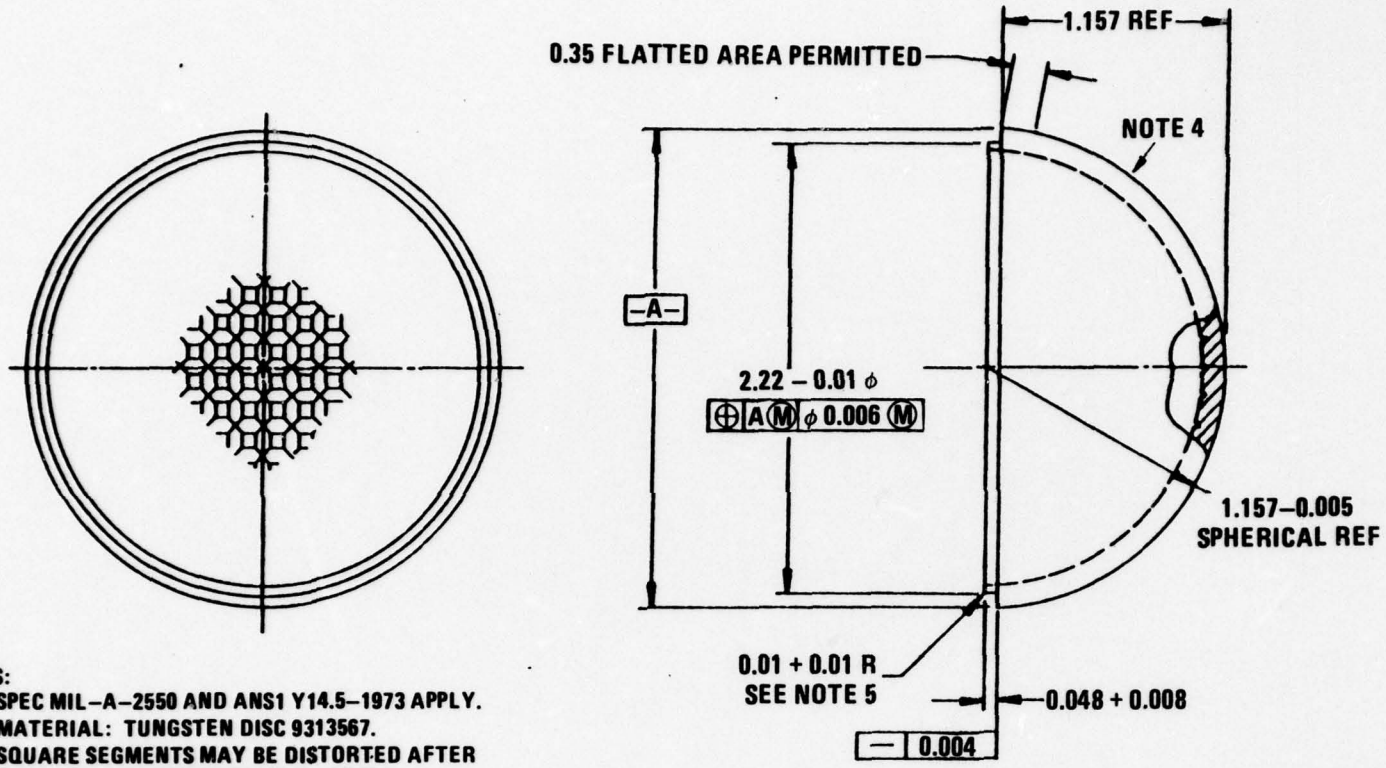


Figure 2–3. Typical Porosity Location and Concentration

SA 3834–1 A

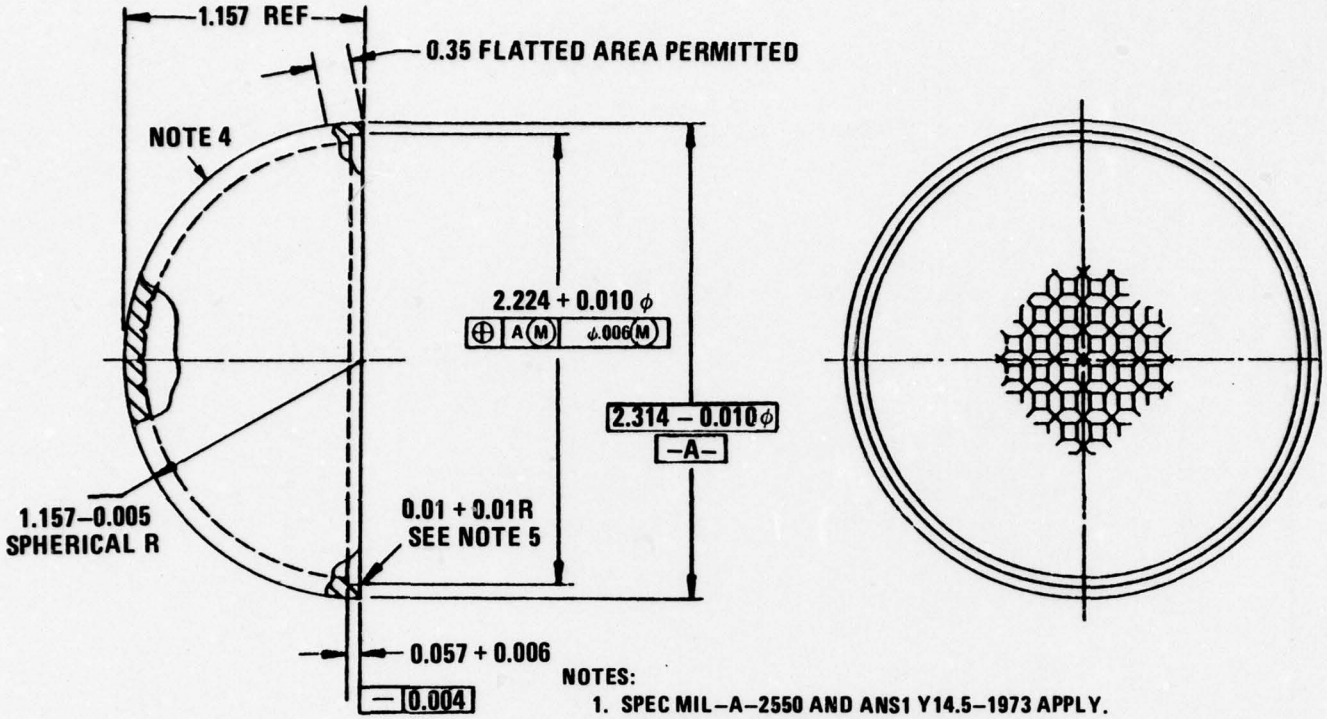


NOTES:

1. SPEC MIL–A–2550 AND ANS1 Y14.5–1973 APPLY.
2. MATERIAL: TUNGSTEN DISC 9313567.
3. SQUARE SEGMENTS MAY BE DISTORTED AFTER FORMING. SEGMENT LOCATION AFTER FORMING IS OPTIONAL.
4. PENETRANT INSPECT PER MIL–I–6866, TYPE AND METHOD OPTIONAL. NO SURFACE CRACKS ON OUTSIDE PERMITTED. OTHER SURFACE IMPERFECTIONS, INCLUDING POROSITY, WILL NOT BE CAUSE FOR REJECTION.
5. 0.01 x 45° CHAMFER OPTIONAL.

Figure 2–4. Hemisphere, Male (Part Number 9298785)

SA 3834–2B



NOTES:

1. SPEC MIL–A–2550 AND ANS1 Y14.5–1973 APPLY.
2. MATERIAL: TUNGSTEN DISC 9313567.
3. SQUARE SEGMENTS MAY BE DISTORTED AFTER FORMING. SEGMENT LOCATION AFTER FORMING IS OPTIONAL.
4. PENETRANT INSPECT PER MIL–I–6866, TYPE AND METHOD OPTIONAL. NO SURFACE CRACKS ON OUTSIDE PERMITTED. OTHER SURFACE IMPERFECTIONS, INCLUDING POROSITY, WILL NOT BE CAUSE FOR REJECTION.
5. 0.01 x 45° CHAMFER OPTIONAL.

Figure 2–5. Hemisphere, Female (Part No. 9298784)

2.1.1 Material Certification and Analysis

The chemical and physical properties tests of the discs are shown in figure 2-6. The first formulation lot 6059 represented 2775 parts. Each of the shipment lots were tested as noted. Of the 546 part lot, 142 were returned due to discrepancies and replaced by lot E which then represented a new formulation (lot 6063).

Lot D consisting of 100 parts required three sample tests since the parts did not meet the elongation requirement (shown as test number 2). Two additional samples were tested at a 0.05 inch per minute strain rate and were acceptable after meeting an elongation of 23.5 and 24.0 percent.

2.2 Production Plan

The production plan as shown in figure 2-1 could not be maintained due to the sporadic delivery of the hardware. (The actual hardware orders and deliveries are shown in figure 2-7. This plan was predicated on receiving the total quantity of 2400 discs by early January and processing weekly quantities of 150 parts. It was recognized early that the forming presses could maintain 150-200 parts per day. The limitation on quantities was in the machining operation where 160 parts were machined on a two-shift basis which was well within the schedule requirements. During the month of January and February, additional orders of 168 and 140 discs were placed to make up for the high scrap rate, and provide hardware for cost reduction testing. The initial shipment of 900 hemispheres was completed on schedule and shipped on 3 February 1978. The schedule called for 1000 parts to be delivered by 1 March 1978 of which 600 parts were delivered. It was agreed the remaining 400 parts would be delivered with the final shipment of 500. This shipment of 900 parts was further delayed by a 6-week long plant strike and was subsequently shipped on 2 August 1978. The schedule delays were caused by multiple hardware inspections to verify drawing conformance and porosity levels. It was decided in June to segregate a shipment of 147 discs by porosity levels to determine if porosity alone was responsible for the surface cracks. Several of the parts were used for material certification and several others were rejected due to surface defects. The parts were segregated as follows:

Category	A Low Porosity	B Medium Porosity	C High Porosity
	47	80	15
First form cracks	5	13	1
Second form cracks	0	0	0
Zyglo inspection	1	7	1
Percent failure	13	25	13

SA 4181–3

DRAWING NUMBER 9313567	DATE TESTED	CHEMICAL					PHYSICAL			
		TUNGSTEN (W) (%)	IRON (Fe) (%)	COBALT (Co) (%)	NICKEL (Ni) (%)	COPPER (Cu) (%)	ELONGATION (%)	DENSITY (g/cm^3)	ROCKWELL (Rc)	TENSILE STRENGTH ($LB/IN.^2$)
REQUIREMENTS FROM FORMULATION DWG T–9313626		91 (MAX)	2.5–5.5	N/A	4.5–7.5	N/A	22 (MIN)	17 MIN	32 (MAX)	
LOT 6059 LOT A – INITIAL 495	11/29/77	90.59	3.02	0.48	5.07	0.84	23	17.04	28	131,288
LOT 6059 LOT B – 497 PARTS	1/12/78	90.05	3.09	0.49	5.44	0.93	23	17.05	27.5	132.166
LOT 6059 LOT C – 500 PARTS	1/30/78	90.61	3.01	0.45	5.03	0.90	23	17.04	27.5	132,042
LOT 6059 546 PARTS	2/2/78	*								
LOT 6059 LOT D – 100 PARTS										
TEST NO. 1	3/11/78	90.29	3.06	0.49	5.28	0.88	23.5	17.10	29	127,586
TEST NO. 2		90.50	3.02	0.49	5.11	0.88	16.5	17.10	29	131,493
TEST NO. 3		–	–	–	–	–	24.0	17.10	26	129,470
LOT 6059 237 AND 400 PARTS	**									
LOT 6063 LOT E – 147 PARTS	4/17/78	90.36	3.22	0.47	5.07	0.88	23	17.06		128,667
LOT 6063 50 PARTS	***									

*142 PARTS WERE DIMENSIONALLY DISCREPANT AND RETURNED TO VENDOR. CHEMISTRY AND PHYSICALS WERE NOT COMPLETED ON THIS LOT SINCE DATA WAS SO CONSISTENT ON FIRST THREE SHIPMENTS.

**NOT TESTED SINCE THE 100 PARTS LOT REPRESENTED A 737 PART QUANTITY.

***NOT TESTED – PART OF LOT E.

Figure 2–6. Chemical and Physical Properties Tests of Disc, Tungsten

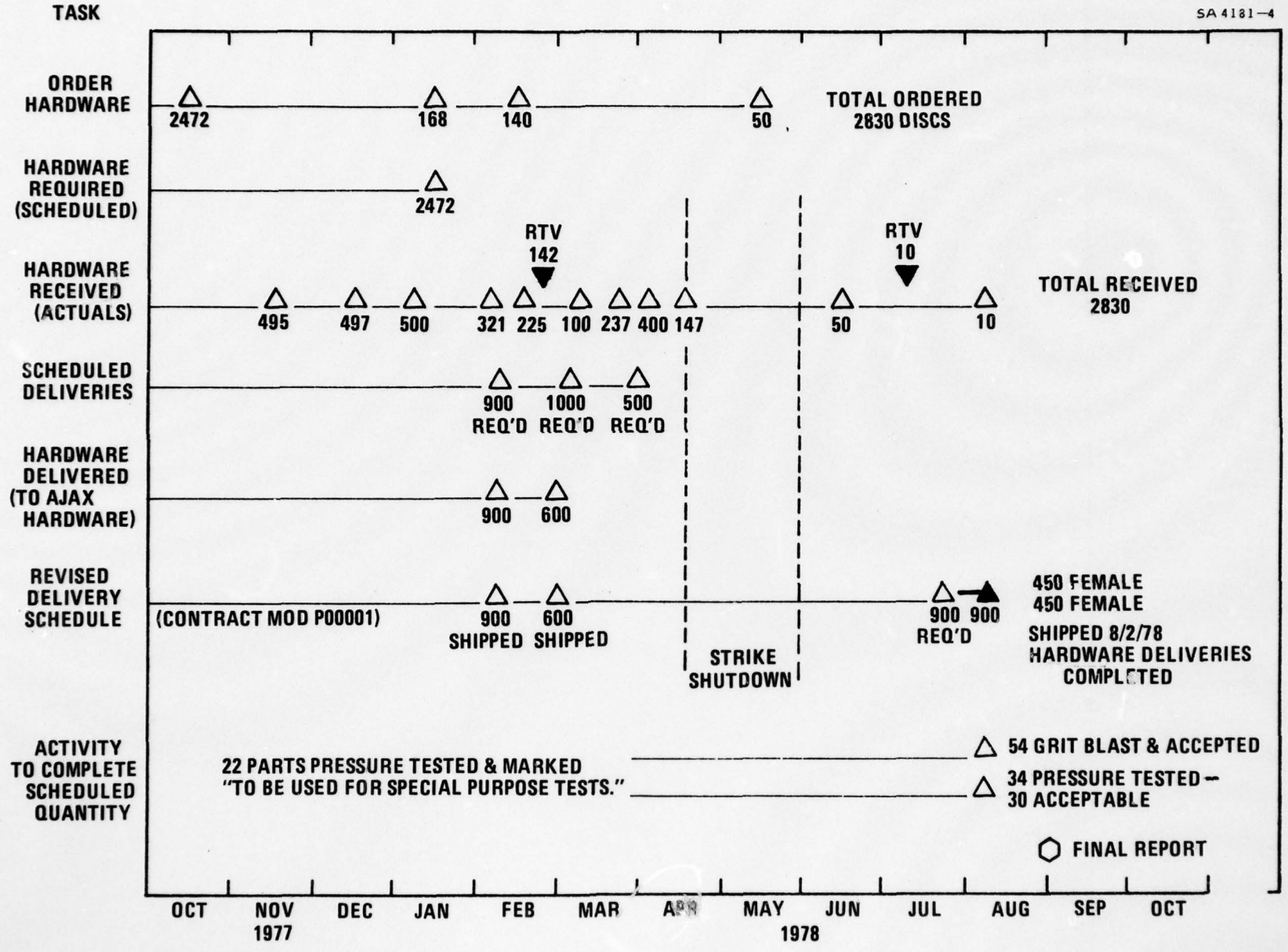


Figure 2–7. Tungsten Hemisphere Status

The results of processing these parts showed that cracking was randomly occurring and was not predictable based on observed surface porosity. It was observed during the zyglo inspection that some porosity was present in or near the cracks. All of the failed parts appear to be tension failures and indicate the ductility of the disc must be increased to alleviate this problem. Other changes to the disc have been recommended as a follow-on development effort prior to attempting a large rate production program.

2.3 Process Plan

The manufacturing process and inspection planning schedule as developed under the prior program with certain changes necessitated during this contract is shown in Addendum A. The hemisphere, during various stages of processing, is shown in figure 2-8.

It was determined that a more economical cleaning method was needed to replace the vapor degreasing operation after forming, and the grit blasting operation prior to penetrant inspection.

A low cost chemical cleaning was attempted without success. A quantity of chemical cleaner was purchased and used but did not completely remove the lubricant. The lubricant used in the forming process is baked in by the high forming temperature and very difficult to remove. It was decided to continue using the vapor degreasing cleaning method after forming since it was more effective in removing the lubricant.

An alternate method of lubrication was to lubricate the forming die instead of the disc in order to reduce the difficulty of removing the lubricant. It was found that the cracking of the hemispheres increased when only the die was lubricated.

The die was initially lubricated using molybdenum disulfide. The heated die caused the lubricant to build up in certain areas requiring cleaning of the die and relubrication after every six or seven parts were formed. The moly-disulfide was difficult to remove from the die. A fluorosilicone grease (FS1281-Dow Corning) was also used briefly but because of its toxic fumes above 500°F, it was replaced with a common lubricating machine oil. The oil is swabbed onto the first forming die each time six to seven parts are formed.

The grit blasting prior to the dye penetrant application was replaced with a vapor degreasing operation since grit blasting was a non-automated single piece cleaning method and the vapor degreasing could be accomplished on 50-100 parts at one time. The vapor degreasing of the parts does not remove the penetrant 100 percent of the time and therefore a black light inspection was requested by DCAS to assure that each part was completely clean of residual penetrant.

Certain additional tasks were performed such as 100-percent penetrant inspection of as "received discs" to determine porosity, 100-percent dimensional inspection on discs lots that were rejected at the receiving inspection level, and, in-process inspections to investigate problems experienced during forming.

N14671C

SA 4142—45

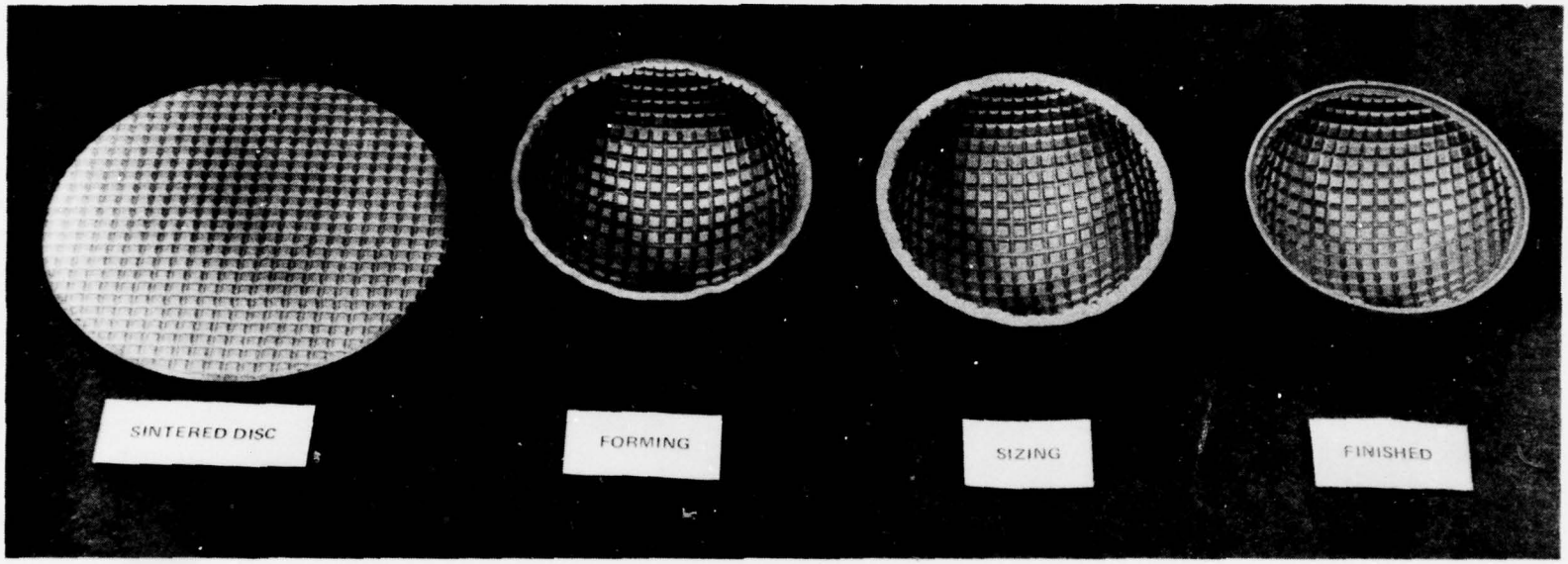


Figure 2–8. XM74 Tungsten Grenade (Current Processing Sequence)

Addendum A, pages A-6 and A-7, shows changes to the AQL level of inspection from the original program plan (Vought Report Number 7-34001/7R-34). The reason for changing was to standardize the lot sizes into quantities of 32 and reject the lot based on two discrepancies. In the case of inspection station 70, checking the $1.157\ ^{+.000}_{-.005}$ spherical radius the lot size was decreased from 50 to 32. This was also the case with inspection station 90 in checking the true position tolerance of 0.006 inch diameter. At all of the other inspection stations, the lot size represented an increase of from 13 to 32 parts. This resulted in a more efficient method of parts accountability.

Addendum B is included as a reference process and material specification for tungsten discs.

2.4 Cost Reduction Events

From the beginning of the program, each process task was investigated to reduce or eliminate certain tasks without degradation of the end item. Several discs were machined to remove the scores from the extreme edges and were first formed to determine if cracking could be reduced. Not all of the tasks were completed due to budget limits and press availability. It was found that many of the investigative tasks were beyond the scope of the present contract and would possibly require tooling rework and readjustment of the presses. It was decided not to interfere with the discs being processed and to separately propose and embark on a more thorough follow-on development program that would also investigate the sintering process. The development program is to include a disc sintered to the drawing thickness without further machining as shown in figure 2-3.

In the process diagram for the discs (figure 2-9) several operations will be eliminated. The disc will be redesigned with an unsocred collar as shown in figure 2-10. If successful, it will be possible to eliminate the grind flat and reheat operations.

It was found that by adding an unscored collar to the disc, the first forming operation greatly improved the condition of the edge of the part which may permit both forming operations within the same preheat. An example of a formed part with a collar is shown in figure 2-11. A target scrappage of 1 percent should be achievable with a material and process refinement. The diagram for the hemispheres showing the processes to be eliminated is shown in figure 2-12. The scrappage rates experienced on the present program were erratic and indicated that material quality was somewhat erratic, since the other mechanical functions were controlled. Following is an approximate summary of this experience.

SA 4151–3

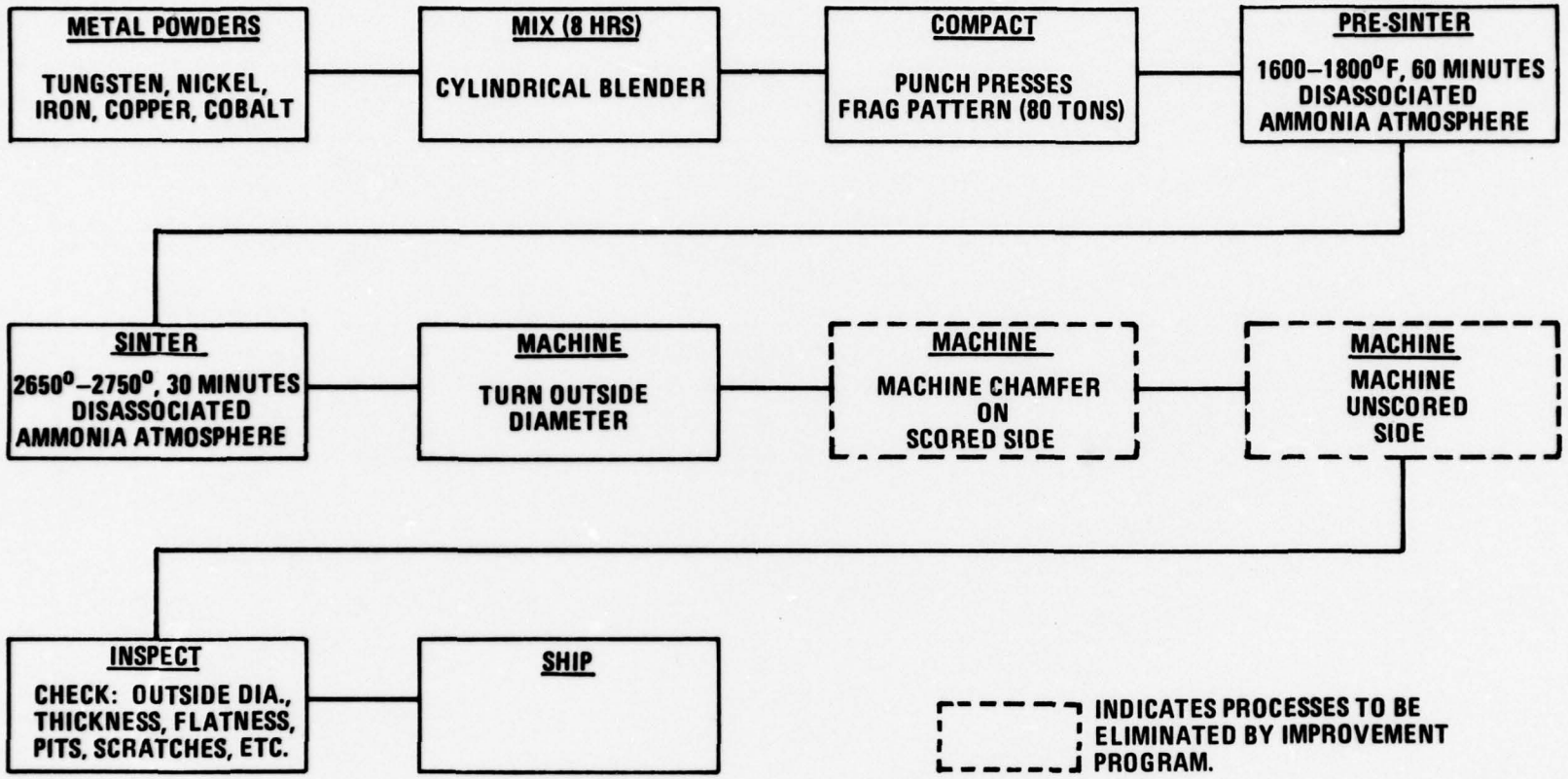


Figure 2–9. Process Diagram for Tungsten Disc

N17227

SA 4151-14

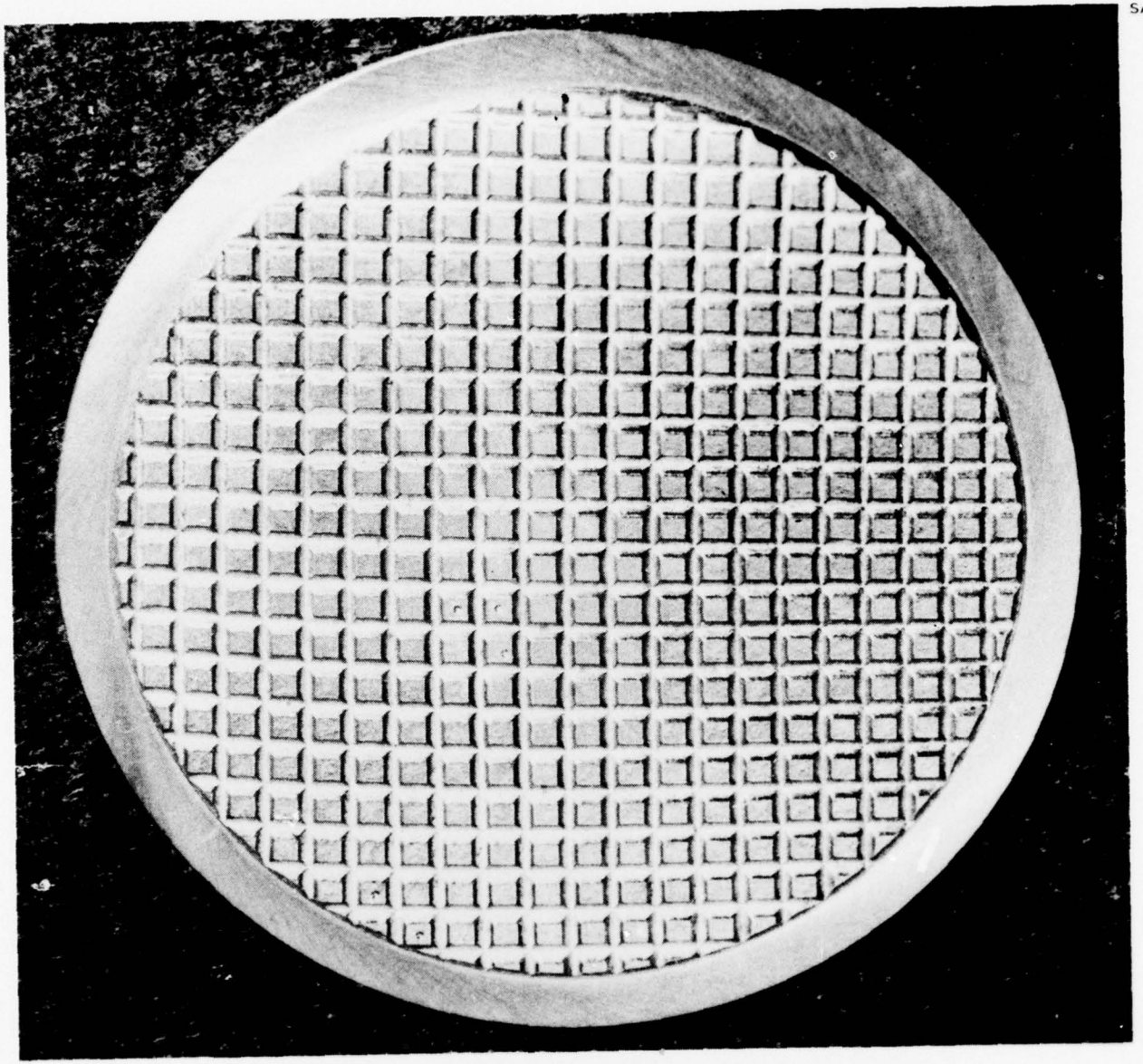


Figure 2–10. Modified Tungsten Disc With Collar

N17225

SA4151—13

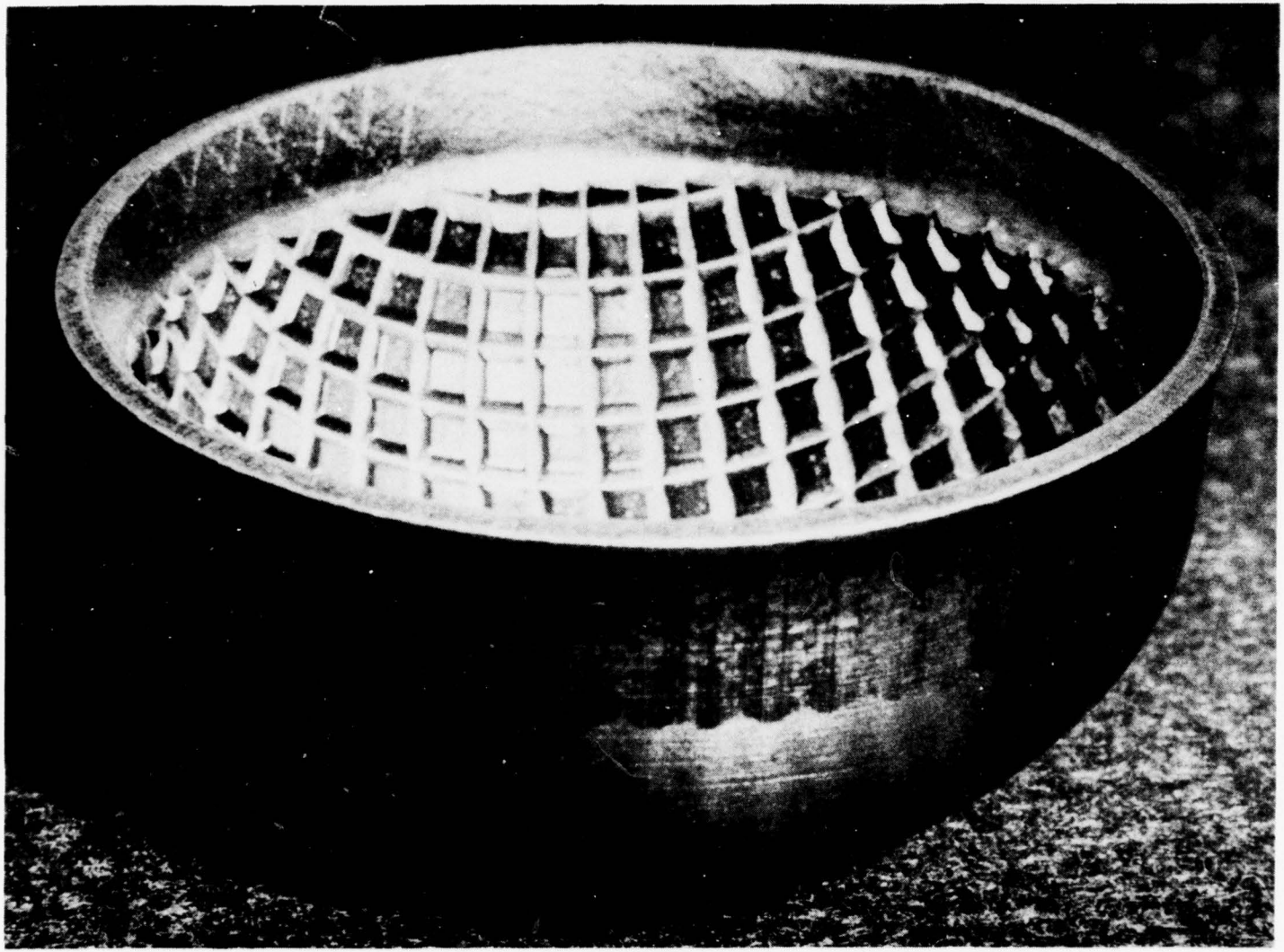


Figure 2–11. Disc With Collar After First Form (Note: No Rough Edge.)

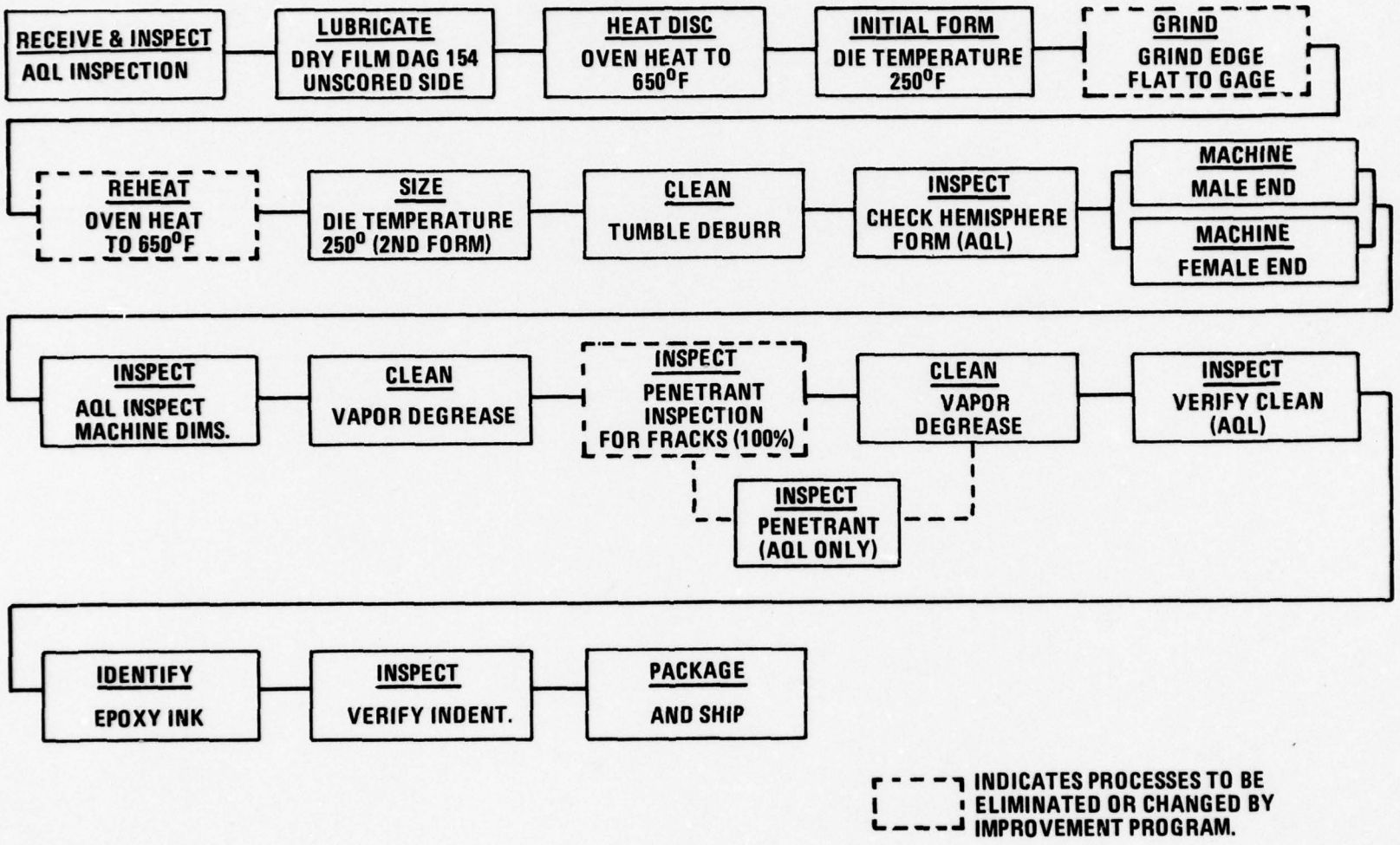


Figure 2–12. Process Diagram for Tungsten Hemisphere

Occurrence	Approximate Scrappage (%)
First 350 parts	35-40
Second 500 parts	20
900 complete	22
1550 complete	17
Next 500-800 parts	6
Remaining parts	15

The 6-percent scrappage rate was achieved by carefully monitoring, inspecting and segregating incoming hardware. The hardware showing surface porosity was polished in the time saver operation, heated and formed at a continuous rate since a large quantity of hardware was available at that time. The remaining parts showed various levels of porosity that appeared more severe than the previously processed hardware.

3. CONCLUSIONS AND RECOMMENDATIONS

The quality of the tungsten disc material must be improved to show minimum porosity and maximum ductility to further improve upon the successful forming of hemispheres from flat discs. The development program described earlier was proposed to accomplish a material improvement, a process improvement and also a relaxation of the acceptance criteria. Superficial surface cracks may be a condition that will exist irregardless of other improvements and should not be cause for final rejection. This criteria should be relaxed to a more acceptable level. It was demonstrated at the conclusion of this program that of 88 parts that were rejected based on cracks, only 4 parts had through material cracks. This was demonstrated by conducting a nitrogen gas pressure test of 30 psig, with the pressure applied for 1-minute duration.

The follow-on recommendations may be summarized as follows:

a. Redesign the disc to incorporate an unscored collar around the periphery of the scored area.

b. Reduce or eliminate the porosity in the sintered disc and closely inspect and control the sintering process.

c. Sinter the disc to the 0.100 - 0.008 inch thickness without machining the smooth face.

d. Increase the ductility requirement and lower the tensile strength requirement.

e. Relax the acceptance criteria.

f. Reduce dye penetrant inspection criteria to an AQL level in lieu of the 100-percent requirement.

Addendum A

PROCESS AND INSPECTION INSTRUCTIONS FOR TUNGSTEN HEMISPHERES

OPERATION INSTRUCTIONS HEMISPHERE, FEMALE PART NUMBER 9298784

OPER. NO.	LOAD GROUP	SET-UP	STANDARD HOURS	OPERATION DESCRIPTION	AQL	TOOLING
0	FM			GATHER TUNGSTEN DISC WITH SINTERED SCORED PATTERN, P/N 9313567. NOTE: (1) LOT TRACEABILITY REQUIRED. (2) FIRST PIECE OF EACH LOT SHOULD BE CHECKED FOR 1.157 SPHERICAL RADIUS AFTER 2ND FORM.		
20	NHG			APPLY LUBRICANT TO SMOOTH (NON-SCORED) SIDE OF TUNGSTEN DISC ONLY. LUBRICANT TYPE - ACHESON - DAG #154 FORMULATION - (2) PARTS (BY VOLUME) OF ISOPROPANOL TO (1) PART LUBRICANT. CAUTION: (1) AGITATE LUBRICANT THOROUGHLY BEFORE APPLICATION. (2) LUBRICANT MUST BE DRY BEFORE HEATING.		
30	JMB			1ST FORM OPERATION LOAD TUNGSTEN DISCS INTO OVEN WHICH IS AT A TEMPERATURE OF 675°F ± 25°F UNTIL PART REACHES AT LEAST 650°F. ADJUST PRESS STROKE DISTANCE OF MALE PUNCH TO 1.900 ± .25 INCHES (APPROX. 1.72 INCHES OPTIMUM) MEASURED FROM TOP SURFACE OF DISC TO BOTTOM OF STROKE. PLACE HEATED TUNGSTEN DISC WITH SCORED SURFACE - "UP" IN HEATED (CONTINUED ON PG. 2)		DIE #83037

CHANGE INSTRUCTIONS

DATE OF CHANGE

REVISION

PAGE NO.

OPERATION INSTRUCTIONS HEMISPHERE, FEMALE PART NUMBER 9298784

OPER. NO.	LOAD GROUP	SET-UP	STANDARD HOURS	OPERATION DESCRIPTION	AQL	TOOLING
				FORMING DIE & FORM WITHIN 15 SECONDS.		
				NOTE: TEMPERATURE OF FORMING DIE TO BE		1100W, 240V
				175^{o} - 250^{o}F.		BAND HEATER
				ALLOW FORMED PART TO AIR COOL TO ROOM TEMPERATURE.		
				CAUTION: EXCESSIVE TEMPERATURE OR OVEN		
				RESIDENCE WILL DEGRADE PARTS.		
40	NBG			FACE HEMISPHERE TO HEIGHT GAGE		P/N 82700
				& BREAK OUTSIDE EDGE .005/.015		
50	JMB			2ND FORM OPERATION		
				LOAD PARTIALLY FORMED PARTS INTO OVEN WHICH IS		
				AT A TEMPERATURE OF 675°F ± 25°F UNTIL PART		
				REACHES AT LEAST 650°F. ADJUST PRESS STROKE		
				DISTANCE TO MAINTAIN $1.157^{+.000}_{-.005}$ INCH SPHERICAL		
				RADIUS. PLACE HEATED AND PARTIALLY FORMED		
				HEMISPHERE INTO HEATED DIE		DIE #82699
				(CENTRALLY LOCATE) & FORM WITHIN 15 SECONDS.		
				NOTE: TEMPERATURE OF FORMING DIE TO BE		1100W, 240V
				175^{o}F - 250^{o}F.		BAND HEATER
				ALLOW FORMED HEMISPHERE TO AIR COOL TO ROOM		
				TEMPERATURE.		
				CAUTION: (1) "DIMPLED" DIE MARK AT TOP OF		
				SPHERICAL RADIUS ON O.D. SURFACE		
				INDICATES "OVER-FORMING".		
				(2) CONTINUED ON PG. 3		

CHANGE INSTRUCTIONS

DATE OF CHANGE

REVISION

PAGE NO.

OPERATION INSTRUCTIONS HEMISPHERE, FEMALE | PART NUMBER 9298784

OPER. NO.	LOAD GROUP	SET-UP	STANDARD HOURS	OPERATION DESCRIPTION	AQL	TOOLING
				(2) EXCESSIVE TEMPERATURE OR OVEN RESIDENCE WILL DEGRADE PARTS.		
60	NV			VIBRATORY DEBURR HEMISPHERES USING 1/4 CUP SOAP, DEBURR FOR AT LEAST 30 MINUTES.		
70	IPR			INSPECT PER IPS NO. 100-3.	AQL 001.50	
80	ARB			MACHINE HEMISPHERES-CENTRALLY LOCATE FORMED HEMISPHERE IN LATHE FIXTURE & MACHINE FEMALE EDGE CONFIGURATION PER IPS ILLUS.#1, AND DEBURR IN MACHINE. NOTE: NO COOLANT ALLOWED.		TO 6-1358
90	ICV			INSPECT PER IPS 100-3.	AQL 001.50	
100	UGL			VAPOR DEGREASE HEMISPHERES MPS 50-51-02.		
110	XZD			PENETRANT INSPECT AQL 100.00 PER MIL-I-6866. USE THE 7 "SHOP AID" PARTS AS ACCEPTANCE AND REJECTION CRITERIA.		
120	UGL			VAPOR DEGREASE HEMISPHERES MPS 50-51-02.		

CHANGE INSTRUCTIONS

DATE OF CHANGE

REVISION

PAGE NO.

OPERATION INSTRUCTIONS HEMISPHERE, FEMALE

PART NUMBER 9298784

OPER. NO.	LOAD GROUP	SET-UP	STANDARD HOURS	OPERATION DESCRIPTION	AQL	TOOLING
125	IPR			INSPECT USING BLACK LIGHT	AQL 001.50	
				TO INSURE PARTS ARE FREE OF RESIDUAL PENETRANT.		
130	YRM			IDENTIFY WITH RUBBER STAMP BOTH PART NO. & LOT		
				NO. ON O.D. SURFACE ADJACENT TO MACHINED EDGE.		
				NOTE: USE BLACK EPOXY INK PER MIL-I-43553.		
				E		
140	IHT			INSPECT PER IPS 100-3.	AQL 001.50	
				F/S		

HANGE INSTRUCTIONS

DATE OF CHANGE

REVISION

PAGE NO.

INSPECTION PLANNING SCHEDULE

PART NAME HEMISPHERE, FEMALE			REC. INSPECTION
PART NUMBER 9298784	DWG. NO. 9298784	REV. O	IN PROCESS INSP X
I.P.S. NUMBER 100-3	I.P.S. REV. A		FINAL INSPEC.
			VENDOR
* CHECK FIRST PIECE OF EACH LOT USING PLASTIC TEMPLATE ON 1.157-.005 SPHERICAL RADIUS			
W/O NO.	S/N	LOT NO.	RATING

SPECIAL INSTRUCTIONS

(1) LOT TRACEABILITY REQ'D (2) INSIDE SURFACE MAY BE DEFORMED AFTER FORMING (3) SEE ILLUS #1 FOR DIM'S, LOCATIONS & VIEWS.

CONFIG	LOT SIZE

NO	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REMARKS
70.	VERIFY THE FOLLOWING:					
*	1.157 $^{+.000}_{-.005}$ SPHERICAL R.	1.5	GO/NO GO TEMPLATE			
90.	VERIFY THE FOLLOWING: (SHARP EDGES PERMITTED AFTER MACHINING).					
	.057 $^{+.006}_{.000}$	1.5	OPTICAL COMPARATOR			
	2.224 $^{+.010}_{-.000}$ DIA	1.5	GO/NO GO PLUG GAGES CT 50010/CT 51265			
	STRAIGHTNESS W/I .004	1.5	FEELER GAGE			
	⊕ A Ⓜ Ø.006 Ⓜ	1.5	PIN MICROMETER			
	2.314 $\pm$ .000/.010 DIA	1.5	VERNIER			
	.01 ± .01 R OR .01 x 45° CHAMFER OPTIONAL	1.5	OPTICAL COMPARATOR OR RADIUS GAGE.			

REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV	REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV
IDENTIFICATION					SERIALIZE				
SURFACE TREATMENT					MAGNETIC PARTICLE				
PENETRANT INSP					RADIOGRAPHIC				
MACHINE					METALGRAPHIC				
FU TIONAL					ULTRASONIC				
CLEAN					PACKAGE				

PREPARED BY	APPROVED BY	DATE	INSPECTOR	DATE
[illegible]	[illegible]	1-4-72		

7-40510 REV 9-67

MISSILES AND SPACE DIVISION - MICHIGAN
LTV AEROSPACE CORPORATION

INSPECTION PLANNING SCHEDULE

PAGE 2 OF 3

PART NAME	HEMISPHERE, FEMALE		REC. INSPECTION
PART NUMBER	9298784	DWG. NO. 9298784 REV. 0	IN PROCESS INSP. X
I. P. S. NUMBER	100-3	I. P. S. REV. A	FINAL INSPECTION

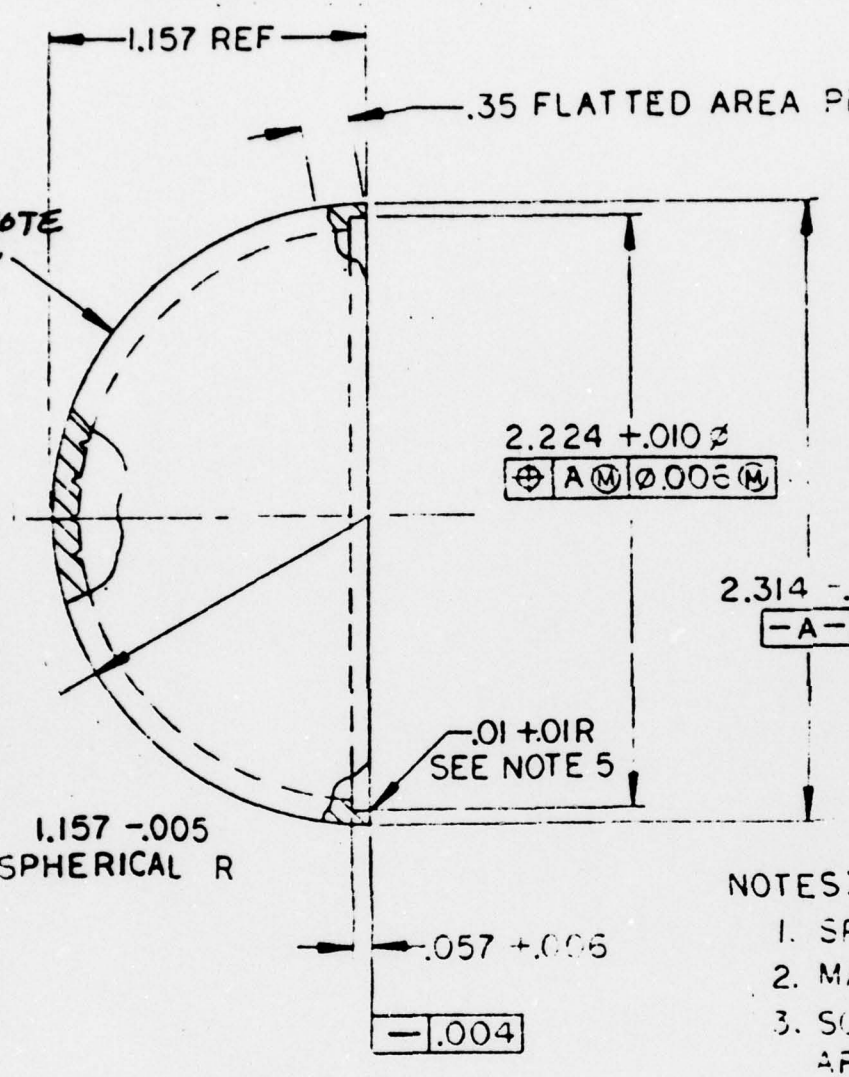
NO.	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REASON FOR REJECT
110.	PENETRANT INSPECT PER MIL-I-6866 TYPE AND METHOD OPTIONAL, NO SURFACE CRACKS ON OUTSIDE SURFACE PERMITTED.	100% INSP	VISUAL			
140.	VERIFY THE FOLLOWING:					
	PART(S) VAPOR DEGREASED PER MPS 50-51-02.	1.5	VISUAL			
	PART IDENTIFIED WITH PART NO. AND LOT NO. ON O.D. SURFACE ADJACENT TO MACHINED EDGE USING BLACK EPOXY INK PER MIL-I-43553.	1.5	VISUAL			

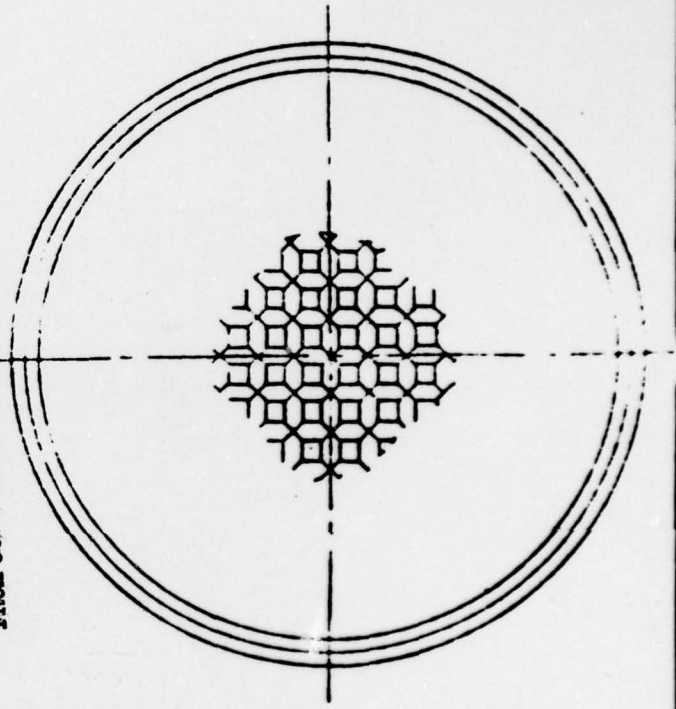
PREPARED BY [illegible] APPROVED BY TVB A-7 DATE 1-4-78 INSPECTOR DATE

INSPECTION PLANNING ILLUSTRATION

PART NO. 9298784

IPS No. 100-3





NOTES:—

1. SPEC MIL-A-2550 AND ANSI Y14.5-1973 APPLY.
2. MATERIAL: TUNGSTEN DISC 9313567.
3. SQUARE SEGMENTS MAY BE DISTORTED AFTER FORMING. SEGMENT LOCATION AFTER FORMING IS OPTIONAL.
4. PENETRANT INSPECT PER MIL-I-6866, TYPE AND METHOD OPTIONAL. NO SURFACE CRACKS ON OUTSIDE PERMITTED
5. .01 x 45° CHAMFER OPTIONAL.

REV. A | ILLUS. TVS | DATE 7-5-78 | PAGE 3 OF 3 | ILLUS. NO. 1

A-8

Addendum B

PROCESS AND MATERIAL SPECIFICATION

FOR

TUNGSTEN BASE, HIGH DENSITY METAL DISCS

ORIG. _____

WRITER Documentation

DISTRIBUTION _____

CODE IDENT NO. 17242

VOUGHT CORPORATION
michigan division

38111 Van Dyke • Sterling Heights, Michigan 48077

ENGINEERING DEPARTMENT SPECIFICATION

NO. 708-256

PAGE 1 OF _____

DATE _____

RELEASE EO _____

PROCESS AND MATERIAL SPECIFICATION

FOR

TUNGSTEN BASE, HIGH DENSITY METAL DISCS

APPROVALS

ORIG. GROUP	PROJ. ENGR.				
W. Mendoza		4/26/78			
DATE	DATE	DATE	DATE	DATE	DATE

1. SCOPE

1.1 This specification covers the materials and fabrication processes to produce tungsten base high density metal parts which are to be severely bent or drawn into hemispheric shape.

2. APPLICABLE DOCUMENTS

2.1 Government documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

STANDARDS

Federal

Fed. Test Method Std. No. 151	Metals; Test Methods

Military

MIL-1-6866	
MIL-STD-105	Sampling Procedures & Tables for Inspection by Attributes
MIL-A-2550	Ammunition, General Specification For
MIL-STD-129	Marking for Shipment and Storage
MIL-T-2104	

DRAWINGS

9313567	Disc, Tungsten

(Copies of specifications, standards, publications, and drawings required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM B-311	Density of Cemented Carbides
ASTM E-8	Tension Testing of Metallic Materials

(Application for copies of the above publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa 19103.)

3. RAW MATERIALS

3.1 Tungsten powder. The powder shall be hydrogen reduced tungsten powder produced by normal production methods. Tungsten powder for this process shall be grade C-8 supplied by Teledyne Wah Chang Huntsville or equivalent meeting the requirements of Table I.

Table I. Tungsten powder requirements

Particle size (Fisher subsieve size)	2.0 to 3.9 microns average and screened thru 200 mesh screen
Tungsten purity, %	99.9% minimum (exclusive of gases)
Metallic impurities, % determined by spectographic method	
Al	0.001 max
Co	0.001 max
Cr	0.003 max
Cu	0.001 max
Fe	0.010 max
Mg	0.001 max
Mn	0.001 max
Mo	0.020 max
Ni	0.004 max
Pb	0.001 max
Si	0.001 max
Sn	0.002 max
Other inpurities, % determined by instrumentation & chemical methods	
Carbon	0.008 max
Nitrogen	0.010 max
Oxygen	0.120 max

3.2 Alloying elements.

3.2.1 Nickel powder. Nickel powder shall be Type 123 supplied by International Nickel Company or its equivalent meeting the requirements of Table II.

Table II. Nickel powder requirements

Chemical composition	
Carbon, % by weight	0.1 max
Oxygen, % by weight	0.15 max
Sulfur, % by weight	0.001 max
Iron, % by weight	0.01 max
Other elements	trace
Nickel	balance
Physical characteristics	
Particle size (Fisher subsieve size)	4 to 7 microns avg.
Apparent density, g/cc	1.8 to 2.5
Typical angle of repose, degrees	62

3.2.2 Iron powder. Iron powder shall be Grade HP supplied by General Aniline & Film Corporation or its equivalent meeting the requirements of Table III.

Table III. Iron powder requirements

Chemical Composition	
Iron, % by weight	99.6 to 99.9
Carbon, % by weight	0.01 to 0.04
Oxygen, % by weight	0.10 to 0.30
Nitrogen, % by weight	0.00 to 0.05
Physical characteristics	
Particle size, microns	10 maximum
Apparent density, g/ccm	2.5 to 3.0

3.2.3 Cobalt powder. Cobalt powder shall be Type COF supplied by African Metals or its equivalent.

3.3 Raw material inspection. A copy of test results showing compliance to the requirements herein shall be provided by the supplier tracing the material to a material lot number.

4.0 MIXING AND BLENDING

4.1 Mill. Blending shall be performed in a ball mill, (Abbe 30 inch diameter by 48 inches long having a 3000 pound capacity, or equal). The mix shall be 2200 pounds of alloy to 500 pounds of one-half inch diameter steel balls or comparable ratio. The mill shall rotate at 30 rpm. Mixing time shall be at least 8 hours.

4.2 Composition of mix. Each mix composition shall be in accordance with Table IV. Alloy constituents shall be carefully weighed on scales which are accurate within 2 percent.

Table IV. Mix composition

Tungsten, % by weight	91 max
Nickel, % by weight	4.5 to 7.5
Iron, % by weight	2.5 to 5.5
Total other elements, % by weight	1.5 max

4.3 Lubrication addition.

4.3.1 Dry lubricants. When dry lubricants are required for successful compacting, they may be added during blending or added to the blended powder mix in a ball mill or paddle mixer (see 4.1 and 4.3.2). The dry lubricants shall be calcium stearate or molybdenum disulfide in proper amount for successful compacting. This mix operation is not critical as long as sufficient time is allowed to obtain a uniform mix.

4.3.2 Binder wax. Household paraffin such as Esso wax, Ovalan 25, or Gulfwax shall be added to the dry powder in a paddle mixer (Hobart Model M280, 200 kilogram capacity, or equivalent). Wax solvent shall be Chlorothene NU supplied by Dow Corning (no substitute). Two (2) percent binder wax by dry powder weight shall be added while mixing, and the mixing continued until the solvent has evaporated. Evaporation time may be shortened by use of a heat lamp on the powder surface. The dried mix shall be cooled to room temperature and screened through a 40 mesh screen.

WARNING

Blending equipment must be properly hooded and vented to prevent escape of solvent fumes into the working area.

4.3.3 Mix control. Each mix of powder shall be subjected to tests before being released for production. The content for each mix shall be chemically analyzed to be in conformance with the requirements herein (see 9.5.3.4). Tungsten discs shall be prepared and at least two (2) test blanks conforming to ASTM E-8, Figure 6, shall be prepared from completed discs. Tensile strength, density, and hardness shall be verified to conform to requirements herein (see 8) for each of the two test blanks. Failure to meet these requirements shall be cause for rejection of the entire mix. Rejected mixes may be completely analyzed to determine possibility of re-working. The re-worked mix may be resubmitted for the mix control tests.

5. COMPACTION. Disc compacts shall be pressed at 80 tons total pressure by a hydraulic press (M & M Hydraulic, Model 1R, 200 ton capacity, or equal). Fill of the die shall be by weight and hand leveling. No dwell time is required during the pressing.

5.1 Pressing checks. The press operator shall check the pressed height and leveling of the first compacted disc produced each day. One randomly selected disc from each days production shall be weighed. In case of any indication of a defect, appropriate corrective action shall be taken prior to proceeding with compaction production.

5.2 Compacted disc identification. Identification shall provide record traceability to the raw material lot, the blended powder mix, and to the discs compacted during each days production.

6. PRE-SINTERING. A pre-sintering operation shall remove the wax lubricant from the compacted discs and provide strength. Discs shall be stoked at temperature for approximately one hour. The furnace shall be a gas fired furnace (Buzzer Muffle Furnace or equal) at 1600 degrees F to 1800 degrees F. Pre-sintering is not a critical operation; but the following must be observed.

a. Pre-sintering atmosphere shall be disassociated ammonia.

b. Temperature shall not exceed 1800 degrees F in order to prevent excessive warpage or damage to the inconel furnace muffles.

7. SINTERING. Sintering of the pre-sintered discs shall be in an atmosphere of disassociated ammonia in an electric furnace (Adomas Type Moly Wound muffle furnace equipped with a stoker mechanism, or equal) at 2650 degrees F to 2750 degrees F. Discs shall be placed on ceramic boats and stoked into the hot zone at a rate for the discs to be at temperature for 30 minutes (feed rate of 1/2 inch per minute).

8. TUNGSTEN DISC REQUIREMENTS

8.1 First article. Unless otherwise specified in the contract or purchase order, before production has commenced a smaple or samples of the tungsten discs shall be made available to the contracting officer or his authorized representative for approval in accordance with 9.4. The approval of the first article samples authorizes the commencement of production but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification.

8.2 Physical and mechanical properties. The discs shall have properties conforming to Table V, as determined using standard test blank(s) from tungsten disc per ASTM E-8, Figure 6. In addition to test blank(s) from tungsten disc, five production parts out of 100 may also be tested for density, hardness, and porosity per the applicable Military Standards.

Table V. Physical and mechanical properties

Parameters	Value
Physical	
Density (g/cc)	17.0 min.
Hardness (Rockwell "C")	32 max.
Mechanical	
Ultimate tensile strength (psi)	130,000 min.
Yield strength (psi) 0.2 percent of set	85,000 min.
Elongation (percent)	22.0 min.

8.3 Microstructure. The microstructure shall exhibit a uniform distribution of tungsten and binder material when viewed at 200 magnifications.

8.4 Dimensions. The dimensions shall be as specified on drawing 9313567 disc, tungsten. Material shall be pressed as one piece with no sinter brazing or other joining methods permitted.

9. QUALITY ASSURANCE PROVISIONS FOR TUNGSTEN DISCS

9.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the procuring activity. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

9.2 Classification of tests. The inspection and testing of the material shall be classified as follows:

a. First article inspection (9.4)
b. Quality conformance tests (9.5)

9.3 Lot. A lot shall be defined as a uniform blend of one batch of powder. If a shipment of items is made from more than one lot, the procuring activity may choose to consider this shipment as a single lot or may separate the shipment into lots for acceptance purposes.

9.4 First article inspection.

9.4.1 Sampling. If first article testing is to be performed by the procuring activity and it is so stated in the contract, it will be the responsibility of the supplier to submit a specified number of test blank(s) from tungsten disc to the procuring activity. The test blanks shall conform to ASTM E-8, Figure 6 and shall be from a single lot.

9.4.2 Tests. The first article tests shall consist of all the tests specified in test methods, 9.7.

9.5 Quality conformance tests.

9.5.1 Sampling. Sampling for inspection and acceptance shall be performed in accordance with MIL-STD-105, except when otherwise specified herein.

9.5.2 Unit of product. The unit of product shall be one item (as sintered or machined) offered for acceptance.

9.5.3 Tests. The quality conformance tests shall consist of the following:

a. Hardness (9.5.3.1)

b. Examination (9.5.3.2)
c. Density (9.5.3.3)
d. Individual tests (9.5.3.4)

9.5.3.1 Hardness. Each sample unit shall be tested for conformance to the hardness requirements of Table I as specified in 9.7.1. The inspection level shall be S-3 with an acceptance number of zero for all sample sizes.

9.5.3.2 Examination. Each sample unit shall be examined for dimensional and finish requirements of the procurement document as specified in 9.7.2. The inspection level shall be Level II, AQL 2.5 defects per hundred.

9.5.3.3 Density. Each sample unit shall be tested for conformance to the density requirements as specified in 9.7.3. The inspection level shall be S-3 with an acceptance number of zero for all sample sizes.

9.5.3.4 Individual tests. Unless otherwise specified (see 14.2), a minimum of two test blanks from tungsten disc conforming to ASTM E-8 Figure 6, shall be made from each powder batch. Composition shall be tested as specified in 9.7.6, and one examination for uniformity of microstructure, 9.7.5, shall be made. Failure of any test blank to pass any one test will cause rejection of the lot represented by the test blank.

9.6 Test conditions. The material shall be subjected to the acceptance tests under the following temperature conditions.

Room ambient, 20° to 35°C (68° to 86°F)

9.7 Test methods.

9.7.1 Hardness. Samples shall be tested in accordance with Method 243 of Federal Test Method Standard No. 151 to determine conformance to Table V.

9.7.2 Dimension and finish. Samples shall be inspected to determine conformance to 8.4.

9.7.3 Density. Samples shall be tested in accordance with ASTM B-311 to determine conformance to Table V.

9.7.4 Mechanical properties. Samples shall be tested in accordance with ASTM E-8 to determine conformance to Table V with respect to tensile strength, yield strength, and elongation. Yield strength may be certified but not tested.

9.7.5 Microstructure. This test shall be accomplished on a test blank from a disc. Metallographic examination at 200 magnifications shall show a structure having uniform distribution of tungsten and binder material.

9.7.6 Chemical analysis. Analysis of the lot or lots in question shall be made by Method 111 or 112 of Federal Test Method Standard No. 151 for conformance to 4.2. In case of dispute, chemical analysis by Method 111 shall be the basis for acceptance.

10. DRAWING OR PRE-FORMING

10.1 Equipment. Equipment items other than normal shop practice tools required for the drawing or pre-forming operation are:

a. Mechanical crank type press (Model 29861, Niagara Machine Tool Works, 220 tons capacity having 12 inch stroke at 20 strokes per minute, or equal).

b. Drawing die (Tool design SN 83037) heated by means of a 6 1/2 inch diameter chromalox 220 volt ac heating band (T1-2-650, Edwin Wiegand Company or equal).

c. Electric furnace (F-A10525P Thermolyne or equal).

10.2 Disc lubrication. Vapor degrease each disc and apply dry film lubricant (DAG #154, Acheson Colloids Company, or equal) to the smooth side of the discs, and allow to dry.

10.3 Disc heating. The discs shall be placed on a rack and placed in an electric furnace, maintained at 650 degrees F plus or minus 25 degrees F, for 10 minutes minimum.

10.4 Pre-forming of discs. Lubricate the drawing die guide bushing with fluorosilicone compound (FS 1281 or FS 3451 manufactured by Dow Corning, or equal). Remove one disc at a time from the furnace and insert it into the recess of the drawing die which shall be maintained at approximately 250 degrees F. Stroke the press one time at 8 inches per second velocity (average punch velocity calculated from the press manufacturer's data) for each disc. Grind uneven edges smooth to remove "earing" caused by the preforming operation.

11. SIZING

11.1 Equipment. Equipment items other than normal shop practice tools required for the sizing operation are:

a. Mechanical crank type press (Model 23862, Ferracute Machine Company, 70 tons capacity having 6 inch stroke at 45 strokes per minute, or equal).

b. Sizing die (Tool design TO-6-1359) heated by means of a 6 1/2 inch diameter chromalox 220 volt ac heating band (T1-2-650, Edwin Wiegand Company or equal).

c. Electric furnace (F=A10525P Thermolyne or equal).

11.2 Heating. The pre-formed discs shall be placed on a rack and placed in an electric furnace, maintained at 650 degrees F plus or minus 25 degrees F, for 10 minutes minimum.

11.3 Sizing operation. Lubricate the sizing die cavity with fluorosilicone compound (FS 1281 or FS 3451 manufactured by Dow Corning, or equal). Remove one part at a time from the furnace and place it into the sizing die which shall be maintained at approximately 250 degrees F. Stroke the press one time at 9 inches per second velocity (average punch velocity calculated from press manufacturer's data) for each part.

12. MACHINING

12.1 Equipment. Equipment items other than normal shop practice tools required for the machining operation are:

a. Turret lathe (Model 1246324, Warner-Swasey Company, 10 horsepower, or equal).

b. Fixture (Tool design T0-6-1358).

c. Adapters for lathe headstock and tailstock.

12.2 Machining operation. The hemispheres shall be vapor degreased prior to machining. Place a formed hemisphere into the fixture. Machine into a male or female configuration per drawing 9298785 or 9298784 as applicable. Mate a male and female hemisphere and place into the adapters. File protrusions off of the outside mating diameters.

12.3 Grit blast cleaning. Each hemisphere shall be grit blasted with No. 220 alumina grit prior to penetrant inspection required by Drawing 9298785 and 9298784.

12.4 Inspection of hemispheres. Hemispheres shall be inspected for conformance to drawing 9298785 and 9298784 during the appropriate manufacturing processes.

13. PREPARATION FOR DELIVERY

13.1 Preservation, packaging, and packing. Tungsten powder parts, in whatever stage of manufacturing completion as may be appropriate, shall be prepared for delivery in accordance with the contractor's commercial practice in such a manner as to insure acceptance for safe delivery by common or other carriers to the point of delivery at the lowest rate.

13.2 Marking. Each individual part and test bar shall be clearly identified with a lot serial number; where parts are too small to be individually identified, they may be grouped for this purpose. In addition, each shipment shall be marked in accordance with MIL-STD-129.

14. NOTES

14.1 Intended use. The hemispheres are intended for use in explosive fragmentation weapons.

14.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this specification.

b. Whether first article inspection is required (see 9.4) and, if required, all pertinent details thereto.

c. Method of sampling and inspection, if other than specified (see 9.5).

d. Requirements for preservation, packaging, packing, and marking, if different (see 13).

DATA ITEM DESCRIPTION

2. IDENTIFICATION NO(S).	
AGENCY	NUMBER
Army	DI-P-1604 (Tailored)

1. TITLE

Manufacturing Methods Report

3. DESCRIPTION/PURPOSE

Manufacturing Methods Report details new or novel manufacturing methods, processes, and techniques in areas where the existing state-of-the-art does not meet military requirements.

4. APPROVAL DATE

15 Dec 69

5. OFFICE OF PRIMARY RESPONSIBILITY

USAMC

6. DTIC REQUIRED

7. APPLICATION/INTERRELATIONSHIP

This data item shall not be cited in contracts where the necessary data is being secured as a part of DI-S-1800, Technical Reports, or DI-E-1118, Drawings, Engineering and Associated Lists, DI-P-1614, Description of Manufacture, or DI-E-1115, Technical Data Package.

8. APPROVAL LIMITATION

9. REFERENCE DOCUMENT(S) (Cited in Block 10)

AMCR 700-24

MODEL NUMBER(S)

10. PREPARATION INSTRUCTIONS

The report shall detail new manufacturing methods, processes and techniques developed under the contract. The description of the process shall include the following as minimum data:

1. Certificate of Analysis for each powder manufacturer's lot of tungsten powder.
2. Type, grade, and purity of all other metal powders, and lubricants or binders.
3. Mix composition and mixing procedure.
4. Compacting equipment (type, model, modifications, etc.) and procedure. Specific data in this category shall include powder loading and leveling method, pressure dwell time, ejection method, and production rate.
5. Pre-sintering or delubrication procedure including specific data such as atm and flow rate, furnace temperature setting(s), stoking rate, total time, and pro rate.
6. Sintering equipment (type, model, modifications, etc.), and procedure. Specific data in this category shall include atmosphere and flow rate, furnace zone(s) temperature setting(s), stoking rate, total sintering time, and production rate.
7. Post-sinter heat-treating equipment (type, model, modifications, etc) and procedures, if applicable. Specific data in this category shall include heat-treating media (vacuum, atmosphere, etc.), temperature, time and production rate.
8. Forming equipment (type, model, modifications, etc.) and procedure(s). Other specific data shall include tooling drawings, tooling pre-heat temperature, disc pre-heat temperature and time, disc transfer time, press speed, and production rate.