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AD 404232

Mechanical and Physical Properties of TZM  
Molybdenum Alloy Sheet and of Tungsten Sheet

May 14, 1963

Prepared under Bureau of Naval Weapons  
Contract N600(19)59530

Second Progress Report  
(March 1 through April 30, 1963)

Southern Research Institute  
Birmingham, Alabama  
5898-1479-II

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## Second Progress Report On

### Mechanical and Physical Properties of TZM Molybdenum Alloy Sheet and of Tungsten Sheet

#### INTRODUCTION

This is the second progress report on a program to determine preliminary design data for tungsten and TZM molybdenum sheet produced in Phase I of the Refractory Metal Sheet Program. The first progress report, which primarily reviewed the scope and procedures for the program, was distributed to the Refractory Metal Sheet Panel at their last meeting on 7-8 March 1963 so that this work could be coordinated with other phases of the Refractory Metal Sheet Program. Since the regular distribution list was not available when the first progress report was prepared, Table 1, from the first report, is reproduced in this report to summarize the program for those organizations that may not be familiar with the program.

The tungsten and TZM sheet to be evaluated were produced by Fansteel Metallurgical Corporation and Universal Cyclops Steel Corporation respectively as part of Phase I of the Refractory Metal Sheet Program.

#### EXPERIMENTAL WORK

Since the experimental materials from Phase I of the Refractory Metal Sheet Program have not been received, no work on the actual evaluations has been possible. However, some work has been done to prepare the apparatus and special fixtures that will be needed for the planned experimental program. We have been notified that the tungsten sheet will be shipped from Fansteel Metallurgical Corporation, and we are prepared to begin the experimental work immediately.

Since the last progress report was prepared, the material gages to be investigated have been established with technical personnel at BuWeps. We originally planned to determine the properties listed in Table 1 for one gage of each material. However, after consultation with BuWeps and after meeting with the Refractory Metal Sheet Rolling Panel at their 7-8 March 1963 meeting, we have recommended that the tensile evaluations be extended to other gages as a practical means to develop some information on the influence of sheet thickness on the mechanical

Table 1  
Summary of Property Evaluations

Property	Alloy	Conditions <sup>1</sup>	Exposure Time, Hr <sup>2</sup>	Temperatures, °F
Tensile	Mo	O, R, C	0.5	RT <sup>3</sup> , 1200, 2000, 2200, 2500, 3000
	W	O, R, C	0.5	RT <sup>3</sup> , 1200, 2000, 2500, 3000, 3500, 4000, 4500
Compression	Mo	O, R		RT
	W	O, R		RT
Tensile Notch Sensitivity	Mo	O, R		RT and to above the transition temp.
	W	O, R		RT and to above the transition temp.
Shear Strength	Mo	O		RT
	W	O		RT
Bearing Strength	Mo	O		RT
	W	O		RT
Tensile Creep	Mo	O	To 100	2000, 2500
	W	O	To 100	2500, 3000
Thermal Stability	Mo	O		RT
	W	O		RT
Bend Transition	Mo	O, R, C	0.5	50° F increments to 50° F above transition temp. <sup>3</sup>
	W	O, R, C	0.5	50° F increments to 50° F above transition temp. <sup>3</sup>
Minimum Bend Radius	Mo	O, R		RT
	W	O, R		RT
Fusion Weld Joint Efficiency	Mo	A. W., H. T.	0.5	RT, 2500° F
	W	A. W., H. T.	0.5	RT, 3000° F
Spot Weld Joint Efficiency	Mo	A. W., H. T.	0.5	RT, 2500° F
	W	A. W., H. T.	0.5	RT, 3000° F
Density	Mo	O		RT
	W	O		RT
Thermal Expansion	Mo	O		Obtain curve RT to 2500° F
	W	O		Obtain curve RT to 2500° F
Thermal Conductivity	Mo	O		500, 1200, 1800, 2500
	W	O		500, 1200, 1800, 2500, 3000
Specific Heat	Mo	O		500, 1200, 1800, 2500
	W	O		500, 1200, 1800, 2500, 3000
Recrystallization	Mo	O		To be determined
	W	O		To be determined
Hot Formability	Mo	O		Above transition temp.
	W	O		Above transition temp.
Oxidation	Mo	C	0.5, 10, 100	2500, 2800
	W	C	0.5, 10, 100	2500, 3000

<sup>1</sup> O - optimum, R - recrystallized, C - coated, A. W. - as-welded, H. T. - heat treated.

<sup>2</sup> Applies only to elevated-temperature determinations.

<sup>3</sup> Evaluations to be made in both transverse and longitudinal orientations; all others in longitudinal orientation only.

properties without increasing the scope of the program. For tungsten, all of the different types of evaluations will be conducted on 0.060 in. thick sheet with additional tensile evaluations at selected temperatures on 0.100 in. thick sheet, and for the TZM sheet all of the different types of evaluations will be conducted on 0.040 in. thick sheet with additional evaluations on 0.020 and 0.060 in. thick sheet. The recommended tensile evaluations are given below:

Tungsten Sheet

Gage In.	Cond.	RT <sup>1</sup>	Evaluation Temp, °F						
			1200	2000	2500	3000	3500	4000	4500
0.060	Opt.	2	2	2	2	2	2	2	2
	Recry.	2	2	2	2	2	2	2	2
	Coated	2			2	2	2	2	
0.100	Opt.	2	-	2	2	2	2	2	-
	Recry.	2	-	-	2	2	-	-	-

TZM Sheet

Gage In.	Cond.	RT <sup>1</sup>	Evaluation Temp, °F				
			1200	2000	2200	2500	3000
0.020	Opt.	2	-	2	2	2	2
	Recry.	2	-	-	2	-	-
0.040	Opt.	2	2	2	2	2	2
	Recry.	2	2	2	2	2	2
	Coated	2	-	-	2	2	2
0.060	Opt.	2	-	2	2	2	2
	Recry.	2	-	-	2	-	-

<sup>1</sup> Transverse and longitudinal orientations; all others longitudinal only.

FUTURE WORK

The evaluation of the experimental materials will be started as the materials are received. Initially, the recrystallization parameters for each material will be determined, and tests will be performed on the sheet in the recrystallized and optimum conditions as originally scheduled. Evaluation of the coated materials will probably be deferred until later in the program pending the selection of suitable coatings for the materials. The Sub-Panel on Coatings of the Refractory Metal Sheet Rolling Panel will probably recommend the protective coatings for each material.

FUTURE REPORTS

In accordance with the request of BuWeps, the quarterly progress reports will be prepared on a schedule so that they can be distributed prior to the regular quarterly meetings of the Refractory Metal Sheet Rolling Panel. To accomplish this, we expect to prepare and distribute future reports as follows:

<u>Reporting Period</u>	<u>Report Distribution Date</u>
May, June, July - 1963	15 August 1963
Aug., Sept., Oct. - 1963	15 November 1963
Nov., Dec., - 1963; Jan. - 1964	14 February 1964
Feb., Mar., April - 1964	15 May 1964
May, June, July - 1964	14 August 1964

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21. General Electric Company, Lamp Metals and Components Dept., 21800 Tungsten Road, Cleveland 17, Ohio.
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