NOTES ON LARGE-SIZE FURNACES

FOR HEAT TREATING METAL ASSEMBLIES

(A Revision of DMIC Memo 63)

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BATTELLE MEMORIAL INSTITUTE

COLUMBUS 1, OHIO

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2. To supplement established Service activities in providing technical advisory services to producers, melters, and fabricators of the above materials, and to designers and fabricators of military equipment containing these materials.

3. To assist the Government agencies and their contractors in developing technical data required for preparation of specifications for the above materials.

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INTRODUCTION

This memorandum is a revision of DMIC Memorandum 63, dated August 25, 1960. The revision was initiated as a result of recent inquiries by defense contractors. Most of these inquiries concerned the availability of heat-treating facilities of larger size than those listed in the original memorandum.

The information given in this memorandum was obtained from telephone conversations with company representatives, company literature, the Defense Metals Information Center files, and published information.[1,2,3]** The names of the companies contacted are listed in the Appendix.

The technology of rockets and missiles has placed great emphasis on the heat treatment of the high-strength steels used in the manufacture of high-speed aircraft and missiles. For example, a rocket body, consisting of a thin-wall cylindrical tank, must be heat treated after fabrication so as to maintain very close dimensional tolerances and at the same time meet stringent specifications for mechanical properties. Decarburization must be held to a minimum, and in some cases no decarburization can be tolerated.

Surface reactions (such as decarburization) that occur during heat treatment are usually prevented, or at least minimized, by filling the heating chamber with a protective atmosphere or by heating in a neutral molten salt. The most familiar types of protective atmospheres are exothermic, endothermic, nitrogen, inert gases (chiefly argon), dry hydrogen, and vacuum. No one atmosphere is suitable for all heat treatments. The most common protective atmospheres, endothermic and exothermic, are obtained from the products of combustion of hydrocarbon fuel gases.

Exothermic gas is obtained from air-gas mixtures that will support combustion. These exothermic gases are saturated at about 10 F above the cooling-water temperature, and auxiliary drying equipment is needed to vary the water-vapor content (dew point) after the mixture leaves the generator.

The gas-air mixture used to produce endothermic gas is too rich to support combustion, and the reaction takes place in an externally heated retort. Within practical limits, the moisture content can be varied by adjusting the air-to-gas ratio without the use of auxiliary drying equipment. It has been established that the dew point of an endothermic atmosphere is a theoretical and practical measure of its carbon potential.

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**References are listed at the end of this memorandum.

AVAILABILITY OF LARGE FURNACES

The availability and location of extra-large-capacity furnaces is summarized in Table 1. Most of the companies listed as having furnaces also have metallurgical test facilities available which include Magnaflux, X-ray, tensile, and hardness testing. Many have additional facilities such as Magnaglo, ultrasonic inspection, spectrograph, chemical analysis, and metallographic laboratories.

As shown in Table 1, most of the furnaces are bottom-open gantry furnaces using an endothermic protective atmosphere. This type of furnace allows loading from or quenching into a pit below the furnace without losing the protective atmosphere or exposing the part to the air. Also, holding the parts to be heat treated in a vertical position assists in reducing distortion during heat treatment.

The endothermic protective atmosphere is the most popular because it is easy to control the carbon potential with this gas by regulating the dew point.(4) The dew point in the furnace can be readily varied by regulating the mixture in the generator and the flow of atmosphere through the furnace. The regulation of the carbon potential of the furnace atmosphere is extremely important in heat treating parts which require close control or elimination of decarburization. An atmosphere which would be neutral to a 0.30 carbon steel could very readily decarburize a 0.40 carbon steel.

Table 1 is not intended to be a complete listing of all heat-treating facilities in the country. It is intended as a guide to the location of unusually large furnaces. Also, the information listed does not cover all available facilities at the various companies. Some of the facilities have a considerable flexibility which cannot be indicated in a brief table. For example, in some instances the same quench tanks and tempering units are available for more than one heating furnace. Other companies have furnaces and facilities which can be readily adapted for a wide range of work. Information as to the availability and uses of the facilities at any given time can best be obtained by contacting the company listed.

In contacting furnace manufacturers and heat treaters in order to bring up to date the list of furnaces in Table 1, most companies indicated they are waiting for definite sizes and material commitments from potential customers before installing any new large furnaces. Large gantry-type furnace installations are a major capital investment, and most companies are reluctant to spend such sums on the basis of speculation.

The largest heat-treating furnaces now available were built specifically to heat treat cases with diameters up to 120 inches. The only larger furnace presently available (204 inches in diameter; Item 11 in Table 1, Eastern Section) is stationary and is presently being used in manufacture of large glass-lined steel tanks. This furnace does not now have a protective atmosphere available. Engineering work has been completed on the design modifications to provide hoists which operate through the furnace arch. Also, shrouds with seals to enclose the work piece, a salt-quench bath, and a separate preheating and tempering furnace have been designed. When a definite need develops for incorporating these features into the furnace, it could be done in a few months' time.

REFERENCES

(1) DMIC Report 119, "Heat Treatment of High-Strength Steels for Airframe Applications", R. J. Fiorentino, D. B. Roach, and A. M. Hall, OTS PB 151076.

(2) "Survey of Special Furnaces for Rocket, Missile and Aircraft Components", Metal Treating, September-October, 1959, and April-May, 1960.

(3) DMIC Memorandum 63, "Notes on Large-Size Furnaces for Heat Treating Metal Assemblies", H. J. Hucek, A. R. Elsea, and A. M. Hall (August 25, 1960).

(4) Round Table on Atmosphere Generation, Metal Progress, 66, N5, pp 81-123 (November, 1954)

TABLE 1. DESCRIPTIONS OF SOME EXTRA-LARGE-CAPACITY

Company	Description of Furnace		Size of Heating Chamber		Types of Protective Atmospheres
	Type of Furnace	Method of Heating	Furnace Opening, inches	Length, feet	
	Central Section				
1. General Electric, Rocket Engine Section, Cincinnati, Ohio	Bottom-open, Gantry	Electric	120 dia	30	Endothermic
2. Army Ballistic Missile Agency, Redstone Arsenal, Alabama	Bottom-opening	Electric	96 dia	10	None (air)
3. Lindberg Steel Treating Co., Melrose Park, Illinois	Bottom-open, Gantry	Electric	80 dia	24	Endothermic, nitrogen, argon
4. Thompson-Ramo-Wooldridge, Inc., Cleveland, Ohio	Bottom-open, Gantry	Electric	72 dia	22	High nitrogen, argon, endothermic
5. Commercial Steel Treating Corp. Detroit, Michigan	Bottom-open, Gantry Ditto	Radiant tube-gas Ditto	70 dia 70 dia	28 14	Endothermic "
6. Goodyear Aircraft Corp., Akron, Ohio	Bottom-open, Gantry	Electric	68 dia	21	Nitrogen
7. Metallurgical Inc., Minneapolis, Minnesota	Bottom-open	Electric	72 dia	24	Any atmosphere required
8. Wall Colmonoy Corp., Detroit, Michigan	Vertical		72 dia	10	Dry hydrogen, argon, nitrogen, carbon dioxide, exothermic
9. Ingersoll Kalamazoo Division, Borg-Warner Corp., Kalamazoo, Michigan	Bottom-drop	Electric	42 dia	13	Endothermic
10. A O. Smith, Milwaukee, Wis.	Top-open pit Ditto	Electric "	60 dia 54 dia	10 12	Inert or recarb. Ditto
11. The National Acme Co., Cleveland, Ohio	Top-open pit Ditto	Electric "	30 dia 30 dia	7.5 6.5	Endothermic "
12. Allison Division, General Motors Corp., Indianapolis, Ind.	Bottom-open	For more information contact Allison			

FURNACE EQUIPMENT AVAILABLE IN THE UNITED STATES

Maximum Temperature, F	Quenching Media	Tempering Facilities: Size[a] Diam, inches; Length, ft.	Tempering Facilities: Maximum Temperature, F	Remarks
		Central Section		
1. 2000	Salt, water, air, oil (available)	120" dia x 30' (two)	1400	Salt quench can be heated 300 F to 1000 F; water quench can be heated to 180 F
2. 1200		96" dia x 10'	1200	
3. 2050	Salt, nitrogen (gas), water	80" dia x 24' (two)	1400	
4. 2050	Salt, oil, water	72" dia x 22'	1400	
5. 1850 1850	Oil Oil	70" dia x 22'	1250	
6. 1950	Salt, water	72" dia x 22' (two)	1400	Plan to add facilities to Gantry; add endothermic
7. 2150	Salt, oil, water	84" dia x 24'	1250	
8.				Furnace used for brazing and heat treating
9. 1800	Oil	72" dia x 14'	1400	
10. 1750 1750		54" dia x 12' (two)	1350	
11. 1900 1900		30" dia x 7'-8" 30" dia x 6'-8"	800 800	
12.		For more information contact Allison.		

TABLE 1.

Company		Description of Furnace				Types of Protective Atmosphere
		Type of Furnace	Method of Heating	Size of Heating Chamber: Furnace Opening, inches	Size of Heating Chamber: Length, feet	
		Eastern Section				
1. J. W. Rex Company, Lansdale, Pennsylvania	On same track	Bottom-open, Gantry	Electric	71 dia	22	Endothermic
	On same track	Bottom-open, Gantry	Electric	60 dia	15	Endothermic
	On same track	Bottom-open, vertical	--	144 dia	32	Endothermic
2. H. K. Porter Company, Inc. Ambridge, Pennsylvania		Bottom-open, Gantry	Gas	48 dia	13	Endothermic
		Ditto	Gas	36 dia	18	"
3. Alco Products Manufacturing Company, Dunkirk, N. Y.		Bottom-opening	Electric	44 dia	13.5	Endothermic
4. Pittsburgh Commercial Heat Treating Co., Pittsburgh, Pennsylvania		Bottom-opening	Electric	44 dia	10	Endothermic
5. Metlab Company, Philadelphia, Pennsylvania		Bottom-opening	Propane gas	36 dia	14	Endothermic or exothermic
6. Parish Pressed Steel, Reading, Pennsylvania		Top-open pit		30 dia	12'-11"	Products of combustion
7. S. D. Hicks, Ashville, North Carolina		Salt pot	Gas	72 sq	20	Neutral salt
8. The Hicks Corporation, Boston, Massachusetts		Salt pot		48 sq	15	Neutral salt
		Salt pot(b)	Electric and gas	33 dia	16	Ditto
9. M. W. Kellogg Company, Jersey City, N. J.		Salt pot		48 sq	15	Neutral salt
		Salt pot(b)	Electric	30 dia	10	Ditto
		Salt pot(b)	Electric	30 dia	10	"
10. Pratt-Whitney, East Hartford, Connecticut		Gantry-type	Electric	90 dia	12	Endothermic and nitrogen
11. The Pfaudler Co. Division of Pfaudler Permutit, Inc. Rochester, New York		Vertical, Bottom-open	Natural gas	204 dia	33	Can be made available

(Continued)

Maximum Temperature, F	Quenching Media	Tempering Facilities: Size[a] Diam, inches; Length, ft.	Tempering Facilities: Maximum Temperature, F	Remarks
			Eastern Section	
1. 1950	Caustic, oil salt, water	71" x 22' (two)	1500	On same track (1500 units bracketed)
		71" x 15' (two)	1500	
1950	Oil, caustic	71" x 8'	1500	
1950		60" x 13'	1500	
1850	Salt	157" x 44'	1250	20 tons
2. 1700		60" x 57" x 12'-6"	850	
		36" x 13'	1700	
1700		48" x 18'	1700	
3. 1950	Oil or water	72" x 48" x 20' (horiz.)	1250	
		44" x 13'-8" (vert.)	1250	
4. 1900		40" x 10'	1850	
5. 1850		Available according to requirements		
6. 1650		36" x 68" x 23'-4 (horiz.)	1300	
7.	Oil			
8. 1700		72" sq x 20' (horiz.)	1300	
9. 1700		36" sq x 12'	1300	
1300		36" sq x 6'	1300	
10. 2000	Tempering facilities will be available			Proposed future construction
11. 2500	Will be made available as needed			50 ton max. work load

TABLE 1.

Company	Description of Furnace				Types of Protective Atmospheres
			Size of Heating Chamber		
	Type of Furnace	Method of Heating	Furnace Opening, inches	Length, feet	
	Western Section				
1. Aerojet-General Corp., Azusa, California	Bottom-open, Gantry	Electric	100 dia	21	Endothermic
Sacramento, California	Bottom-open, Gantry	Electric	96 dia	20	Endothermic
2. North American Aviation, Los Angeles, California	Bottom-open, Gantry	Electric	84 dia	29	Exothermic nitrogen base
3. Menasco Manufacturing Co., Fort Worth, Texas	Bottom-open, Gantry		80 dia	24	Endothermic
4. Lindberg Steel Treating Co., Los Angeles, California	Bottom-open, Gantry	Electric	80 dia	16	Exothermic, argon, nitrogen
5. The Marquardt Corp., Ogden, Utah	Bottom-opening	Electric	80 dia	10	Endothermic and exothermic
6. Marquardt Aircraft Co., Van Nuys, California	Bottom-open, Gantry	Electric	72 dia	10	Endothermic
7. Norris-Thermador, Los Angeles, California	Bottom-open, Gantry	Gas	60 dia	11	Endothermic
	Ditto	"	96 dia	20	"
8. Douglas Aircraft Company, Inc., Torrance, California	Bottom-open, Gantry (two)	Electric	74 dia	18	Endothermic and exothermic
	Bottom-opening	Electric	48 dia	10	Exothermic
9. Menasco Manufacturing Co., Burbank, California	Vertical	Electric	72 dia	13	Endothermic
10. California-Doran Heat Treating Co., Los Angeles, California	Bottom-open, Gantry	Radiant tube-gas	60 dia	16	Exothermic, nitrogen Endothermic, or argon
	Top-open pit	Gas	60 dia	6	Endothermic and exothermic
	Bottom-open, Gantry	Gas	154 dia	14	
11. Boeing Airplane Company, Seattle, Washington	Gantry	Electric	60 dia	14	Endothermic
12. Lockheed Aircraft Corp., Burbank, California	Bottom-open, Gantry	Electric	60 dia	15	Endothermic
13. E and J Heat Treating Inc.	Bottom-open, Gantry	Radiant tube-gas	84 dia	10	Endothermic
	Top-open pit	Electric	48 dia	16	Endothermic
14. Solar, A Subdivision of International Harvester, San Diego, California	Top-open pit	Electric	108 dia	30	Endothermic, nitrogen hydrogen, argon
15. North American Aviation, Downey, California	Horizontal		78 dia	40	Vacuum or inert gas
16. Convair, Astronautics San Diego, California	Vacuum	Electric	72 dia	10	Vacuum

(a) Vertical unless noted.

(Continued)

Maximum Temperature, F	Quenching Media	Tempering Facilities: Size[a] Diam, inches; Length, ft	Tempering Facilities: Maximum Temperature, F	Remarks
			Western Section	
1. 2050		100" dia x 21'	1450	
	Salt, oil			
2. 2050	Nitrogen-base atmosphere water,	84" dia x 29'	1450	Subzero cooling chamber 84" x 29' cools to -110 F
3. 2050	Salt, water	80" dia x 24'	1250	
4. 2050	Salt, water		1400	
5. 2000		80" dia x 10'	1000	
6. 2000		72" dia x 10'	1000	
7. 1800	Salt	60" dia x 16'	1300	
8. 2000	Oil, water, salt atmosp.	74" dia x 18'	1450 F	11 pit stations
1800	Oil		1250	
9. 2000	Water, oil, salt	72" dia x 13'		
10. 1900		60" dia x 16'	1150	
1800	Water			
11. 1900		42" dia x 16'	1700	
2050		60" dia x 14'	1450	
12. 2050		60" dia x 15'	1450	
13. 1950	Oil, water	48" x 16'	1250	Can temper in Gantry (has circulating fan) also, a 48" x 16' pit is available for subzero treatment to -110 F
1900	Oil, water	72" x 20'	Quench pits for both furnaces	
14. 1950	Air	108" dia x 30'	1950	
15. 2250	Cooled inside furnace by inert atmosphere			Furnace used for degassing, heat treatment and brazing
16.				

(b) Two salt pots of this size.

APPENDIX

APPENDIX

Companies and individuals contacted in the survey of extra-large-capacity furnace equipment available in the United States.

General Electric Corporation
Rocket Engine Section
Cincinnati, Ohio
Mr. N. C. White

Lindberg Steel Treating Co.
Melrose Park, Illinois
Mr. G. H. Bodeen
Mr. J. Boerema

J. W. Rex Company
Lansdale, Pennsylvania
Mr. John E. King

Commercial Steel Treating Company
Detroit, Michigan
Mr. Patterson

Thompson-Ramo-Wooldridge, Inc.
Cleveland, Ohio
Mr. Jim Long

Metallurgical, Inc.
Minneapolis, Minnesota
Mr. Paul Wallace

Pacific Scientific Company
Los Angeles 22, California
Mr. Bob Grossman

Surface Combustion Division of
Midland-Ross Corporation
Toledo, Ohio
Mr. Koch

Allison Division of General Motors
Corporation
Indianapolis, Indiana
Mr. Roger Fleming

Sunbeam Equipment Corporation
162 Mercer Street
Meadville, Pennsylvania
Mr. Dain

Excelco Developments, Inc.
Silver Creek, New York
Mr. W. D. Abbott

Goodyear Aircraft Corporation
Akron, Ohio
Mr. Ed Saneoska
Mr. Bob Barch

Rheem Manufacturing
Downey, California
Mr. Sykes

E and J Heat Treating, Inc.
Los Angeles 58, California
Mr. D. Leach

General Electric Corporation
Industrial Heating Department
Shelbyville, Indiana
Mr. Richardson

Lindberg Engineering Company
Chicago, Illinois
Mr. Norbert K. Koebel

Pfaudler Company
Rochester, New York
Mr. William Galloway
Mr. J. W. Glenn

LIST OF DMIC MEMORANDA ISSUED
(Continued)

A list of DMIC Memoranda 1-164 may be obtained from DMIC, or see previously issued memoranda.

DMIC Memorandum Number	Title
165	Review of Uses for Depleted Uranium and Nonenergy Uses for Natural Uranium, February 1, 1963
166	Literature Survey on the Effect of Sonic and Ultrasonic Vibrations in Controlling Grain Size During Solidification of Steel Ingots and Weldments, May 15, 1963