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PRIORITIES FOR DETAILED QUALITY ASSESSMENTS OF THE NATIONAL DEFENSE STOCKPILE NONFUEL MATERIALS

Report of the
Committee on Assessment of the Need for Quality Determination of
Nonfuel Materials in the National Defense Stockpile

NATIONAL MATERIALS ADVISORY BOARD
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
NATIONAL RESEARCH COUNCIL

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

The report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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This study was done in two phases: Phase I was conducted under contract EMW-C-1022 with the Federal Emergency Management Agency and Phase II was conducted under contract BA-83-SAC-12407 with the Department of Commerce by the National Materials Advisory Board.

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ABSTRACT

Forty-four nonfuel materials, or groups of related materials, in the National Defense Stockpile were examined to determine which need detailed quality assessment. Based on available purchase and storage data, 18 were found to be usable by today's industry and 12 need no immediate quality assessment. Eight materials need immediate quality assessment because of their critical role in national defense; two now are subjects of detailed examination by industry panels. The remaining six materials need quality assessment but are regarded as less critical in today's industrial climate. Summary data on storage conditions and specifications are presented for these materials. Detailed analyses of the entire stockpile should be considered with due regard for such factors as likelihood of deterioration or contamination, technological changes in specifications, deficiency in analyses, quality data, end use tests or specifications, inability to expeditiously use the material in an emergency, and the costs involved. Biennial review of data on all holdings for technological currency is advised. There is a clear need for detailed evaluation of many materials.

PREFACE

Recent emphasis on the need for this nation to focus attention on critical and strategic materials that are either totally or partially obtained from foreign sources has underscored the importance of the ability of the National Defense Stockpile to meet the nation's industrial needs in an emergency. The Strategic and Critical Materials Stockpiling Revision Act of 1979 (P.L. 96-41); The National Materials and Mineral Policy, Research and Development Act of 1980 (P.L. 96-479); and the Critical Materials Act of 1983 (H.R. 4186) reflect legislative actions concerned with materials availability.

Since 1951, the National Academy of Sciences (NAS), through the National Materials Advisory Board (NMAB) and its predecessor boards, has assisted various government agencies in examining materials and stockpiling issues by assembling the nation's technical and economic experts to address questions of concern. In a 1982 report, Considerations in Choice of Forms for Materials for the National Stockpile, the NMAB Panel on Upgraded Forms of Materials and Recycled Materials for the National Stockpile examined the methodology applicable to assessing forms in which materials are stored in the national stockpile and the advisability of retaining recyclable materials in the stockpile. Examination of all the materials in the stockpile was beyond the scope of that study, but the method used and the conclusions drawn by the panel identified the problems and implications of existing policies or the lack thereof.

At the request of the Federal Emergency Management Agency (FEMA) and the Department of Commerce (DOC), Office of Strategic Resources, the NMAB Committee on Assessment of the Need for Quality Determination of Nonfuel Materials in the National Defense Stockpile was appointed to develop overall criteria for determining whether or not the quality of materials (excluding fuels and agricultural and medicinal materials) in the National Defense Stockpile needs to be investigated to determine their usability in the event of a national emergency. The committee was composed of 12 members who were assisted by four technical advisors representing specific industrial organizations of the U.S. metals industry. Committee member resumes appear as Appendix B.

The committee's study involved consideration of the probability of contaminants, susceptibility to deterioration, changed industrial and technical specifications, and the time, since quality was last determined. The stockpile inventory was examined to determine which materials need detailed examination, which require only simple, nondetailed examination, which require further consideration before a judgment can be made, and which require no further study. To the extent possible, the priority in which materials should be examined is suggested.

This report is based on information available to the committee up to December 1983. It includes a summary of technical information and a discussion of the technical questions left to be resolved. Emphasis is placed on the technical requirements of materials and their uses. The need for these materials and stockpile goals are outside the scope of this inquiry.

R. L. Smith
Chairman

ACKNOWLEDGMENTS

The committee is grateful to a number of individuals for their contributions to the committee's assessment program. The government liaision representatives are thanked for their cooperation in supplying pertinent historical acquisition and storage data to the committee. In particular, Catherine Law, Director of the Quality Assurance Division, General Services Administration (GSA) (assisted by R. Dundon of the same division), furnished available stockpile records for the committee's examination; Richard Corder, Industrial Specialist, FEMA, furnished additional data on acquisitions and policy; and David Glancy, Technical Advisor for the Office of Strategic Resources, U.S. Department of Commerce, provided guidance to the committee throughout its study. Paul Butler of the Department of Commerce supplied the latest purchase specifications. J. Wayne Kulig, Assistant Commissioner for Stockpile Management, General Services Administration, is thanked for meeting with the committee to discuss stockpile management actions and problems. Special thanks go to the technical advisors of the committee who not only provided important dialogue during the committee's deliberations, but also undertook specific tasks concerning the assessments of certain materials of concern to the industries they represent. These advisors are Gerald Houck for the American Iron and Steel Institute, George Watson for the Ferroalloys Association, and John Wandrisco for the Specialty Steel Industry of the United States (assisted by David Nolan, Crucible Specialty Metals of Colt Industries, Inc.).

Industry experts, knowledgeable in processing and applications of specific materials, provided the committee additional background data. Acknowledgment is given for the assistance given by members of the Cabot Corporation technical staff: E. Mosheim, KBI Division; F. R. Mollard, Reading Research Laboratories; F. Richmond (deceased); D. Richards, Wrought Products Division. Assistance was received also from the Ray-O-Vac Corporation, M. A. Kepros and J. Simonides; from the Manville Corporation, D. Keliher; Raymark Corporation, J. Wronski (retired); Abrasive Grain Association, J. Phillips and J. Wherry; Wicker Engineered Materials Corporation, J. Clayton; Asbury Graphite Mills, Incorporated, S. Riddle; and Union Carbide Corporation, R. Bacon.

Finally, the chairman thanks the entire committee for its patience during the interval between Phases I and II and for picking up the task quickly and completing their assessment in a professional manner.

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CHAPTER 1

CONCLUSIONS AND RECOMMENDATIONS

Criteria were developed and used for setting priorities to identify those materials in the stockpile that need assessment most urgently. These also would be useful future guides in assessing materials and quality levels in the National Defense Stockpile. The criteria developed for use in this study are condensed as follows:

1. The likelihood of deterioration or contamination since acquisition.

2. The degree of technological change (for processing or end use) in specifications since acquisition.

3. The deficiency of analyses, quality data, end use tests or specifications.

4. The inability to use the material expeditiously from stock in an emergency.

Using these criteria, the materials were separated into four priority categories, in terms of the urgency of the need for further assessment. Of the 44 materials (or groups) examined, 18 need no further assessment and 12 are in the low-priority category requiring no immediate attention. Of the 14 remaining materials, 8 were placed in the high-priority category for further assessment and 6 in the medium-priority category.

In its assessment of currently held stockpile materials, the committee arrived at the following conclusions:

Conclusions

1. Chromium metal, chrysotile asbestos, the columbium group, ferrochromium, nickel metal, the tantalum group, titanium sponge, and vanadium pentoxide are in the high-priority assessment category. (Two of these materials, chrysotile asbestos and chromium metal, are already under study by the Interagency Commodity Committee). Aluminum oxide, abrasive quality; antimony; fluorspar, acid grade, iodine; silicon carbide, crude; and manganese dioxide, natural ore and synthetic material, are in the medium-priority assessment category.

2. Many of the data on materials now in the stockpile are inadequately recorded as a result of these materials having been acquired over a 30-year period. It is vital that records and samples on all acquisitions and materials re-examinated be retained in order to permit lots to be requalified as new specifications are developed and to optimize the usability of these materials for particular defense needs in the event of an emergency release. Further, it is essential that no future changes in personnel, record-keeping procedures, and offices and storage depot locations (114 locations) affect the integrity of data over long periods of time.

3. Tantalum and columbium merit special consideration due to the critical use of tantalum (powder) for electronic applications (capacitors) and of both metals in superalloys. Problems are created by rapid technological changes and the difficulty of storing in powder form. Joint assessment by experts on these materials is considered essential.

4. Developing up-to-date specifications and maintaining their currency are essential for evaluating on a continuing basis, how much of a commodity is expeditiously usable for all essential end uses; for acquiring new material when stocks are below goals; and for selecting less desired materials for disposal when stocks are in excess of goals.

5. Certain materials in the stockpile are in a state of technological obsolescence, which impairs their utility in the time of emergency with respect to their timely availability and breadth of application. Options available to stockpile management are restrictive and limit managements' ability to keep the stockpile dynamic as is required to stay abreast of technological and industrial practice advances (National Academy of Sciences 1982, and Government Accounting Office 1978).

6. Stockpile inventories need to be structured and allocated with respect to form and purity in order to recognize the diversity of critical end uses, the demand surges that would result from a national defense emergency, and the time required to upgrade lower forms to end use requirements.

Based on its study and conclusions, the committee makes the following recommendations:

1. Initiate action to provide for the immediate detailed examination of materials in the high-priority category and then for those in the medium-priority category.

2. Keep accurate and complete records on new acquisitions and those materials reassessed in the program initiated (Recommendation 1) and retain test samples for possible future re-evaluation.

3. Examine in detail all materials in the tantalum and columbium groups with the guidance of experts on these materials.

4. Develop and maintain up-to-date specifications on all stockpile materials so as to identify how much of a commodity is available for a specific end use or must be acquired or upgraded to meet goals and to identify which materials can be disposed of if in excess of goals.

5. To minimize obsolescence and keep the stockpile dynamic, expand the options available to stockpile management. Empower stockpile management to review all holdings biennially for technological currency, to rotate materials on an appropriate time scale (in general, in terms of years rather than decades), and to report annually all actions or nonactions and the reasons for them. Authorize stockpile management to engage in barter, exchange, and toll conversion of materials to current specifications and to different forms that may be required to meet a surge in industrial demand in the initial stage of a national emergency.

6. Structure the stockpile inventories so that forms and purity will be available for direct application to a diversity of critical end uses, cover the demand surge during a national emergency, and will minimize the time needed for upgrading the lower forms to meet end use requirements.

CHAPTER 2

INTRODUCTION

The forms and quality levels in which the critical and strategic materials are held in the National Defense Stockpile* affect their ready availability during a national emergency. The majority of materials in the stockpile were acquired over 20 years ago and questions have been raised, primarily by the industrial sector, concerning the quality and form of the presently held materials as they affect their immediate usefulness. Technological advances and industry practices have changed the quality requirements for many industrial materials. In addition, domestic processing capacity shifts may present difficulties both in the processing of these stored materials and in the ultimate ability of industry to use the materials to fabricate needed components.

This study was initiated to develop overall criteria for determining whether or not the quality of certain materials in the National Defense Stockpile needs to be investigated. These criteria relate to the adequacy of the records, the probability of contamination or deterioration, changed industrial and technical specifications, and the potential for expeditious use in an emergency. Sixty materials were examined including different forms of the same material. As a result of the committee's assessment, the materials were placed in four priority categories in terms of the need for future detailed examination. The criteria used by the committee and the resulting priority listing are presented in Chapter 3.

Materials selected for consideration by the committee were derived from FEMA's October 1983 Stockpile Report to the Congress (Federal Emergency Management Agency 1983). A great deal of analytical and storage data were furnished to the committee as the basis for its assessment. The materials considered in detail by the committee are as follows:

Aluminum metal group
- Aluminum
- Bauxite, metal grade
  - Jamaica type
  - Surinam type

* In this report, the National Defense Stockpile will be referred to variously as the "defense stockpile", the "national stockpile," or just the "stockpile."

Aluminum oxide, abrasive grain group
    Aluminum oxide, abrasive grain
    Aluminum oxide, fused, crude
    Bauxite, abrasive grade

Antimony

Asbestos crysotile

Bauxite, calcined refractory grade

Beryllium metal group
    Beryl ore (11% BeO)
    Beryllium-copper master alloy

Bismuth

Cadmium

Chromium, chemical and metallurgical group
    Chromite
        Chemical grade ore
        Metallurgical grade ore
        Refractory grade ore
    Chromium, ferro-
        High-carbon
        Low-carbon
        Silicon
    Chromium metal

Columbium group
    Columbium carbide powder
    Columbium concentrates
    Columbium, ferro-
    Columbium metal

Copper

Fluorspar group
    Acid grade
    Metallurgy grade

Graphite group, natural
    Ceylon, amorphous lump
    Malagasy, crystalline
    Other than Ceylon and Malagasy

Iodine

Lead

Manganese dioxide, battery grade
    Natural ore
    Synthetic material

Manganese, chemical and metallurgical group
- Manganese ore
  - Chemical grade
  - Metallurgical grade
- Manganese, ferro
  - High-carbon
  - Low-carbon
  - Medium-carbon
  - Silicon
- Manganese metal, electrolytic

Mercury

Nickel

Platinum group metals
- Iridium
- Palladium
- Platinum

Rutile

Silicon carbide, crude

Tantalum group
- Tantalum carbide powder
- Tantalum metal
- Tantalum minerals

Tin

Titanium sponge

Tungsten group
- Tungsten carbide powder
- Tungsten, ferro-
- Tungsten metal powder
- Tungsten ores and concentrates

Vanadium group
- Vanadium, ferro-
- Vanadium pentoxide

Zinc

Table 1 identifies materials that were excluded and the reason for their exclusion.

Government representatives supplied the committee with the available original acquisition data for each of the materials examined including: the latest specification applicable (listed in Appendix A), the form stockpiled, chemical and physical analyses, and the packing and storage information of the stockpile lots. In addition, the committee members

TABLE 1 National Defense Stockpile Materials Excluded From Committee Examination

Material	Reason for Exclusion
Alumina	No inventory to assess
Asbestos, amosite	Ongoing study by separate government study group (IACC)*
Beryllium metal	Inventory too small to warrant examination
Cobalt	ASM panel study report issued (ASM 1983).
Diamond, industrial group	Requires special visual examination by diamond experts
Diamond dies, small	
Diamond, industrial	
Crushing bort	
Stones	
Jewel bearings	Requires special visual examination by experts
Mica group	Requires special visual examination by mica experts
Muscovite block	
Stained and better	
Film, 1st and 2nd qualities	
Splittings	
Phlogopite	
Block	
Splittings	
Quartz crystals	Subject of separate studies by IACC study and a NMAB committee
Rubber	Requires special visual appraisal by experts
Sapphire and Ruby	Requires special visual examination by gem experts
Silver, fine	Subject of a special study by Cabinet Council on Natural Resources and the Environment
Talc, steatite block and lump	Requires special visual examination by experts.
Thorium nitrate	Subject of a separate IACC study.

* Interagency Commodity Committee.

individually contacted various associates and experts for up-to-date input data. The committee did not independently verify the data furnished by the government representatives. Time and funding limitations did not permit storage site visits; such direct observations were not deemed essential by the committee for its assessment of the available data.

The committee ranked the materials into four priority groups that relate to the relative urgency for an in-depth examination. Within groups the materials are listed alphabetically. It will be noted that some of the listed materials not found explicitly in the 1983 FEMA report are stockpile items held as offsets (or credits) to a stockpile goal and are evaluated accordingly. The procedures and limitations for acquisition, disposal, and release of materials are set by law (P.L. 96-41) and deviations must be approved by Congressional or the executive branch. The following short discussion covers some of the major aspects of government stockpiling.

The Strategic War Materials Act of 1939 (P.L. 76-117) provided for the identification of materials that are critical and strategic to the nation's wartime economy. The Strategic and Critical Materials Stockpiling Act of 1946 (P.L. 520) and subsequent legislation provided for the stockpiling of these materials. Considerable time has passed since many of the stored materials were acquired; therefore, the concerned sponsoring agencies requested an in-depth examination of some of the stored materials to determine their technical currency. The Strategic and Critical Materials Stockpiling Act of 1979 (P.L. 96-41) authorizes the President to release materials from the stockpile at any time he "determines the release of such materials is required for purposes of national defense." Although the act does not limit the President's disposal authority simply to military requirements, it does not permit release of strategic stockpiles for economic reasons.

The committee is aware that the National Defense Stockpile goals encompass a three-tier, three-year conventional war matrix (Figure 1) and that the material in the stockpile has application in a wide variety of important applications within this matrix. In this procedure, the defense requirements for the first year of the emergency are placed in the upper left-hand corner. Essential civilian needs for the same period are placed just below and basic industrial needs below that. Corresponding requirements for the second and third years of the national emergency for each category are set in columns to the right. Thus, priorities increase from botton to top and from right to left.

For arriving at goals for materials to be stockpiled, the "variable-confidence level" approach is used which involves such factors as:

1. Materials required during a war period are specifically identified in three groups (defense, essential civilian, and basic industrial).

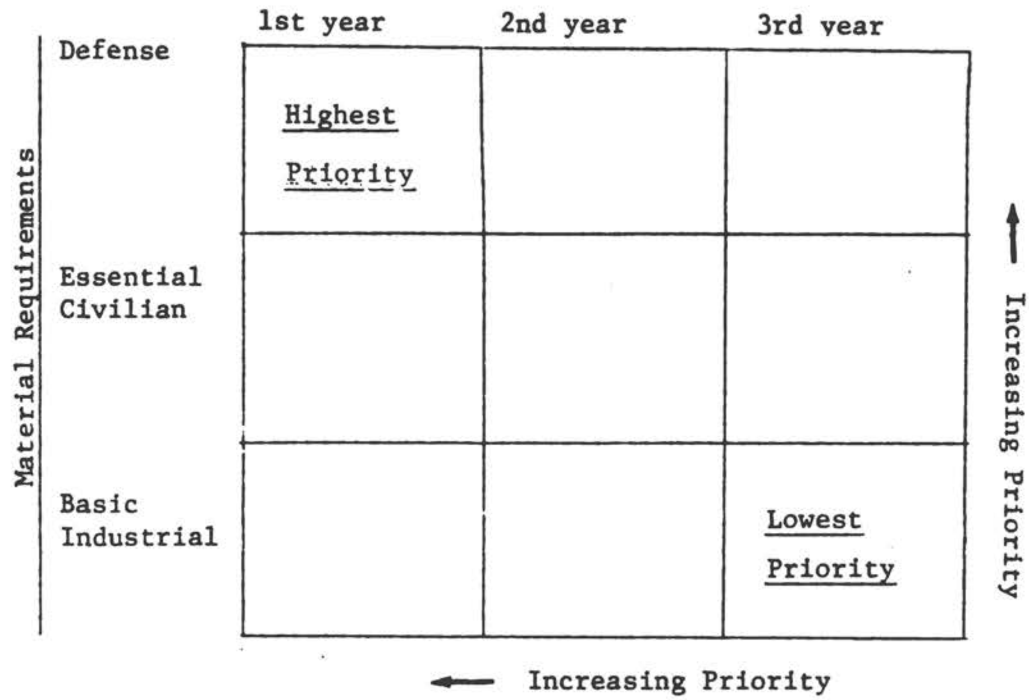

FIGURE 1 FEMA matrix chart.

2. The planning factors used to estimate the supply sources and amounts available can be varied for the three requirements groups.

3. Conservative estimation factors can be used for the defense portion of the total requirement with more moderate factors for the other requirements.

4. Separate estimates for each year of an assumed war and a relative priority based on the three groups also can be used.

Barter, exchange, trading, and tolling are cost-effective ways that should be considered for upgrading stockpiled materials (Government Accounting Office 1983). Of these, trading higher-grade materials that belong to industrial companies for lesser-quality materials from the stockpile is perhaps the least expensive way to upgrade enough stockpiled material to meet the three-year essential needs. In particular, meeting "essential" needs refers to that portion required to meet the most critical needs such as the defense section of the matrix. Legal issues limit the options for immediate action.

Industrial stockpiling has been suggested as an alternative stockpiling action (Manly 1981) and some countries have adopted this as a strategy (Government Accounting Office 1982a). A discussion of alternatives to the national stockpile is beyond the scope of this study.

CHAPTER 3

PRIORITY LISTINGS

The committee's assessment, based on the available data and background information assembled by its members and their associates, resulted in the materials being grouped into four priority categories--high, medium, low, and acceptable--in terms of their potential for meeting urgency of the industrial requirements for immediate use, and therefore, the need for further detailed assessment. The high-priority materials are identified as those needing immediate assessment of quality in terms of current needs. It is interesting to note that of the 44 materials (or groups) considered, only 8 are ranked as high-priority items requiring immediate assessment. There are some serious questions concerning the immediate usefulness in today's industrial production cycle of six more materials, they are identified as medium-priority items (Table 3). The largest number of materials are in the low-priority and "acceptable" categories; none of these materials needs immediate attention. Summary listings of the four category groups are provided in Tables 2-5. Pertinent data on the current status of the stockpile materials being assessed by the committee are presented in Chapter 4.

The committee's evaluations were based on specific information available on each material. The committee's value judgments on the need for further assessment were made using the following criteria:

1. Likelihood of deterioration or contamination since acquisition.

2. Degree of technological change (for processing or end use) in specifications since acquisition.

3. Deficiency of analyses, quality data, end use tests, or specifications. (The latest specification numbers are listed in Appendix A.)

4. Inability to use expeditiously from stock in an emergency.

The criterion numbers used here correspond to those used in Tables 2-5 to indicate which apply to the specific material. The reader will note that criterion #3 (deficiency of analyses, quality data, end use tests and specifications) is the main item identified as leading to the need for further quality assessment in 23 of the 26 materials in the priority listings in Tables 2, 3, and 4.

TABLE 2 High Priority List

Material	Criteria	Comment
Asbestos, crysotile	2,3	Being evaluated by GSA on its assessment programs, analyses were made by an outside contractor who provided data not available in the old records. GSA's assessment report is in preparation.
Chromium metal	2,3	Material is critical to superalloy production (particularly degassed material). The ASM (1981) study on quality is in progress.
Ferrochromium, low-carbon	2,3	The extra-low-carbon content and low nitrogen is required for superalloy production.
Columbium group	2,3,4	The columbium group is comprised of ferrocolumbium, columbium carbide powder, columbium concentrates, and columbium metal. A study needs to be conducted to evaluate the quality and form of each of the components of this group as well as the requirements for various uses. The basic form of this group is columbium pentoxide and concentrates; the other materials are upgraded forms. Even though the goals for some of the individual components are zero, these components have been assessed in their present form. Trace element content is needed to determine its application in aircraft turbine engine component fabrication. Most appear usable for many other applications. Reprocessing or melting could help improve its usefulness for some applications. Ferrocolumbium and columbium metal are no longer goal items but are held as offsets against the columbium concentrates goal. The concentrates now constitute the major portion of the goal, with the carbide powder being a rather small portion of the columbium group goal. The former is the lowest form of the material and offers the necessary versatility for converting to any form needed for industrial use, including purification to meet specification changes.

Material	Criteria	Comment
Nickel metal	1,2,3	Specification for high purity nickel for superalloy production is not met; analyses now available are incomplete. Trace element analysis is needed because of possible contamination.
Tantalum group	1,2,3,4	The tantalum group is comprised of tantalum carbide powder, tantalum metal powder, and tantalum minerals and concentrates. A study needs to be conducted to evaluate the quality and form of each component of this group as well as the requirements for various uses. The basic form of this group is tantalum pentoxide and concentrates; the other materials are upgraded forms. Even though the goals for some of the individual components are zero, these components have been assessed in their present form. The inventoried tantalum powder is adequate for normal capacitor production. High-capacitance capacitor production today specifies high CV/g powders that are not met by the stockpile materials according to data available. Knowledge of the trace element content is necessary for determining its use in high-temperature rotating parts manufacture. There is a need for a comprehensive evaluation of the specifications and forms for the entire tantalum group even though there are no stockpile goals for tantalum metal and tantalum carbide powder. Tantalum minerals, which now are the only goal item, are the lowest stockpile form and offer the necessary versatility for converting to any form needed for industrial use, including purification to meet specification changes.
Titanium sponge	2,3,4	Insufficient chemical analysis data for current specifications limit its usefulness. Physical deficiencies such as nitrides, discolorations, and salt inclusions also need attention.
Vanadium pentoxide	2,3	Catalyst and master alloy production require a higher grade (99.5 percent) of material than the older stockpile materials. New specifications are needed.

TABLE 3 Medium Priority List

Material	Criteria	Comment
Aluminum oxide, abrasive grain	3	Detailed materials data, particularly physical property data for abrasive grain, are lacking. The zero goal is being changed to include this material.
Antimony	3	Chemistry, form, and storage condition data are needed.
Fluorspar, acid grade	3	Analytical data for meeting current specifications are not available.
Iodine	1	Packaging problem may have contaminated the contents of some lots. Analysis needed to ensure the integrity of the contents.
Manganese dioxide, battery grade (natural ore and synthetically prepared)	1,3	Usefulness of the natural ore material appears very dependent on the source of supply. Chemistry alone is not sufficient to judge quality for battery manufacture. Storage time may be a factor even if well packaged in the case of the synthetic material. Test data are needed from simulated (or true) battery-use tests.
Silicon carbide, crude	1,2,3	Data are inadequate for a quality determination; analyses for tar and water content are important in today's specifications. New specifications are being developed by Abrasive Grain Association (AGA). Inventory appears usable for most nonabrasive uses without major reprocessing.

TABLE 4 Low Priority List

Material	Criteria	Comment
Aluminum oxide, fused crude	3	The stockpile goal of zero for this fused crude material is to be changed to accommodate this inventory. The material appears acceptable but additional background data would enhance its usefulness.
Bauxite, metall. grade (Jamaica type)	3	Inventory appears satisfactory for use but must be designated for plants capable of handling it.
Bauxite, metall. grade (Surinam type)	3	Inventory appears satisfactory but some lots need evaluation.
Bauxite, refractory grade	3	Some data on the old inventory are lacking, but the stockpile could be used if the need was pressing enough.
Beryl	3	Analytical data needed to properly characterize this material are lacking. It is the basic form so it can be processed to upgraded forms as needed.
Bismuth	3	Analytical data are lacking and may be needed before this material can be used by industry.
Cadmium	3	Analytical data are lacking. Substitutes today may fill most needs for this material.
Fluorspar, metallurgical grade	3	Analytical data are incomplete.
Lead	3	Missing analytical data might cause delays in use of this material in some applications.
Nickel oxide	1	Nickel oxide is not a stockpile goal item but counts against the nickel goal. For noncritical uses, visual inspection is recommended for possible storage contamination.
Platinum group	2,3	All three stockpiled materials (Pt, Pd, Ir) can be used for most general applications. Higher purity may be needed for some special minor uses.

TABLE 4 Low Priority List (continued)

Material	Criteria	Comment
Tungsten	4	Lack of detailed data on all forms of tungsten in the stockpile does not detract from its usefulness in some essential industrial applications. Characterization and upgrading may be advised for materials in some critical uses.

TABLE 5 Materials Needing No Additional Assessment

Material	
Aluminum metal (very small inventory)	
Bauxite, abrasive grain	
Beryllium-copper masteralloy	
Chromite ores	
Copper metal	
Ferrochromium, high-carbon	
Ferrochromium-silicon	
Ferromanganese, high-carbon	
Ferromanganese-silicon	
Ferrovanadium (no inventory; needs an industry standard)	
Graphite group	
Manganese metal, electrolytic	
Manganese ore, chemical grade	Manganese ore, metallurgical grade
Mercury	
Rutile	
Tin metal	
Zinc metal	

CHAPTER 4

SUMMARY OF DATA USED

This chapter presents some of the pertinent data used by the committee in its assessment of the quality of the materials examined. Information presented is excerpted from stockpile documents made available to the committee. These background data helped provide the rationale for the committee's assessment of the need for further actions on handling these stockpile materials, some of which are 30 years old. The materials are considered in alphabetical order and a basic material/material group provided to facilitate reference by the reader. To the extent possible, factors such as method of storage, possible deterioration, comparison of old and new purchase specifications, and changed technological requirements are addressed. The goals and the inventory quantities are those listed in the 1983 FEMA Stockpile Report to the Congress. Materials carried as "offsets" (FEMA 1983) are stockpile materials from previous acquisitions (some from surplus defense purchases during earlier conflicts, e.g., WWII, Korea, Vietnam). They are inventoried in a generalized category (usually a form having a zero or reduced goal) as being usable in an emergency and are not available for disposal but are credited to a goal item.

The quantity abreviations used in these tabulations are in accordance with those used by FEMA in its listings: ST for short ton (2000 pounds), MT for metric ton (2205 pounds), LDT for long dry ton (2240 pounds), SDT for short dry ton (2000 pounds), LCT for long calcined ton (2240 pounds), LB for pound, FL for flask (76 pounds), and TrOz for troy ounce (1.097/avdp. oz.).

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ALUMINUM METAL

Goal--700,000 ST
Inventory--2,080 ST

The quantity of aluminum metal held in the stockpile is too small to warrant an assessment by the committee. Acquisitions to meet the new goal will be in accordance with the most recent specifications for the metal.

ALUMINUM OXIDE, ABRASIVE GRAIN

Goal--0
Inventory--50,904 ST

Abrasive grain aluminum oxide is packaged in sealed polyethylene bags placed in steel drums having airtight seals. The drums are stored outside, which is adequate as long as the soundness of the drums is checked periodically. Repackaging must be initiated when necessary. "Protected" drum storage would extend the life of the drums during long periods of storage. Inadequate or improper packaging or storage over the years can affect the usefulness of this material.

This material was held against the stockpile goal for "abrasive grade bauxite," but identification of a goal for abrasive-grain aluminum oxide as a separate item in the stockpile inventory is being considered. Data on file on this material are inadequate. Listed analyses lack vital characteristics such as fracture, degree of fusion, crystal size, and general customer (user) acceptance. A thorough search of the files may provide some of the missing data, if not sampling and analysis may be necessary.

ALUMINUM OXIDE, FUSED CRUDE

Goal--0
Inventory--249,867 ST

Fused crude aluminum oxide is stored bulk in the open, which appears adequate for this relatively inert material. Minor problems result from losses due to wind and water erosion, from airborne and waterborne impurities, and from the mixing of the bottom material with the base support materials. Only minor deterioration in quality can be expected, primarily due to contamination, over a period of years.

The goal for this material is zero, making this inventory surplus or an offset for abrasive-grade bauxite. Consideration is being given to changing the goal for this material to cover this inventory plus an additional amount necessary to fill an emergency surge in demand.

The specifications for this material are similar to those for abrasive grain aluminum oxide. Acquisition data are incomplete; therefore, information on the physical characteristics of this inventory (e.g., fracture, degree of fusion, crystal size, and user acceptance) would be needed before the inventory material could find general use in industry. No serious threat of technical obsolescence for this material was identified.

ANTIMONY

Goal--36,000 ST
Inventory--40,402 ST

Antimony is primarily in cake and ingot forms variously packed (box, loose, drums, and tanks) and stored both in warehouses and in the open. Ingot and box packaging is specified, therefore, much of the older material is not packaged correctly. Open storage is very questionable because the material should be kept dry. Drum rusting can seriously contaminate the contents. Details on storage conditions for all materials could not be found in the records.

The forms of stockpiled antimony are inadequately described in the records. Analyses of the materials and the dates of acqusition were not available so an assessment to determine which lots meet current specifications was not possible. Grades A, B, C, and D are held, but only grades A and B are in the specifications. It is therefore assumed that much of the material does not satisfy the specifications. The major use for antimony is for alloying with battery lead.

ASBESTOS, CHRYSOTILE

Goal--3,000 ST
Inventory--9,957 ST

Deterioration of bagging materials (jute) had been noted but overbagging by Government Services Administration (GSA) maintenance personnel has corrected this problem. Moisture is a continuing problem; before the material can be used it must be thoroughly dried to rejuvenate it to a dry and open state. The magnetic iron rating (MIR) of the material is important in electronic and electrical applications, particularly in sophisticated military hardware.

Storage data (dates, etc.) were not available in documents provided; the GSA states that closed warehouses are used, but no extensive temperature and moisture controls are employed. Analytical tests were completed in 1983 by the Ontario Research Foundation as part of an assessment program by GSA and the results are being analyzed.

BAUXITE, ABRASIVE GRADE

Goal--1,000,000 LCT
Inventory--0

Abrasive grade bauxite is a new material for which a rather high inventory goal has been set. Some concern has been expressed by the committee about the bulk, open storage of acquisitions of this material. The material's highly hygroscopic nature causes it to pick up water, which can result in serious handling and processing problems. Industry uses a very short-term inventory turnaround period. The calcined refractory grade bauxite (a recent purchase) should have better storage properties; the fused crude aluminum oxide is even easier to store and process to abrasive grain.

The purchase specification (P-90a, June 22, 1981) appears to meet current industry standards. Abrasive grade bauxite is described therein as a calcined material suitable for use in the production of aluminum oxide abrasives. Calcining materially enhances its storage and handling properties. No technological changes are anticipated which will affect the usefulness of the properly prepared material.

BAUXITE, METAL GRADE, JAMAICA TYPE

Goal--21,000,000 LDT
Inventory--10,458,000 LDT

Metal grade bauxite, Jamaica type, is stored bulk in open piles on the ground. This mode of storage will have no effect on its usefulness to the aluminum industry. The Jamaica type metal grade bauxite can be efficiently used only in alumina refining plants that are equipped for high-temperature digestion and high mud loads.

Some important analytical data are missing that detract somewhat from its ready availability for industrial use. In particular, the monohydrate content, iron oxide, and titanium dioxide are not recorded for some large lots. These data are necessary to properly characterize the material for processing it most efficiently.

BAUXITE, METAL GRADE, SURINAM TYPE

Goal--6,100,000 LDT
Inventory--5,299,597 LDT

Metal grade bauxite, Surinam type, is bulk stored in open piles, and only minor losses occur, primarily at the bottom of the pile.

Acquisition specifications, which are now being revised, should conform with current industrial purchasing standards. Original analytical data on the stockpile material are not complete. Some important data necessary for effective processing (e.g., iron oxide and titanium dioxide) are needed to accurately characterize the material. All aluminum refineries are capable of using this type of bauxite.

BAUXITE, REFRACTORY GRADE

Goal--1,400,000 LCT
Inventory--199,926 LCT

Calcined refractory grade bauxite is bulk stored in open piles. Only minor losses can be expected over the years from wind and water erosion and from mixing of the bottom of the pile with the support base.

Older material, not specifically identified in the 1983 FEMA listing cannot be adequately characterized because of incomplete and missing purchase data, (e.g., chemical constituents and screen analysis). Recent acquisitions conform with current specifications. Types I and II are identified in the recently revised specifications (P-5C-R5, June 22, 1982). No technological changes that would affect its usefulness could be identified.

BERYL ORE

Goal--18,000 ST (11% BeO)
Inventory--17,987 ST (11% BeO)

No analytical data are available on the beryl stockpile inventory; therefore, no determination can be made concerning the 11 percent minimum beryllium oxide (BeO) content and the maximum calcium content. This is the lowest stockpile form, which has no apparent storage problems.

A thorough search should be made in the files for possible analytical data obtained at the time of purchase or during a subsequent evaluation. Lacking the above data, a sampling and analyses plan should be developed to adequately characterize the stockpiled material for future use; this action has low priority.

BERYLLIUM-COPPER MASTER ALLOY

Goal-7,900 ST
Inventory--7,387 ST

Available data on the analyses of the stockpiled Be-Cu master alloy indicates it could be slightly out of specification limits for beryllium content (high or low) and for iron (on the high side). Despite this shortcoming, the stockpiled master alloy could be used, with no identified risk, for the most critical applications especially in the press of time during an emergency when time is short.

BISMUTH

Goal--2,200,000 LB
Inventory--2,081,298 LB

Detailed specifications for the bismuth in the stockpile and data on the form stored are lacking. Bar form, packed in boxes and stored in protected areas is specified. Specifications call for 99.99 percent purity as required for pharmaceutical uses. Acquisition dates, which are not available, could help establish the purity level at time of purchase. Existing specifications appear adequate (P-7-R4, June 10, 1980) but there must be some differentiation regarding end use requirements--alloy production and pharmaceutical preparations.

Analytical data must be obtained on the stockpile bismuth. Documentation also is needed on the form stored and the storage conditions to ensure that the material is in a condition acceptable for its intended use.

CADMIUM

Goal--11,700,000 LB
Inventory--6,328,809 LB

Detailed analytical data and acquisition dates are lacking for the cadmium in the stockpile. The inventory is in the form of bars (sticks) and balls, packed in wooden boxes and stored in warehouses. Available data were inadequate to verify the form, packaging, or the storage for all stockpiled materials. A question was raised concerning whether the goal, about 54 percent of which is fulfilled, is proper because of the substitutes available today. The specification (P-8-R2) is old (March 7, 1979) and may not conform with current industrial standards.

No immediate action is needed on the cadmium in the stockpile. The available chemistry data (although meager) on the material held indicates that the material should be adequate for most major applications.

CHROMITE ORES

Chemical Grade

Goal--675,000 SDT
Inventory--242,414 SDT

Metallurgical Grade

Goal--3,200,000 SDT
Inventory--2,488,043 SDT

Refractory Grade

Goal--850,000
Inventory--391,414 SDT

Chromite ore, both the chemical and metallurgical grades, is stored as open piles without pads. It is relatively inert so it needs no special attention.

All chromite ore materials held in the stockpile appear satisfactory for their intended use. Chemical grade chromite ore is used for producing various chromium-base chemicals for plating baths, paint pigments, leather tanning, drilling muds, and chromium metal. Production of a lower grade, high-carbon ferrochrome, containing 50 to 60 percent chromium, from this ore is also possible.

Metallurgical grade chromite ore is used for the production of low- and high-carbon ferrochromiums and ferrochromium-silicon. Changing requirements for these chromium ferroalloys has not altered the usefulness of the existing inventory.

Refractory grade chromite ore is used primarily to produce refractories for the steel and glass industries and in certain high-temperature furnaces. No changes have been made in the requirements for this application and none are anticipated.

CHROMIUM METAL

Goal--20,000 ST
Inventory--3,763 ST

Chromium metal is in lump form packed in steel drums some of which are are stored in the open, some in closed storage, an industrially acceptable method of packaging and storing. No major effect on the quality of the material is expected from this storage mode even over long periods of exposure. The usual care of maintaining the integrity of the drums is necessary to ensure the least amount of contamination from this source.

Purchase specifications for most of the stored material are known and the material met the existing specifications at the time of purchase. Available data show that the elements nitrogen and carbon were not considered as being critical to the end user at the time of purchase. The primary use of chromium metal is in the production of cobalt- and nickel-base superalloys where the permitted iron content is low and the use of ferrochromium alloys is not possible. Other identified low-iron-content alloys using chromium metal are electrical resistance alloys (nichrome) and certain high-performance aluminum alloys. Some high-performance superalloys require the use of a low-oxygen, low-nitrogen grade of chromium metal that is produced by degassing either the electrolytic or aluminothermic types of metal.

The current stockpile inventory contains no degassed material so the quality limits its general use. However, the current inventory is less than 20 percent of the goal of 20,000 short tons, and purchases of degassed chromium metal would eliminate the need for upgrading. An alternative is to upgrade this small inventory to meet the most critical applications, pending the purchase of new material.

A study should be initiated to accurately determine what lots, if any, meet the low-oxygen, low-nitrogen requirement for use in high-performance superalloys. Upgrading should be done only on lots to be designated for this strategic application.

COLUMBIUM CARBIDE POWDER

Goal--100,000 LB
Inventory--21,372 LB

None of the lots of columbium carbide powder held in the stockpile has analytical data on all the elements contained in the current specifications. Although the data are incomplete, it is highly probable that the carbide could be used in conjunction with tungsten carbide tool steel applications.

No action is necessary for the amount of columbium carbide powder held in the stockpile, now at about 20 percent of the goal. Future stockpile acquisitions are expected to conform with the latest specifications; therefore, in total, all anticipated needs could be met.

COLUMBIUM CONCENTRATES AND PENTOXIDE

Goal--5,600,000 LB
Inventory--1,806,218 LB

The stockpile material is the lowest form of the material so it can be readily processed to all forms needed by the industry. Special processing is required to obtain highest purity levels and reduce the trace or residual elements to levels indicated in the latest specifications. Although analtyical data on the impurity content are lacking, the material could be used directly in a number of applications depending on the impurity levels permitted. Future acquisitions to fill the remaining two-thirds of the goal would meet current specifications regarding permissable impurity levels, in particular, reduced U_3O_8 and ThO_2 content to comply with U.S. Department of Transportation shipping regulations. The tantalum pentoxide contained in this material is credited toward the tantalum groups inventory goals.

COLUMBIUM METAL

Goal--0
Inventory--44,851 LB

The available analytical data, while incomplete, indicate that the stockpile material does not meet current specifications for vacuum-melt applications (e.g., rotating parts for turbine engines). As in the case of the ferroalloy, impurity levels and residual elements need to be accounted for before proper evaluation can be made of its applicability in critical end use products. For high-strength, low alloy (HSLA) steels, stabilized stainless steels, and most wrought columbium-base products, the entire inventory appears applicable. In any event, reprocessing by electron beam (EB) melting could upgrade this inventory, possibly even to aircraft quality standards.

COPPER

Goal--1,000,000 ST
Inventory--29,048 ST

Stockpiled copper metal is primarily in the form of wirebars and billets stored in the open. Deterioration or other stockpiling storage conditions do not seriously limit its ultimate use, although some loss in yield can be anticipated. Most of the current inventory meets current industry specifications. The amount that is suspect can be handled adequately in subsequent processing operations, possibly for use in brass production or as anode furnace feed.

Future acquisitions for the stockpile should be in the form of the more versatile electrolytic cathode as recommended by the NMAB Panel on Upgraded Forms of Materials and Recycled Materials for the National Stockpile (National Academy of Sciences 1982). To the extent possible, storage conditions should minimize the entrapment of water that appears to cause the observed deterioration (e.g., use of protective covering or warehousing). Good manufacturing practice also can reduce adverse surface effects. There is no urgency to initiate action on assessing the quality of the existing inventory.

FERROCHROMIUM, HIGH CARBON

Goal--185,000 ST
Inventory--402,696 ST

High-carbon ferrochromium is in lump form and stored in large piles outdoors on pads. This form of ferrochromium is inert, compared with lower-carbon ferroalloys, and should not deteriorate seriously during long-term exposure to the elements.

High-carbon ferrochromium is used primarily in the production of stainless steels using the argon-oxygen decarburization (AOD) process; this process allows the use of any grade of ferrochromium. A secondary use is for ladle or furnace additions of the ferroalloy to molten steel to produce a wide variety of alloy, tool, bearing, and certain heat-resistant steels that have less than 5 percent chromium. In view of these uses, the entire stockpile of this material is acceptable for current industrial practice.

FERROCHROMIUM, LOW-CARBON

Goal--75,000 ST
Inventory--318,892 ST

Low-carbon ferrochromium is in lump form, packed in drums and stored outdoors. This is acceptable for storing this material even for long periods. No major deterioration or contamination of the material was identified as being caused by this method of storage as long as the drums remain watertight. The AOD process for stainless steel production has caused a marked decrease in demand for low-carbon ferrochromium. There is still substantial use of this ferroalloy in the production of nickel-iron base superalloys and stainless steel by processes not using the AOD process and of certain low-carbon, low-chromium alloy steels.

Data on the inventory show that about 88 percent of the inventory contains over 0.05 percent carbon and is not acceptable in most current uses. The superalloy requirement is for extra low carbon (below 0.02 percent carbon) and low nitrogen for use in the production of nickel-iron base superalloys, which can be a substitute for certain cobalt-base superalloys. Superalloy uses require close control of these elements.

An action that could be taken to meet this critical need (nickel-iron base superalloys) is to initiate an analysis program to check both the carbon and nitrogen content. Lots containing carbon below 0.02 percent and nitrogen below 0.02 percent should be segregated and retained for this special purpose (e.g., gas turbine engine components). If none is found, reprocessing should be considered.

For uses other than for aircraft gas turbine engines, the low-carbon ferrochromium inventory requires some study and possible subsequent improvement. It is possible that, in an emergency, the industrial processor would conduct the needed analysis to see if his processing can be adjusted to accommodate any identified variation. This requirement will detract from the immediate applicability of the material and possibly cause a bottleneck in processing.

Analytical characterization is needed for making immediate use of this material for general low-carbon ferrochromium use. Lots found to be out of specification should be reprocessed or downgraded for other less critical applications. The out-of-specification lots can be placed on the disposal list as an alternative action (the goal is less than 25 percent of the current inventory) or downgraded for use as high-carbon ferrochromium, which has less stringent requirements. In an emergency, argon may not be available in sufficient quantities for all AOD processing, so the old processing using the proper low-carbon ferrochrome would be employed.

As in the case of the superalloy use of low-carbon ferrochromium, the only future technological change identified that may affect the ultimate use of this inventory is the possible expanded use of the AOD process. This development would materially decrease the use of this ferroalloy and, thus, render surplus a similar amount of the material in an adjusted stockpile goal.

FERROCHROMIUM SILICON

Goal--90,000 ST
Inventory--58,357 ST

Ferrochromium-silicon is in lump form and stored in piles outdoors on pads. No serious deterioration is expected from this method of storage.

Ferrochromium-silicon is used primarily as a ladle or furnace additive to produce various alloy steels. The high silicon and low carbon content of the material makes it desirable but not critically necessary for present uses. It is a useful but not a necessary additive in stainless steel production by other than the AOD process. Low-carbon ferrochromium is an adequate substitute.

No further evaluation of this inventory is required because it can be effectively used where needed. The recent increase in the goal for this material should permit an upgrading of a part of the inventory to meet more stringent needs for critical applications.

FERROCOLUMBIUM

Goal--0
Inventory--930,911 LB

Ferrocolumbium is purchased as lumps packed in drums and stored in warehouses. The material will remain usable even after years of storage as long as the drums remain watertight. None of the ferrocolumbium held in the stockpile will meet the current specifications for vacuum-grade material. Analytical data are needed because trace elements can be very detrimental in using this ferroalloy in the manufacture of aircraft turbine engine components. It is possible that the material could be used in superalloys produced by the air-melt process; however, the impurity content type and amount would govern its applicability. The entire inventory could be retained and designated for these lower specifications uses (other than aircraft turbine engine components). It appears usable for producing stabilized stainless steels and HSLA steels.

Current standard grade specifications require the control of residual elements; however, in an emergency situation, the material could be used in all but the most critical applications. Future acquisitions of columbium concentrates to meet the expanded goal would provide a more versatile material that could be processed to all forms required by industry.

FERROMANGANESE, HIGH-CARBON

Goal--439,000 ST
Inventory--599,978 ST

High-carbon ferromanganese is in lump form and is stored in piles outdoors on pads. This method of storing is acceptable providing the chemistry of the stored material meets the criteria to prevent disintegration.

This material is used almost entirely as an additive in iron and steel production where it is an essential ingredient to neutralize the harmful effects of sulphur in steel. The carbon content in the inventoried material appears slightly different from that considered standard today but does not seriously detract from its usefulness.

FERROMANGANESE, MEDIUM-CARBON

Goal--0
Inventory--28,920 ST

Medium-carbon ferromanganese is packed in drums and stored outdoors. The integrity of the steel drums should be maintained to keep the material from oxidation and contamination over long storage periods.

Production of low-carbon steel may require the use of medium-carbon ferromanganese. Higher efficiency and production rates of low-carbon steels can result from the replacement of high-carbon ferromanganese by the medium-carbon grade; however, its use is not really essential in contemporary industrial practice. No action is needed on this inventory, which presently is being carried as an offset for metallurgical grade ore.

FERROMANGANESE-SILICON

Goal--0
Inventory--23,574 ST

Ferromanganese-silicon is packed in drums and stored outdoors. As long as the drums remain watertight, no major deterioration or contamination of the original material will occur.

This material is used almost entirely for steel production. In particular, it is a replacement for ferrosilicon and ferromanganese in the production of low-carbon, killed steels. The inventory appears adequate for these applications. It is presently held as an offset for part of the metallurgical ore goal.

FERROVANADIUM

Goal--1,000 ST
Inventory--0

There is no inventory of ferrovanadium in the stockpile. The committee agrees with the inclusion of ferrovanadium in the stockpile but believes that consideration also should be given to stockpiling the master alloys 65V-35Al and 85V-15Al which are industrially important today (National Academy of Sciences 1978), for meeting surge conditions. These master alloys will continue to have widespread use and there are no identified substitutes.

FLUORSPAR, ACID GRADE

Goal--1,400,000 SDT
Inventory--895,983 SDT

Acid grade fluorspar is bulk stored in covered piles, an acceptable method of storage. Other than the mixing at the bottom of the pile with the base material, the piles are reasonably stable for years of storage.

Most analytical data are available in the records, but some individual lots (about one-third of the samples listed) have specific important data omitted or are out of specifications (e.g., in terms of chloride content and screen analysis). Some of these data may be in the files, and so a thorough search should prove worthwhile. No technological changes are anticipated that would affect the usefulness of this material.

FLUORSPAR, METALLURGICAL GRADE

Goal--1,700,000 SDT
Inventory--411,738 SDT

Metallurgical grade fluorspar is bulk stored in open piles. This method of storage is normal for this material, despite minor losses that occur from wind and water erosion and mixing at the bottom of the pile with the base material. No deterioration over years of storage is expected except for minor acceptable airborne and waterborne impurity pickup.

Analytical data for many lots are incomplete with no values for trace elements and spotty screen size analyses. These data are required by current industrial and stockpile purchase specifications and are needed by the user to determine how to use the material effectively. Identified deficiencies are small and reduce the urgency for immediate action. Also, the amount in the inventory is less than 25 percent of the stockpile goal, which offers the opportunity for new acquisitions to counterbalance the need for analysis of the older material. Blending would be a way to use these lots "as is."

GRAPHITE GROUP

Ceylon, Amorphous Lump

Goal--6,300 ST
Inventory--5,499 ST

Malagasy, Crystalline

Goal--20,000 ST
Inventory--17,899 ST

Other Than the Above

Goal--2,800 ST
Inventory--2,804 ST

Deterioration does not appear to be a problem with natural graphite storage; nevertheless, it is stored in warehouses. Data available indicate that most of the inventory meets established specifications.

One use for natural graphite, by the steel industry to raise the carbon content of steels, appears to have acceptable substitutes (e.g., anthracite coal and calcined petroleum coke). The refractories industry continues to use natural graphite in magnesite brick and for crucibles; the latter use is growing. Flake grade graphite, primarily from Madagascar, but also some from Austria, Brazil, Canada, and Mexico, continues to be used in lubricants, however, new materials for bearings could reduce the need for graphite lubricants. A similar situation exists with respect to the foundry industry's use of natural graphite for mold washing in iron casting. Possible substitutions exist but the low cost of natural graphite minimizes the potential for serious changes.

IODINE

Goal--5,800,000 LB
Inventory--7,525,930 LB

Analytical data are not available on the stockpiled crude iodine so it cannot be evaluated to current specifications; acquisition dates also are lacking. Storage is as granules or crystals in glass jars with plastic caps. Iodine is very corrosive, and some corrosion has been observed on the jar caps and replacement has been or is being made. The excess inventory can be used to dispose of the lower quality material. Its major uses in pharmaceuticals and catalysts have no substitutes.

Possible contamination of the stockpile iodine should be examined further, especially where jar cap corrosion has been observed. Contamination makes the material unsuitable for use in some applications. Analytical data are a necessary requirement to determine if the material can be used effectively without additional reprocessing.

LEAD

Goal--1,100,000 ST
Inventory--601,032 ST

All lead in the stockpile is in pig form as required in the specifications and is stored in the open, a satisfactory condition. The specifications identify four grades (corroding lead, chemical lead, acid-copper lead, and common desilverized lead) and are so identified for each lot. No verifying analytical data on these lots or the acquisition dates are available.

Numerous substitutes for lead are used today that reduce its total use spectrum. It is advisable that the use patterns for lead be followed closely to keep the stockpile requirements and the specifications up-to-date. A re-examination of the inventory mix of the stockpile grades is advised so that the inventory will be appropriate to fill intended industrial needs. Lack of adequate analytical data could cause delays in its use. Purification technologies are not very complex and could be implemented when the need arises.

MANGANESE DIOXIDE, BATTERY GRADE

Natural Ore

Goal--62,000 SDT
Inventory--215,394 SDT

Synthetic

Goal--25,000 SDT
Inventory--3,011 SDT

Natural manganese dioxide for battery use has a chemical variability, as mined and beneficiated, depending on the source. Users state that chemical analysis and physical characterization of the stockpile material are not adequate to judge the performance of the material in its end use. Storage method and packaging can be important in keeping the material ready for use. Bulk storage of natural ore in the open is acceptable; however, storage time may be a factor for this active material. Deterioration by air, water, and organic materials can be detrimental.

The data available on the stockpile material may not be complete enough for today's use, so periodic inspection and analysis may be advisable. Since the original purchases of the inventoried material, technological advances have taken place in the industry that may affect its acceptance by the battery industry. Detailed analysis and end use tests (simulated or true battery-use tests) are needed to ascertain the quality of the existing stockpile. Specifications appear to need an end-use test to qualify the material for its intended primary end use. Much of the inventory has been declared surplus, and some selectivity would permit retention of the most suitable material.

Synthetic battery grade manganese dioxide is a chemically prepared material. The chemical variability is considerably lower than the natural ore, but the time-dependent change in chemical activity still may be a factor in its end use. Storage location (outdoors for steel drums and inside for fiber containers) and packaging method (steel and fiber drums) appear adequate and are as specified. The soundness of the drums is important for ensuring the reactivity of the material. Periodic examination and analysis may be advisable to verify the integrity of the material.

Serious questions exist in the industry concerning the usefulness of the current synthetic stockpile inventory due to possible deterioration; up-to-date data are needed. Acquisitions to increase this portion of the stockpile and the disposal of the least desired part of the natural ore now declared surplus would retain materials that most closely meet the latest specifications.

MANGANESE METAL, ELECTROLYTIC

Goal--0
Inventory--14,172 ST

Electrolytic manganese metal is packed in steel drums and stored outdoors. Maintaining the soundness of the drum ensures that the stored material remains in the form acceptable to the industrial user.

Electrolytic manganese metal finds use both in steel and aluminum production. Its use is mostly in special grades of steel that require very low silicon content, particularly free-machining grades, and in stainless steels of low-carbon content. Additions of manganese metal to aluminum acts as a strengthening agent in sheet and can stock. No difficulty is identified in using the stockpile inventory in these applications.

No action is needed on this stockpile inventory, which presently is held as an offset for the metallurgical grade manganese ore goal.

MANGANESE ORE, CHEMICAL GRADE

Goal--170,000 SDT
Inventory--221,044 SDT

Chemical grade manganese ore is stored in piles on the ground outdoors. This method of storage is adequate because, generally, the user of the ore employs chemical processes that are tolerant of minor deviations in form and purity.

A variety of manganese chemicals are prepared from this grade of manganese ore (e.g., oxidants, mordants for various dyes, fungicides, and pharmaceuticals). The inventory appears satisfactory for these uses. Selective disposal of the excess matrix would retain that portion of the inventory that most closely meets current specifications.

MANGANESE ORE, METALLURGICAL GRADE

Goal--2,700,000 SDT
Inventory--3,370,104 SDT

Metallurgical grade manganese ore is stored in piles on the ground outdoors. No deterioration will occur from this method of storage. Airborne and water-borne contamination is minimal, especially as related to the metallurgical application. No serious technological changes in steelmaking or acceptable substitutes for manganese in metallurgy have been identified that might affect the future usefulness of this inventory.

The primary use of the metallurgical grade manganese ore is for the production of manganese ferroalloys and electrolytic manganese metal. In normal iron and steel production, the ferroalloys are an essential ingredient in the refining and production processes. The inventory appears satisfactory for these purposes.

MERCURY

Goal--10,500 FL
Inventory--182,815 FL

The mercury in the stockpile was purchased to the industry standard of 99.9 percent purity. Storage method (flasks in trays) and storage conditions (in warehouses) appear adequate to minimize possible contamination and loss. Losses are easily checked by simple weighing, and contamination generally is easily detected by visual examination for oxide formation. When needed, purification is rather simple, in most cases involving only distillation to restore it to its original state. Electronic and scientific research uses require higher purity attained by triple distilling. The 99.9 percent purity specification is adequate for general use.

NICKEL METAL

Goal--200,000 ST (Ni + Co)

Inventory--32,209 ST (Ni + Co)

Nickel metal is purchased as briquettes and electrolytic chunks and packed in drums which are stored in the open and some in closed storage. Data on old acquisitions indicate that the contents of the drums do not comply with today's specifications (P-36-R4, January 26, 1983) for vacuum grade, high-purity nickel. This deviation, however, does not detract from its acceptance for other less stringent applications such as alloy additives to conventional alloys or stainless steels.

Deterioration of the nickel is possible due to exposure to the elements over very long periods. Most of it is 25 or more years old. Primary concern for contamination applies to high-purity nickel that can pick up trace elements from the packaging material and can increase its oxygen content from the storage environment.

Nickel held in the stockpile was originally intended mainly for use as an alloy addition to stainless steels, specialty steels, alloy steels, and superalloys, many of which are vital to the defense heavy industry and other defense needs such as aircraft and vehicles. Analytical data available indicate that all the nickel in the stockpile meets Specification P-36-R3 (June 10, 1980), which specifies a minimum nickel content of 99.5 percent and has controls only on the content of cobalt, iron, sulfur, and carbon. Specific chemical analysis records have not been maintained. Lots have been mixed over the long storage period making it impossible to accurately identify materials by individual lot.

Current specifications for nickel have changed substantially. In the high-purity nickel specification, (P-36-R4, January 26, 1983), nickel must be either 99.95 percent for vacuum grade or 99.8 percent for pure grade. Furthermore, 21 elements including 16 trace elements are required in the analyses of these respective grades. This differs sharply from the older specification to which the stockpile nickel was acquired. Clearly, the substantial change in specifications and required purity in combination with the absence of detailed chemical analysis plus lot mixing means that <u>none</u> of the stockpiled nickel can be assumed to be adequate for today's most stringent needs.

The most serious deficiency for the nickel inventory is that it cannot meet the stringent technological requirements for nickel used for producing superalloys, in particular, the critical rotating grade types used in jet engines. Since none of the material in the stockpile can be counted on as suitable, some action is warranted. This could be either new acquisitions for the stockpile to meet the expanded goal, or a program of sampling, sorting, and reprocessing. Since the stockpile is only at 16 percent of its goal, acquisitions of high-purity material, followed by maintenance of segregated lots for the "known" material, might be the better answer. This would permit use of the existing stockpile nickel for the more routine, less technically stringent uses.

Furthermore, the task of analysis and sampling becomes quite difficult because the mixed lot situation causes all stockpile material to be random in its chemical content. Future technological changes in the use of nickel are possible but cannot be predicted with certainty. Continued monitoring of the technological environment is recommended to ensure that the proper quality and amounts will be available when needed.

NICKEL OXIDE

Goal--0
Inventory--447 ST

Some nickel oxide is held in the stockpile as a credit against the nickel goal. Its use in stainless steels has no major critical requirements so the quality appears suitable for most needs. Originally, the material came in bags, but later it was repackaged in drums, stored in warehouses. The original storage mode may have caused contamination, suggesting that an examination of the material is necessary.

A cursory examination of the stockpiled nickel oxide would be appropriate to judge the form and appearance of the product prior to its use. No detailed analysis is required at this time.

PLATINUM GROUP

Iridium

Goal--98,000 TrOz
Inventory--23,590 TrOz

Palladium

Goal--3,000,000 TroOz
Inventory--1,255,003 TrOz

Platinum

Goal--1,310,000 TrOz
Inventory--452,642 TrOz

Sponge of platinum group metals is packaged in polyethylene jars with screw caps that are then packed in wooden boxes. Ingots, bars, and plates are wrapped in kraft paper and tightly packaged in wooden boxes. The mode of packaging and storage is adequate for these noble metals which are not subject to serious corrosion problems. The only adverse effect could be the formation of a thin, strongly adherent, absorbed contamination layer on the surface during long (years) exposure to air because of this metal group's appreciable affinity for oxygen and sulfur. This layer is removed easily during processing for the desired application.

Acquisition dates and purchase specifications for most of these metals (except for about 10 percent of the iridium) are not on file. The analytical data for the small amount of iridium, a recent acquisition, shows it meets current specifications. It can be assumed that those materials acquired some time ago met specifications considerably less stringent than today's industrial requirements. These lots of material may not be suitable, on a selected basis, for current applications in the chemical and petroleum refining industries.

No urgent action is necessary for this inventory, because end-use processing can readily clean the surface layer and also upgrade the material, where needed, to meet more stringent specifications.

RUTILE

Goal--106,000 SDT
Inventory--39,186 SDT

Rutile is stored outdoors in bulk piles, a method acceptable for this material. Purchase specifications for these lots are available and generally appear to be adequate in terms of today's varied industrial uses. The higher level of MgO plus CaO content in several lots (higher than currently desired by industry), although within the 0.25 percent maximum in the specification, could cause problems in the processing to convert it to the tetrachloride (prior to preparing titanium sponge). These lots could be blended with low MgO plus CaO material, but proper identification of these high-MgO lots is necessary.

It is advisable to revise Specification P-49-R6 (November 3, 1981) to reduce the specified MgO plus CaO content from 0.25 percent to the industry acceptable 0.13 percent maximum. This change would provide a higher grade material in new acquisitions to meet the greatly expanded stockpile goal.

SILICON CARBIDE, CRUDE

Goal--29,000 ST
Inventory--80,550 ST

The crude silicon carbide in the stockpile is intended for use as abrasive grain. Most of it is stored in the open. A concern voiced by the Abrasive Grain Association (AGA) is about tar and water contaminants. Data on date of storage in the stockpile are not available. The outside storage conditions consist of piles of material covered with chicken wire and tarpaulin sprayed with asphalt. The materials that are in closed storage do not have sieve analysis data as is required in the 1981 specifications (P-95-R2, January 12, 1981). AGA, in a cooperative effort with the National Bureau of Standards, is conducting standards testing which is expected to be completed by mid-1984. Generally, the material in the stockpile could be used if proper backup data can be presented.

It is necessary to check the asphalt and water contamination of the stockpiled material to see if current specifications are met. Close liaison should be maintained with the AGA in establishing near-future specification recommendations.

For general use, not abrasive grain production, the silicon carbide in the inventory is satisfactory. Refractories and heating element production are the most important of these applications. While some is used as silicon additions to alloy melts, AGA requirements should be used as guidelines for its final applications.

TANTALUM CARBIDE POWDER

Goal--0
Inventory--28,688 LB

Analytical data on the inventoried tantalum carbide powder are incomplete and, in some cases, missing; therefore, a technically based assessment is not possible. It is possible that the material could be used, with low risk, as carbide tool additions. About 86 percent of the inventory falls in this category. Additional data are needed for the remaining amount before its applicability can be ascertained.

No action needs to be taken on the tantalum carbide powder inventory, which now has a zero goal and is carried as an offset for tantalum concentrates.

TANTALUM METAL AND POWDER

Goal--0
Inventory--201,133 LB

The tantalum ingot and slab inventory lacks detailed analytical data. It appears usable as a starting material for EB processing of the metal for preparing capacitor powder and for metallurgical grade melting stock. The grade 7 slab material also lacks analytical data. The inventory now is carried as an offset for tantalum minerals and concentrates.

Low capacitance value, general use capacitors could be made from the inventoried tantalum metal powder. Based on current industry requirements and processing practice, the stockpile inventory of tantalum capacitor powder cannot perform according to today's more stringent standards, particularly for high-performance capacitors, a major consumer of this material. The high CV/gm (a capacitor figure-of-merit) for the powder used by today's capacitor manufacturers requires a completely different powder applicable to current manufacturing techniques.

Storage of the powder in polyethylene bottles has been questioned. The migration of organic materials (e.g., plasticizers and mold release agents) to the powder surface can lead to detrimental low breakdown voltage in the capacitors. Verification of this condition is advised if the material is to be retained in the stockpile. In any event, the powder can be downgraded for metallurgical uses.

Evaluation could be undertaken to determine what CV/gm values are possible with the stockpiled powder. The breakdown voltage behavior, as related to pickup of organic contaminants during storage also could be determined. These data would be of doubtful use to the end user because it is being held as a credit against the concentrates goal.

TANTALUM MINERALS AND CONCENTRATES

Goal--8,400,000 LB
Inventory--2,584,195 LB

Tantalum minerals and concentrates are the lowest form of the tantalum group and can be processed to all other forms. The inventory acquired before 1982 lacks detailed trace and residual elements data. Antimony content is particularly important in the use of tantalum for aircraft turbine engine components. Current specifications for this end use places a 100 ppm maximum for antimony. Technology exists for removing the antimony from the processing circuit and allowing the tantalum separation to occur with less antimony carryover. In an emergency situation, the reduced columbium recovery of the minerals concentrate could be considered if the tantalum content was the primary objective of the processing. The columbium pentoxide contained in this material is credited toward the columbium group inventory goal. Additional requirements on U_3O_8 and ThO_2 content now in the specifications are not accounted for in the inventory.

It is suggested that the tantalum minerals and concentrates now held in the stockpile be retained, keeping in mind that future processing must take into consideration the possible high antimony content that must be handled. Future stockpile acquisitions of this basic stockpile form (about 80 percent of the goal has yet to be filled) must meet current low antimony requirement and the limits on U_3O_8 and ThO_2.

TANTALUM PENTOXIDE

No goal, small inventory

Detailed data are lacking on the stockpiled tantalum pentoxide so no determination can be made on its usefulness for all applications based on current specifications. This inventory, although not listed in the FEMA report, is credited against the total stockpile tantalum goal and possibly is an offset for part of the tantalum minerals category.

It is suggested that this material be retained and purified during processing to an upgraded form as is done for the tantalum minerals. Reprocessing into tantalum carbide powder is another possible action. For retention as an optical grade pentoxide, extensive characterization (and for possible purification) is necessary before it can be used. The columbium pentoxide contained in this material is credited toward the columbium group inventory goal.

TIN

Goal--42,700 MT
Inventory--193,642 MT

Data available indicate that the stockpile material meets the highest specifications, which have changed little over the years. The large excess stock now being sold off permits selection of the least desired lots for disposal.

TITANIUM SPONGE

Goal--195,000 ST
Inventory--32,331 ST

Titanium sponge is packaged in tightly sealed steel drums and stored in the open. This is the normal storage method for this material and requires only a minimum maintenance with periodic physical inspection of the drums for soundness. Ideally, argon flushing of the drums before closing would reduce long-term surface oxidation of the packaged materials. Also, warehouse storage of the drums would reduce drum corrosion and minimize the need for physical inspection of the drums. These actions are intended to reduce the adverse effect from contamination by foreign materials such as rust from the drums and oxidation from oxygen and moisture that enters the drum. Warehousing will extend the storage life of the drums considerably.

Not all the titanium sponge in the stockpile can be related properly to the original purchase specifications. The missing data thus limit the usefulness of many lots for producing critical aerospace parts. Sufficient chemical analysis (especially of oxygen content) is available for only about 40 percent of the titanium sponge inventory. Close examination of available data indicates that the lots identified as having a Brinell hardness number (BHN) of 120, or an oxygen analysis of 0.10 percent or less, are acceptable for titanium alloy applications. The balance of the inventory lacks these data so can be considered as acceptable primarily for iron- and nickel-base alloy additions, and not as the metal.

No near-term technical changes were identified that would affect the usefulness of the material that meets today's chemical and physical specifications. This critical stockpiled material needs attention in terms of obtaining complete analytical data and in initiating programs to fill the goal over a given time period. Upgrading is required for off-specification stockpile lots to the specification BHN value of 120 or less (and with an oxygen analysis of 0.10 percent or less). Also, deficiencies in the physical quality (e.g., the presence of nitrides, discolored sponge, and salt inclusions) may preclude the use of this sponge for the fabrication of rotating parts, or may necessitate triple melt practices for preparing ingot for the more critical applications.

To characterize properly the questionable material, an elaborate and expensive analytical procedure would be needed: sampling of the drums, melt to get a test ingot, conversion to a bar, then the evaluation of the chemistry and physical quality. A major portion of the goal has yet to be met; therefore, large-scale acquisitions should be initiated, the stockpile material should be upgraded to meet the most recent alloy-grade titanium specifications (P-97-R7, June 2, 1982).

TUNGSTEN GROUP

Tungsten Carbide Powder

Goal--2,000,000 LB
Inventory--2,032,942 LB

Ferrotungsten

Goal--0
Inventory--2,025,361 LB

Tungsten Metal Powder

Goal--1,600,000 LB
Inventory--1,898,911 LB

Tungsten Ores and Concentrates

Goal--55,450,000 LB
Inventory--86,044,819 LB

Most tungsten materials are packed in sealed steel drums and some in boxes and bags; all are stored in warehouses. The materials in bags are of concern due to the potential for a bad spill as a result of deterioration of the bagging material. Dry storage conditions are adequate for these materials except for the metal powder that will deteriorate (oxidize) if left open in storage.

The stockpile inventory of all tungsten materials, whether it is specification grade or not, is usable in some essential industrial application. The variety of manufacturing processes employed, the diversity of end products produced, and the technical sophistication of the industry permit various grades to be readily used. Although there are specific individual specifications and preferences of the convertors and fabricators, there is reasonable industry satisfaction with stockpile characterization of tungsten as to grade (WO_3 content). The impurity content and particle size characterization, gives rise to some difficulties. Convertors and fabricators perform their own analyses on incoming materials and will select and blend lots to suit desired end products. Reducing the inventory to the new goal levels permits selective disposal of the least desired materials from the stockpile.

There appears to be little value in further sampling and analyzing the stockpiled tungsten materials. A more appropriate action would be to direct attention to ensuring that the suitable stockpiled material is allocated to meeting the demand surge precipitated by a national emergency. The desirability and importance of the intermediate product, ammonium partungstate (APT), has been identified by industry as such a product (National Academy of Sciences 1982). It can be produced in a purified state from less pure materials. It is reasonably stable, is easily stored as an inert powder, and can be readily converted to the metal and, subsequently, to the carbide.

It is suggested that some of the existing subspecification grade ores and concentrates be converted to APT for the stockpile inventory. Toll conversion would be appropriate, whereby the government retains title to the material. Consideration should be given to stockpiling APT in an amount equal to a minimum of one-half the defense plus essential civilian needs for the first year of an emergency, which is estimated to be about 10 million pounds contained tungsten.

VANADIUM PENTOXIDE

Goal--7,700 ST
Inventory--541 ST

Vanadium pentoxide is packed in steel drums and stored in warehouses. This method of storing is acceptable, and it presents no particular problems for long term storage. No deterioration of the material or contamination from the packaging or the environment is to be expected.

Vanadium pentoxide is normally used for the production of ferrovanadium. For that application, the specification is not as stringent as it is for other applications (e.g., catalysts for chemical processes and for a vanadium-aluminum master alloy used for producing the high-strength 6V-4Al titanium alloy needed in many defense-related applications). These other applications require the use of a high-purity grade pentoxide of 99.5 percent minimum. Specification (P-58-R2, June 25, 1981) needs revision to meet the 99.5 percent requirement. The goal increase to more than 14 times the current inventory level offers an opportunity to include a reasonable proportion of pure material.

Regular vanadium pentoxide is needed for producing the ferrovanadium used extensively in HSLA steel production. The old stockpile inventory could well be applied to this production.

No urgent action is needed for this portion of the vanadium pentoxide inventory, but data should be on file indicating where it can be used most effectively.

ZINC

Goal--1,425,000 ST
Inventory--378,316 ST

Zinc metal is in ingot form, packed on pallets or on cast lifts and stored outside. Some surface oxidation can occur over a period of years but would not seriously affect its end use.

Data available indicate that the zinc stockpile inventory is acceptable for industrial use, although not all lots can be adequately identified. Nearly three-quarters of the goal has yet to be met, which should permit materials meeting the most recent specifications to be added while keeping the old material for general use. Minor deficiencies in chemical composition can be adjusted readily by simple reprocessing. Should the need arise, the existing stockpile can be easily upgraded.

CHAPTER 5

TOPICS RELATED TO STOCKPILING

The committee's primary objective was to assess the currency of most of the stockpile materials. During the committee's deliberations, however, members discussed various issues, which are being openly debated, relating to the National Defense Stockpile. Some of these are touched on briefly below to highlight the committee's awareness of the differences in opinion that currently exist. The committee recognizes the importance of these issues, but finds it beyond the scope of this study to examine them in detail. A strong recommendation is made that consideration be given to address these in a follow-on study. It should be noted first that all generally agreed on the great value of the stockpile as a national asset and on the possibility of increasing its value to the nation through actions to improve any serious deficiencies.

Questions by the industrial sector on the immediate usefulness of the stockpile materials for various industrial needs have prompted government action. It is known that some--but not how much--of the material in the stockpile cannot be used directly for certain end use applications. The committee agrees that detailed assessment and analyses of all stockpiled materials may be economically impractical (e.g., conducting a detailed physical inventory is estimated by GSA to cost about $3 million and an estimated $1 million is needed for chemical analyses of the old cobalt inventory in order to identify what program would be needed to update records of this one material).

Present U.S. capacity to reprocess materials is very limited and is rapidly decreasing. The reprocessing of large quantities of materials to meet specific high-performance end use requirements could not be accomplished quickly in existing U.S. facilities without affecting normal industrial output. Delays also would occur if the upgrading required changes in existing processing technology and equipment. The committee concluded that judicious evaluations of priorities for detailed examination and on the quantities needed for a strategic application are important. Such evaluations must be based on cost-benefit relationships involving market pricing and quality requirements, and the probability of supply interruptions.

In order to determine whether or not there are sufficient directly usable materials in the stockpile to meet immediate U.S. defense needs, data on quantities, lot analyses, and storage locations of the materials in the stockpile must be available (General Services Administration 1982b). Although data on quantities and storage locations are published, the chemical analyses of each lot are not always available or are incomplete in terms of today's needs in strategic materials such as superalloys. Recent acquisitions added to the stockpile are in accordance with current specifications which require more detailed analyses than those performed in earlier purchases. Annual review of all holdings in the stockpile for technological currency is impractical, but biennial review, on a rotating basis, of the most questionable materials makes sense. These "paper examinations" could provide data for rotating and upgrading the inventory on an appropriate time scale. Thus, the stockpile would be dynamic, rather than static as it has been in the past.

Consideration was given by the committee to furnishing data on applicable sampling techniques (i.e., the types of tests and analyses needed to carry out an analytical program to properly characterize the materials needing examination). The complexity of the factors involved and the individuality of the programs needed made the task a formidable one that could not be adequately dealt with by this committee. Experts on each of the relevant materials should make these determinations.

A general policy to replace the stockpile would involve unnecessary cost to the government. Rotation is a useful concept but should not be done automatically or without proper thought. Contact and cooperation of the responsible government agencies with industry on specification changes and technological advances must be continued. Participation in stockpile actions by members of professional organizations such as The ASTM, ASM, AIME, and SAE is necessary if the stockpile is to reflect current technology and industrial needs. Analyses of all materials must be consistent with current specifications to ensure that the quality of the stockpile materials conforms with industrial practice. Industry changes need not always mean a need for higher quality (e.g., development of AOD greatly reduced the need for low-carbon ferrochromium).

Many findings in this report also have been endorsed by the recent ASM panel that assessed the cobalt inventory (ASM 1983). Recommendations which that panel presented for cobalt are applicable generally to other stockpile materials and reflect many of the more general recommendations made in this report. All involved agree that decisions must recognize the diversity of applications for which the stockpile is intended and that the highest priority applications often might constitute only a small portion of the total inventory. As for overall strategies for improving domestic strategic and critical nonfuel materials availability, congressional initiative and administrative support are needed to cause this arena to improve (Congressional Budget Office 1983).

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APPENDIX A

PURCHASE SPECIFICATIONS FOR NATIONAL DEFENSE STOCKPILE MATERIALS
(Updated list dated July 18, 1983)

The specification numbers and dates contained in this appendix are the latest available from the Department of Commerce* and are used by stockpile management for making authorized acquisitions for the National Defense Stockpile. All materials in the stockpile, which include the materials examined in this study, are listed and specification revisions now being reviewed by industry concerned have been added. Comments by interested parties on the content of these documents are welcomed by the compiling agency, the Office of Industrial Resource Administration of the U.S. Department of Commerce.

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* Copies of these specifications are available from Mr. Paul H. Butler, Jr., Stockpile Program Manager, Office of Industrial Resource Administration, U.S. Department of Commerce, Room 3876, Washington, D.C. 20230, Telephone:(202) 377-2322.

APPENDIX A (continued)

Material	Ident.	No.Issue Date
Aluminum	P-62-R2	October 21, 1968
Aluminum oxide abrasive, fused, crude	P-90-R3	November 13, 1980
Antimony metal	P-2a-R4	June 10, 1980
Antimony sulphide ore and concentrates, chemical grade	P-2b-R2	June 10, 1980
Antimony, liquaded	P-2c	June 29, 1950
Asbestos, amosite	P-4-R6	September 27, 1971
Asbestos, crysotile	P-3-R6	February 26, 1982
Asbestos, crocidolite		June 15, 1960
Bauxite, abrasive grade	P-90a	June 22, 1981
Bauxite, chemical grade	P-111	March 10, 1965
Bauxite, metal grade	P-5a-R3	October 30, 1968
Bauxite, metal grade, jamaica type	P-5b-R1	February 9, 1983
Bauxite, refractory grade	P-5c-R5	June 22, 1982
Beryl concentrates	P-6-R5	November 13, 1980
Beryllium, copper master alloy	P-94-R3	November 13, 1980
Beryllium metal, hot-pressed powder blocks	P-110a-R	March 25, 1983
Beryllium metal, vacuum cast ingot	P-110-R2	June 25, 1981
Bismuth	P-7-R4	June 10, 1980
Cadmium	P-8-R2	March 7, 1979
Castor oil	P-9-R3	June 22, 1982
Celestite	P-10-R3	April 25, 1968
Chestnut tannin extract	P-86-R2	February 1, 1980
Chromite, chemical use	P-65-R4	February 1, 1980
Chromite, metallurgical grade, lump	P-11-R2	June 30, 1971
Chromite, refractory grade	P-12-R4	October 19, 1973
Chromium metal	P-96-R2	May 28, 1971
Ferrochromium, low carbon	P-11a-R6	June 9, 1976
Ferrochromium, high carbon	P-11b-R3	February 2, 1983
Ferrochromium, silicon	P-11c-R3	March 3, 1958
Cobalt	P-13-R5	June 28, 1983
Columbium carbide powder	P-105-R1	September 3, 1963
Columbium, commerical grade	P-103-R1	July 12, 1963
Columbium and tantalum source materials	P-113-R1	May 6, 1968
Ferrocolumbium	P-104-R1	October 3, 1966
Copper	P-16a-R2	March 7, 1979
Copper, oxygen free, high conductivity	P-16b-R2	November 27, 1972
Cordage Fibers, abaca	P-17a-R6	October 25, 1972
Cordage Fibers, sisal	P-17b-R6	October 19, 1977
Corundum, massive micro-crystalline ore	P-18-R2	January 23, 1967
Diamond dies	P-67-R2	February 24, 1965
Diamonds, industrial	P-19-R2	December 15, 1967
Feathers and down, waterfowl	P-82-R	October 20, 1954
Fluorspar, acid grade	P-69a-R2	January 2, 1976
(Review Draft 2)	P-69a-R3	November 22, 1983
Fluorspar, metallurgical grade	P-69b-R2	January 2, 1976
Graphite, Ceylon, amorphous lump	P-21-R3	June 30, 1971

APPENDIX A (continued)

Material	Ident.	No.Issue Date
Graphite, Natural, malagasy, crystalline	P-22a-R3	May 4, 1970
Graphite, crystalline or flake, lubricant and packing grade	P-22b-R	December 16, 1952
Hyoscine	P-23	November 13, 1951
Iodine	P-24-R4	August 15, 1970
Iridium	P-40-R	June 25, 1981
Jewel bearings	P-25-R2	March 27, 1981
Kyanite, mullite	P-27-R	February 29, 1960
Lead	P-28-R2	November 16, 1970
Magnesium	P-71-R2	February 26, 1969
Manganese dioxide, battery grade	P-29-R3	June 16, 1961
Manganese ore, chemical grade	P-81-R	October 28, 1957
Manganese, metallurgical (ore, nodules, and sinter)	P-30-R2	August 31, 1971
Manganese Metal, electrolytic	P-98-R3	June 9, 1976
Ferromanganese, standard high-carbon	P-30a-R3	February 2, 1983
Ferromanganese, low- and medium-carbon)	P-108-R1	April 12, 1965
Silicomanganese	P-109-R1	April 10, 1968
Mercury	P-31-R2	June 15, 1971
Mica, muscovite block	P-32a-R3	October 31, 1968
Mica, muscovite film	P-32b-R2	October 31, 1968
Mica, muscovite splittings	P-33-R	November 2, 1955
Mica, phlogopite block	P-73	February 27, 1969
Mica, phlogopite splittings	P-34-R	November 2, 1955
Molybdenum	P-74-R5	July 15, 1963
Morphine sulphate	P-37a-R	March 7, 1979
Nickel, high purity	P-36-R4	January 26, 1983
Opium	P-37-R3	March 7, 1979
Palladium	P-99-R6	June 25, 1981
Platinum	P-41-R5	June 25, 1981
Pyrethrum extract	P-42-R2	February 1, 1980
Quartz crystals, raw	P-43-R2	February 26, 1973
Quebracho tannin extract	P-44-R3	February 1, 1980
Quinidine sulfate	P-45-R4	January 26, 1983
Quinine Sulfate	P-46-R3	November 13, 1980
Rare earths	P-35-R	August 1, 1957
Rubber, crude natural	P-48a-R5	October 19, 1977
Rubber, technically specified rubber, hevea	P-48b-R	June 2, 1982
Rubber, parthenium, guayule	P-48c	February 1, 1980
Rutile	P-49-R6	November 3, 1981
Sapphire and ruby	P-50	November 1, 1947
Sapphire and ruby components, synthetic	P-25a	March 27, 1981
Sebacic acid	P-107-R2	August 22, 1969
Selenium	P-75-R	June 20, 1958
Shellac	P-51-R2	March 30, 1970
Silicon carbide, crude	P-95-R2	January 12, 1981
Silk, raw	P-83a-R1	August 14, 1959
Silk noils	P-83b-R1	April 18, 1961

APPENDIX A (continued)

Material	Ident.	No.Issue Date
Silver	P-112-R2	June 10, 1980
Sperm oil	P-52-R1	June 2, 1969
Talc steatite block	P-53-R2	June 10, 1980
Talc steatite lump	P-53a-R2	June 10, 1980
Tantalum Metal, capacitor grade	P-101-R4	November 20, 1967
Tantalum carbide powder	P-106-R3	February 1, 1980
Ferrotantalum, columbium	P-88-R1	March 17, 1961
Tantalum source materials	P-113a	August 3, 1981
Tin	P-55-R3	June 10, 1980
Titanium metal sponge	P-97-R7	June 2, 1982
Tungsten carbide, crystalline	P-92-R1	January 5, 1966
Tungsten carbide powder	P-93-R2	January 5, 1966
Tungsten metal powder carbon-reduced	P-102-R1	January 5, 1966
Tungsten metal powder hydrogen-reduced	P-89-R2	January 5, 1966
Tungsten ores and concentrates	P-57-R6	August 15, 1967
Ferrotungsten	P-57a-R5	December 18, 1969
Vanadium pentoxide	P-58-R2	June 25, 1981
Ferrovanadium	P-100-R1	October 19, 1977
Wattle tannin extract	P-87-R2	February 1, 1980
Zinc	P-59-R	June 22, 1981

Other materials names related to this listing are:

Abaca--see cordage fibers
Amosite--see asbestos
Bastnaesite--see rare earths
Chrysotile--see asbestos
Platinum group--see iridium, palladium, platinum
Sisal--see cordage fibers
Vegetable tannin extracts--see chestnut, quebracho, wattle)

APPENDIX B

BIOGRAPHICAL SKETCHES OF COMMITTEE MEMBERS

CHARLES W. BERRY received a B.S. degree in mining engineering in 1952 from Lehigh University, a M.S. degree in mineral engineering in 1959 from the University of Minnesota, and a Ph.D. degree in mining engineering in 1972 from Pennsylvania State University. He worked in the mining and minerals engineering area between 1952 and 1981 for U.S. Steel Corporation, Reserve Mining Company; the Minnesota Department of Revenue; Olin Corporation; AMAX, Inc.; and AMAX Exploration, Inc. He is a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers. He is currently Professor and Head of the Mineral Economics Department of the Colorado School of Mines and is involved in research in mining engineering, mineral economics, mineral projects evaluation by economic and financial analysis, and computer applications. He is a registered professional engineer.

JERE H. BROPHY received a B.S. degree in chemical engineering in 1956 and a B.S. degree in 1957 and a Ph.D. degree in 1958, in metallurgical engineering from the University of Michigan. He served as Assistant Professor of Metallurgy at the Massachusetts Institute of Technology from 1958 to 1963. He worked in various research areas at the International Nickel Company and INCO's P.D. Merica Research Laboratory between 1963 and 1977 and served as Director of Research and Development of the INCO Research and Development Center from 1977 to 1982. He is a fellow of the American Society for Metals and a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers and the British Institute of Metals. He is currently Vice President and Director of the Materials and Manufacturing Technology Center, TRW, Inc., specializing in refactory metals, powder metallurgy, precious metals processing, superalloys, superplasticity, microduplex alloys, and materials development.

ROLAND P. CARREKER, JR. received a B.S. degree in 1945 and a M.S. degree in 1947 from the University of Illinois and a Ph.D. degree in 1955 from Rensselaer Polytechnic Institute, all in metallurgical engineering. He has worked at the General Electric Company since 1947 in Research and Process Metallurgy and metal economics. He is a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers; the American Society for Metals; and the National Association of Manufacturers. He is currently Manager of Materials Resource Analysis at GE and is involved with materials procurement, forecasting metal prices and availability, corporate planning for major commodities, econometrics and computer-based analytical systems, and interfaces with government agencies on materials availability.

JOEL P. CLARK received a B.S. degree from Florida State University in 1966 and a M.S. degree in 1968 and a Sc.D. degree in 1972 from the Massachusetts Institute of Technology, all in materials science and engineering. In 1975 he received a S.M. degree in management from the Sloan School of Management at MIT. He is a member of the American Society for Metals; the American Institute of Metallurgical, Mining, and Petroleum Engineers; the American Economic Association; and the American Association for the Advancement of Science. He is currently Professor of Materials Systems at MIT specializing in engineering systems analysis and metallurgy and materials substitution and economic trade-offs.

JAMES A. FORD received a B.S. degree in chemical engineering in 1956 and a M.S. degree in 1957 and a Ph.D. degree in 1962 in metallurgical engineering, all from the University of Michigan. He served as Instructor of Metallurgical Engineering at the University of Michigan from 1959 to 1961. Between 1961 and 1982 he worked in research and various technical areas at United Aircraft Corporation; the Olin Metals Research Laboratories of the Olin Corporation; Conalco, Inc.; the Composite Can Division of Boise Cascade Corporation, and the Cabot Corporation. He is a member of the American Society for Testing Materials, the National Association of Corrosion Engineers, the Electrochemical Society, and the American Society for Mechanical Engineers. He is currently Director of Advanced Technology at Aerojet Ordnance Company, Heavy Metals Division, and is involved in the development of new and improved alloys and research in corrosion of alloys.

THOMAS L. ISENHOUR received a B.S. degree in 1961 from University of North Carolina and a Ph.D. degree in 1965 from Cornell University, both in analytical chemistry. He was Assistant Professor of Chemistry at the University of Washington from 1965 to 1969. He joined the University of North Carolina in 1969 as Chairman of the Chemistry Department. He is a member of the American Chemical Society and the Pattern Recognition Society. In 1982, he was on leave from the University to the Chemistry Division of the National Science Foundation specializing in computerized chemical information processing, search and retrieval systems, molecular structure encoding, computerized learning machines, and pattern recognition and interpretation in mass, infrared, and gamma-ray spectra.

JAMES L. McCALL received a B.Met.E. degree in 1958 and a M.S. degree in 1961 in metallurgical engineering from the Ohio State University. He has worked in the Battelle Columbus Laboratories since 1965 in various metallurgical programs and has been Manager of the Material Resources and Process Metallurgy Department since 1976. He is a member (and a fellow) of the American Society for Metals; the American Institute of Mining, Metallurgical, and Petroleum Engineers; the Electron Microscopy Association of America, and the Institute for Microstructural Analysis. His areas of interest include metallographic research on metals and ceramics, process metallurgical research on minerals processing, primary ferrous and nonferrous metals processing, recycling, and energy and environmental concerns of metallurgical operations.

WILLIAM A. McNEISH received a B.S. degree in metallurgical engineering in 1950 from Grove City College, Pennsylvania. He worked in various metallurgical areas between 1950 and 1969 at National Steel Company, Oak Ridge National Laboratory, Bettis Atomic Power Division of Westinghouse Electric Corporation, Universal Cyclops Division, and Special Metals Corporation. He is a member of the Society of Manufacturing Engineers; the American Institute of Mining, Metallurgical, and Petroleum Engineers; and the American Society for Metals. He is currently Director of Quality Assurance at Teledyne Allvac and is involved in melting processing, and materials specifications; nonferrous metallurgy and alloys; superalloys; titanium; and materials evaluation and quality assurance.

WILLIAM A. OWCZARSKI received a B.S. degree in electrical engineering in 1955 from the University of Massachusetts and a M.S. degree in 1958 and a Ph.D. degree in 1962 in materials engineering from Rensselaer Polytechnic Institute. He worked as a manufacturing engineer at Sprague Electric Company from 1955 to 1957, and as a metallurgist at General Electric Company from 1958 to 1961. Since 1962 he has worked in various materials and manufacturing programs at the Pratt & Whitney Group, United Technologies Corporation. He is a member (and Fellow) of the American Society for Metals, American Welding Society, and the National Association of Manufacturers. He currently is Technology Manager of the Manufacturing Division of the Pratt & Whitney Group of the United Technolgies Corporation and has experience in process metallurgy, high-temperature nickel alloys, and manufacturing technology.

ALLEN S. RUSSELL received a B.S. degree in 1936, a M.S. degree in 1937, and a Ph.D. degree in 1941, all in physical chemistry from Pennsylvania State University. He worked as a chemist at Bell Telephone Laboratories in 1937 and then returned for graduate study at Pennsylvania State from 1937 to 1940. He joined ALCOA in 1940 and became Vice President of Science and Technology of the ALCOA Laboratories in 1978. He is a member of the National Academy of Engineering, the American Chemical Society, and the Sigma Xi Society, and a Fellow of the American Society for Metals and of the American Institute of Mining, Metallurgical, and Petroleum Engineers. In 1982 he retired from ALCOA and currently is Adjunct Professor at the University of Pittsburgh. His area of expertise covers all phases of process metallurgy of aluminum and its applications.

SUBHASH C. SINGHAL received a B.S. degree in 1963 in chemistry and physics from Agra University (India), a B.E. degree in metallurgical engineering in 1965 from the Indian Institute of Science, a Ph.D. degree in metallurgy and materials science in 1969 from the University of Pennsylvania, and a M.B.A. degree in 1977 from the University of Pittsburgh. He worked at Chromalloy American Corporation from 1969 to 1971 and joined Westinghouse in 1971. He currently is Manager of Advanced Materials at the Westinghouse Research and Development Center. He is a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers; the American Ceramic Society; the National Institute of Ceramic Engineers; the Electrochemical Society; the American Society for Metals; The Sigma Xi Society; and Beta Gamma Sigma. His expertise is in refractory metal alloys, superalloys, structural ceramics, composites, graphite compounds, protective coatings, recycling and reclamation of strategic materials, and research planning and management.

RAYMOND L. SMITH received a B.S. degree in 1943 from the University of Alaska and a M.S. degree in 1951 and a Ph.D. degree in 1953 in metallurgical engineering from the University of Pennsylvania. He was Assistant Professor of Metallurgy at the University of Alaska in 1946 and in 1949 entered the University of Pennsylvania for graduate study. Since 1953 he has worked in the metallurgy field and he become Technical Director at the Franklin Institute Research Laboratories in 1957. He joined the faculty of Michigan Technological University in 1959 and was made President in 1965, a position he held until his retirement in 1979. He is a member and Fellow of the American Society for Metals; Sigma Xi; and American Institute of Mining, Metallurgical, and Petroleum Engineers and a Fellow of the The Metals Society. His areas of expertise include physical metallurgy, low-temperature mechanical properties, ultra-high-purity metals, and research administration.