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MATERIALS DIVISION
PROPULSION AND VEHICLE ENGINEERING LABORATORY

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
January 13, 1966

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ABSTRACT

"1965 Publications" is a compilation of abstracts of NASA Technical Memorandums and MSFC Internal Notes, written by personnel of the Materials Division and released during 1965.

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GEORGE C. MARSHALL SPACE FLIGHT CENTER

TECHNICAL MEMORANDUM X-53378

1965 PUBLICATIONS

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Materials Division

SUMMARY

This report lists and abstracts NASA Technical Memorandums' and MSFC Internal Notes written by personnel of the Materials Division, Propulsion and Vehicle Engineering Laboratory, George C. Marshall Space Flight Center, National Aeronautics and Space Administration, during 1965.

INTRODUCTION

The mission of the Materials Division is to conduct research and development in materials science and engineering as related to the programs of the George C. Marshall Space Flight Center. This report lists and abstracts the technical reports written by personnel of the Materials Division during 1965.

Requests for copies of these reports should be addressed to:

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812
Attention: MS-IPL

NASA TECHNICAL MEMORANDUMS

January 30, 1965

1964 PUBLICATIONS

NASA TM X-53191

by Materials Division

Unclassified, 18 pages

"1964 Publications" is a compilation of abstracts of a NASA Technical Note, NASA Technical Memorandums, and MSFC Internal Notes, written by personnel of the Materials Division and released during 1964.

January 20, 1965

SPECTROGRAPHIC SOLUTION ANALYSIS
OF ALUMINUM ALLOYS

NASA TM X-53192

by D. Hamilton and S. Corbitt

Unclassified, 18 pages, 5 tables, 6 figures, 1 plate

To obtain accurate analyses of metals and alloys with the most widely used technique of spectrographic analysis, i.e., the point-to-plane spark technique, the standards and the unknown material must be quite similar in size, shape, chemical composition, and metallurgical state. By dissolving the sample and using the vacuum cup spark technique to analyze the solution, these limitations can be circumvented. Standards can be synthesized easily by mixing aliquots of master reference solutions. The solution technique also offers the possibility of adding an internal standard and, thereby, obtaining a wider selection of reference lines to use in the analysis.

The solution spectrographic method has been investigated and applied to a wide variety of analytical problems at this Center. As an example, the procedure for the determination of manganese, zirconium, magnesium, vanadium, titanium, and iron in types 2219 and 2319 aluminum alloy is presented. The results agree with the results of classical wet methods and are precise to ± 0.005 percent in the concentration ranges involved.

January 22, 1965

NONMONOTONICITY IN SENSITIVITY
TEST DATA

NASA TM X-53194

by J. B. GAYLE

Unclassified, 9 pages, 2 figures

In general, the frequency of reactions for sensitivity test data of the "go-no-go" type increases monotonically with increasing levels of stimulus. However, occasional instances of nonmonotonic behavior have been noted.

Unclassified, 26 pages, 18 figures

An experimental investigation was carried out to study the decrease in reactivity of materials with liquid oxygen (LOX) that is caused by dilution of the LOX with liquid nitrogen (LN₂). A wide range of materials was selected for testing, each of which previously had been shown to be sensitive to impact in LOX. Tests were made with the ABMA LOX Impact Tester using LOX/LN₂ mixtures ranging in concentration from 20 percent LOX in LN₂ to pure LOX. The results showed that relatively large proportions of LN₂ were required to effect an appreciable decrease in reactivity; however, all materials tested were insensitive to impact at 10 kg-m in liquid air.

March 17, 1965 ACOUSTIC TECHNIQUES FOR THE NASA TM X-53219
 NONDESTRUCTIVE EVALUATION OF ADHESIVELY
 BONDED COMPOSITE MATERIALS

by W. N. Clotfelter

Unclassified, 43 pages, 27 figures

The extensive usage of composite materials in the Saturn vehicle has required considerable effort in the development of nondestructive inspection methods to evaluate the mechanical integrity of these materials. This report describes through-transmission and single-side acoustic methods applicable to the quality verification of composite panels. Some of the techniques discussed are "off the shelf." Others are believed to be unique. All of these inspection methods are discussed and illustrated to show their applicability to the quality verification of certain types of composite structure used in the Saturn. An attempt has been made to relate selected techniques to the acoustic characteristics of the materials used.

March 18, 1965 H-1 ENGINE LOX DOME FAILURE NASA TM X-53220

by C. E. Cataldo

Unclassified, 22 pages, 6 tables, 9 figures

A 7079-T6 aluminum forging, which is the forward closure of the H-1 rocket engine combustion chamber, failed after the engine was installed on the Saturn S-I-7 vehicle. It was concluded that the failure, occurring several weeks before launch at the Kennedy Space Center, was caused by stress corrosion. This report describes the metallurgical analysis of the failure and discusses previous failures experienced on this same part and the corrective actions that were taken.

March 26, 1965

COMPARISON OF TWO INSTRUMENTS
FOR DETERMINING HARDNESS OF ELASTOMERS

NASA TM X-53226

by J. T. Schell and C. D. Hooper

Unclassified, 31 pages, 5 tables, 18 figures

To reach a higher degree of accuracy in control evaluations of rubber compounds, a comparison was made of two commercially available instruments for measuring hardness of elastomeric compounds. These instruments, the Shore durometer and ASTM (Tinius Olsen), were compared over a wide hardness range on 13 types of rubber formulations.

Studies indicated that, although the ASTM (Tinius Olsen) instrument requires a more refined test specimen and is somewhat more difficult to operate, it is a more precise instrument and should be used where very close tolerances are involved or as a "referee" in case of doubt with other instruments. The Shore durometer provides a rapid means for measuring hardness of elastomers; the specimen size is not critical; and the Shore durometer accuracy is sufficient for control evaluations as well as for the majority of end items.

With the graphs and tables in this report, it is possible to convert units of measure from one instrument to the other for a particular compound of interest; however, to prepare a single table (or graph) illustrating a "typical" correlation for all elastomers is not practical because of the variation in creep with different formulations.

March 30, 1965

EFFECTS OF NUCLEAR RADIATION,
CRYOGENIC TEMPERATURE, AND VACUUM ON THE
ELECTRICAL PROPERTIES OF DIELECTRIC MATERIALS

NASA TM X-53230

by R. L. Gause and E. C. McKannan

Unclassified, 29 pages, 6 tables, 11 figures

The dielectric properties of polymeric materials probably are among the most sensitive to the effects of radiation from the space environment, from nuclear power sources, or from nuclear rockets. These properties also are affected in various ways by other parameters of the space environment such as vacuum and temperature. Therefore, a combined environmental evaluation of four commonly used dielectrics was made. Some preliminary results indicate that the effect on the dielectric constant and dissipation factor of the polymers was minor for vacuum alone but of major significance for radiation alone. The cryogenic temperatures had

a minor effect on the dielectric properties of silicone rubber and polytetrafluoroethylene but a direct and significant effect on the epoxy and polyurethane materials. It appeared that the effect of cryogenic temperatures may have counteracted the radiation effects in some cases. Obtaining dielectric measurements within the combined environmental simulator posed some special problems and required some novel techniques which are described.

April 2, 1965

ACCELERATED COMPRESSION SET
PROPERTIES OF FOURTEEN ELASTOMERS

NASA TM X-53232

by C. D. Hooper and J. T. Schell

Unclassified, 44 pages, 35 figures

Fourteen types of synthetic elastomers, from which O-rings and other gaskets might be fabricated, were investigated for their compression set properties. Each compound was tested at a minimum of three temperatures (ranging from 70°C (158°F) to 250°C (482°F)) during various periods of time up to 32 days.

Results showed that most elastomers have reasonably good compression set properties at room temperature (25°C) but that many of these might have critical limitations when subjected to the same compression at an elevated temperature. These tests, like other accelerated tests, were not expected to indicate the small differences that might be encountered in actual service; however, they do provide a practical evaluation of the properties that are useful where a high degree of precision is not expected.

A summary of the data obtained from this study is presented in graphical form, illustrating the characteristics and limitations of each compound tested.

April 9, 1965

PRELIMINARY INVESTIGATION OF
BLAST HAZARDS OF RP-1/LOX AND
LH₂/LOX PROPELLANT COMBINATIONS

NASA TM X-53240

by John B. Gayle, Charles H. Blakewood, James W. Bransford,
William H. Swindell, and Richard W. High

Unclassified, 31 pages, 20 figures

This report discusses the current status of information regarding the blast hazards of liquid propellants and presents results obtained from one part of a comprehensive analytical and experimental investigation of this problem. The data generally were consistent with siting

tube fittings in the S-I and S-IC stages of the Saturn I and Saturn V vehicles, respectively. Various heat treated conditions were investigated and relative stress corrosion cracking susceptibility determined. Of the generally used heat treatments, the fully hardened SCT 1000 treatment was found to be superior in stress corrosion resistance.

September 13, 1965 EXPERIMENTAL X-RAY STRESS NASA TM X-53329
ANALYSIS FOR PRECIPITATION
HARDENED ALUMINUM ALLOYS

by J. H. Wharton and W. L. Prince

Unclassified, 26 pages, 12 figures

X-ray diffraction techniques for determining stress in precipitation hardened aluminum alloys have been developed and evaluated. The materials investigated included 2014-T6, 2219-T37, and 7075-T6 aluminum alloys. A precision corresponding to ± 5 percent of the alloy yield strengths was obtained under laboratory conditions. Further studies are needed to evaluate this method for field measurements of stress in vehicle components.

September 14, 1965 INVESTIGATION OF THE NASA TM X-53331
COEFFICIENT OF FRICTION OF VARIOUS
GREASES AND DRY FILM LUBRICANTS AT ULTRA
HIGH LOADS FOR THE SATURN HOLD DOWN ARMS

by K. E. Demorest and A. F. Whitaker

Unclassified, 29 pages, 2 tables, 12 figures

A series of high load, low speed sliding friction tests was made on 8 fluid lubricants and 18 dry lubricants at normal unit loads from 10,000 psi to 150,000 psi. Four different substrate materials having a range of hardnesses from Rockwell C 18 to Rockwell C 55 were used. The ultimate load capability of both fluids and dry films is a function of substrate hardness with the best ultimate load capability being provided by inorganically bonded molybdenum disulfide films with small amounts of graphite added. The coefficient of friction of the fluid lubricants appears to be an inverse function of substrate hardness and a direct function of the normal load. The coefficient of friction of the dry lubricants is an inverse function of the normal load, but it does not appear to be related to the substrate hardness.

September 14, 1965 LOW TEMPERATURE MECHANICAL NASA TM X-53332
PROPERTIES OF ALUMINUM ALLOY
2219-T87, 0.040-INCH THICK SHEET
THROUGH 5.000-INCH THICK PLATE

by C. R. Denaburg

Unclassified, 15 pages, 2 tables, 7 figures

The freezing and boiling points of 0 -40 percent mixtures of various nitrogen compounds and water in monomethylhydrazine (MMH) were determined experimentally. The additives for these mixtures were selected on the basis of chemical similarity to MMH, mixture thermal stability, probability of contamination occurrence, cryoscopic and ebullioscopic effects, and anticipated effects on propellant performance.

Theoretical specific impulses were calculated as a function of additive concentration using nominal values of the Saturn S-IVB Vehicle Auxiliary Propulsion System as a basis.

November 4, 1965 SIMULATION STUDY OF THE AMOUNT OF NASA TM X-53357
SENSITIVITY TEST DATA REQUIRED TO REJECT
THE HYPOTHESIS OF NORMALITY WHEN THE
SAMPLE POPULATION IS NONNORMAL

by J. B. Gayle and C. L. Hopkins

Unclassified, 13 pages, 3 tables, 3 figures

Computer simulation techniques were used to study the number of sensitivity tests which are required to reject the hypothesis of a normally distributed sample population when the population actually was nonnormal. The results indicated that, even under the most favorable conditions, the number of tests required far exceed the number usually run in sensitivity type testing. This suggests that any assumption concerning the statistical nature of the distribution ordinarily will not be verified experimentally.

November 4, 1965 STATUS REPORT ON CHEMICAL SYNTHESIS NASA TM X-53358
OF MONOMERIC SELF-SEALANT TYPE ESTERS

by Lawrence R. Moffett, Jr.

Unclassified, 21 pages, 8 figures

The purpose of this program was to develop an efficient synthetic chemical route or the preparation of alkyl esters of α -cyanosorbic acid (1-cyano-hexadienoic acid) as intermediates in self sealant polymerization studies. The in-house investigation of the direct and indirect esterification of α -cyanosorbic acid, employing standard and non-conventional techniques, has resulted in the development of a satisfactory procedure for the preparation of *n*-butyl- α -cyanosorbate and *n*-amyl- α -cyanosorbate in yields approaching 90 percent. Parallel studies which were initiated by the Research and Technology Division of the Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (ASD) under Government Work Order H-71461, have resulted in the preparation of

n-butyl- α -cyanosorbate in somewhat lower yields with concomitant longer reaction periods. The synthetic procedures developed in both investigations are discussed in detail in this report, and chemical and spectral data are presented to verify the identities of the esters formed in the various reactions.

This program established that the direct esterification of α -cyanosorbic acid is quite feasible and is a much preferred route to the indirect esterification through preparation of such intermediates as the corresponding acid chlorides and sodium salts.

December 15, 1965 A COMPILATION OF RADIANT AND NASA TM X-53369
CONVECTIVE HEATING TEST RESULTS

by F. Uptagrafft, L. A. Soileau, and T. Barkley

Unclassified, 104 pages, 12 tables, 5 figures

The report is a compilation of data which characterize the response of approximately 1,500 insulation materials when they are exposed to a variety of temperature and pressure environments. To establish the capability of these materials to satisfy the many conditions to which they could be exposed in the Saturn launch vehicles, a multitude of different heat pulses was included in the material evaluation. The purpose of the program was to define the characteristics of these materials in peculiar environments (e.g., radiant heating, heating at reduced pressure, etc.) which are experienced in the Saturn stages and for which no data were available. The preponderance of the materials evaluated are available commercially.

INTERNAL NOTES

January 4, 1965 FLEXURE FATIGUE PROPERTIES OF IN-P&VE-M-65-1
TYPICAL S-IV COMMON BULKHEAD COM-
POSITE SANDWICH STRUCTURE
AT LIQUID NITROGEN TEMPERATURE

by O. Y. Reece and R. S. Harvey

Unclassified, 12 pages, 1 table, 4 figures

A series of fatigue tests was completed at -196°C (-320°F) in the 0 to 5 million cycles range for the purpose of establishing an S-N curve for a honeycomb structure typical of that used for Saturn S-IV common bulkhead construction. The data and projections show that the average fatigue strength of the panels exceeded the proportional limit in the

range of 0 to 10 million cycles, and the 95 percent confidence limit of the fatigue strength exceeded the proportional limit in the range of 0 to 400,000 cycles.

January 28, 1965 LOW TEMPERATURE MECHANICAL IN-P&VE-M-65-2
 PROPERTIES OF "TENSILIZED"
 WASPALOY BOLTS

by J. W. Montano

Unclassified, 22 pages, 7 tables, 6 figures

This report presents the mechanical properties of "Tensitized" Waspaloy bolts and reduced shank bolt specimens which were tested at temperatures from ambient to -423°F (-253°C). The mechanical properties of the bolt specimens were compared with those of high strength A-286 alloy. It was concluded from the low temperature tests that the "Tensitized" Waspaloy bolts of 5/16-inch diameter, 24 threads per inch should be satisfactory for structural applications in space vehicles at temperatures from ambient to -423°F (-253°C).

April 9, 1965 PRELIMINARY INVESTIGATION OF IN-P&VE-M-65-3
 EXPLOSIVE HAZARDS OF SOLVENTS IN
 CONTACT WITH LIQUID OXYGEN

by C. F. Key and J. B. Gayle

Unclassified, 9 pages, 1 table, 1 figure

Small scale tests were carried out to study the explosive hazards of selected solvents in contact with liquid oxygen. The results indicated that many solvents react explosively with liquid oxygen when suitably initiated. These findings are similar to results of previous studies using nitrogen tetroxide.

June 22, 1965 S-13 THERMAL CONTROL COATING IN-P&VE-M-65-4
 FOR SA-9/PEGASUS A SPACECRAFT

by L. K. Zoller

Unclassified, 15 pages, 5 tables

Optical property data from various tests of the S-13 thermal control coating used on the SA-9 launch vehicle are tabulated. Specimens of the S-13 coating were prepared when the SA-9 vehicle components were painted. These specimens were located in the Launch Complex 37 Service

general, the tensile properties increased with a decrease in temperature, and the properties in the longitudinal direction increased slightly more than in the transverse direction at -253°C (-423°F). The notched tensile strength and notched/unnotched tensile ratio in the transverse direction were slightly higher than in the longitudinal direction at all test temperatures.

January 13, 1966

APPROVAL

NASA TM X-53378

1965 PUBLICATIONS

by Materials Division

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.



W. R. Lucas, Chief, Materials Division



F. B. Cline
Director, Propulsion and Vehicle Engineering Laboratory

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