FY 1978 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 78. It also includes papers of MSFC contractors.

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The information in this report will be of value to the scientific and engineering community in determining what information has been published and what is available.
FOREWORD

In accordance with the NASA Space Act of 1958 the MSFC has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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This document provides guidelines on terrestrial environment data specifically applicable for NASA aerospace vehicles and associated equipment development. The primary geographic areas encompassed are the Kennedy Space Center, Florida; Huntsville, Alabama; Vandenberg AFB, California; Edwards AFB, California; Honolulu, Hawaii; Guam; Santa Susana, California; Brigham, Utah; New Orleans, Louisiana; Bay St. Louis, Mississippi; Houston, Texas; Wallops Flight Center, Wallops Island, Virginia; and the White Sands Missile Range, New Mexico. In addition, a section has been included to provide information on the general distribution of natural environmental extremes in the conterminous United States that may be needed to specify design criteria in the transportation of space vehicle subsystems and components. Although not considered as a specific vehicle design criterion, a section on atmospheric attenuation has been added since certain earth orbital experiment missions are influenced by the earth's atmosphere. A summary of climatic extremes for worldwide operational needs is also included. This document presents the latest available information on probable climatic extremes and succeeds information presented in TM X-64589 and TM X-64757. Information is included on atmospheric chemistry, seismic criteria, and on a mathematical model to predict atmospheric dispersion of aerospace engine exhaust cloud rise and growth. There is also a new section on cloud phenomena. The information in this report is recommended for use in the development of aerospace vehicle and associated equipment design and operational criteria, unless otherwise stated in contract work specifications.

* See notation, page 19.

TM 78125* November 1977
Space Processing Applications Rocket Project SPAR II Final Report. Space Processing Applications Rocket Project Office, Special Projects. N78-15145

This document summarizes the experiment objectives, design/operational concepts, and final results of each of six materials science experiments conducted during the second Space Processing Applications Rocket (SPAR) mission flown by NASA May 17, 1976. The six individual SPAR experiments, covering a wide and varied range of materials processing objectives, were entitled:

1. Solidification of Pb-Sb Eutectic
2. Feasibility of Producing Closed-Cell Metal Foams
3. Direct Observation of Dendrite Remelting and Macrosegregation in Castings
4. Agglomeration in Immiscible Liquids
5. Casting Dispersion – Strengthened Composites at Zero Gravity

The LSI standard cell array technique has been used in the fabrication of more than 20 C-MOS custom arrays. This technique consists of a series of computer programs and design automation techniques implemented at Marshall Space Flight Center and referred to as the Computer Aided Design And Test (CADAT) system that automatically translate a partitioned logic diagram into a set of instructions for driving an automatic plotter which generates precision mask artwork for complex LSI arrays of C-MOS standard cells. The standard cell concept for producing LSI arrays begins with the design, layout, and validation of a group of custom circuits called standard cells. Once validated, these cells are given identification or pattern numbers and are permanently stored. To use one of these cells in a logic design, the user calls for the desired cell by pattern number. The Place, Route in Two Dimension (PR2D) computer program is then used to automatically generate the metalization and/or tunnels to interconnect the standard cells into the required function.

This report contains data sheets that describe the function, artwork, and performance of each of the standard cells, the general procedure for implementation of logic in C-MOS standard cells, and additional detailed design information.

TM-78130 August 1977

The Earth Resources Office, Data Systems Laboratory, Marshall Space Flight Center, hosted a Regional Transfer Activity Contracts Review on February 15-17, 1977. Twenty-one contracts in the Earth resources field primarily directed toward applications of satellite data and technology in solution of state and regional problems were reviewed.
This report gives a summary of the progress of each contract. The purpose of the review, and of this report, is to encourage the sharing of experiences of the researchers across a seven-state region. The region includes Missouri, Kentucky, Tennessee, Mississippi, Alabama, Georgia, and North Carolina.

In addition to research in several Earth science disciplines, which included forestry, limnology, water resources, land-use, geology, and mathematical modeling, the use of computers for establishment of information retrieval systems in the several states was emphasized.

TM-78131 September 1977
A Prediction Model to Forecast the Cost Impact from a Break in the Production Schedule. Dr. Leon M. Delionback. Systems Analysis and Integration Laboratory. N77-34044

The losses which are experienced after a break or stoppage in sequence of a production cycle portends an extremely complex situation and involves numerous variables, some of uncertain quantity and quality. There are no discrete formulas to define the losses during a gap in production. The techniques which are employed are therefore related to a prediction or forecast of the losses that take place, based on the conditions which exist in the production environment. Such parameters as learning curve slope, number of predecessor units, and length of time the production sequence is halted are utilized in formulating a prediction model.

The pertinent current publications related to this subject are few in number, but are reviewed to provide an understanding of the problem.

Example problems are illustrated together with appropriate trend curves to show the approach. Solved problems are also given to show the application of the models to actual cases or production breaks in the real world.

TM-78132 August 1977
Large-Size Monodisperse Latexes as a Commercial Space Product. Dale M. Kornfeld. Space Sciences Laboratory. N78-10293

Dr. John W. Vanderhoff of Lehigh University has proposed Orbital Flight Tests and Spacelab experiments leading to the production of large-size (2 to 40 μm diameter) monodisperse latexes in microgravity. Explanations are given as to why monodisperse particles in this size range are not currently available. The four main topics discussed are: (1) the potential uses of these large particle size latexes, (2) why it is necessary for the particles to have a very narrow size distribution, (3) why large amounts of these monodisperse latexes are needed, and (4) why it is necessary to go to microgravity to prepare these latexes.

TM-78133 October 1977

This report describes a routine for calculating multidimensional histograms of multivariate data using a combination table look-up and search procedure. The software was originally developed to compute four-dimensional histograms from Landsat multispectral imagery, but the concept can be used on other types of data and the program can be modified for the desired type of output information.
The problems of rejecting large amounts of heat have been significantly studied during the past decade. Shuttle Space Laboratory heat rejection uses 1 kW_e for pumps and fans for every 5 kW_t heat rejection. This is rather inefficient, and for future programs more efficient methods must be developed.

This review is based on a 1971 Grumman Aerospace Corporation study with slight changes and improvements. Two advanced systems were studied and compared to the present pumped-loop system. The advanced concepts are the air-cooled semipassive system, which features rejection of large percentage of the load through the outer skin, and the heat pipe system, which incorporates heat pipes for every thermal control function.

Other systems should be reviewed to find the most efficient heat rejection system for payloads in the 1990's. The system selected must use standardized components to reduce test requirements. Paints and other materials used for long-life duration must also be found.

"Off-the-shelf" components which have been demonstrated to offgas considerable quantities of trace contaminant gases will be flown as a part of Spacelab payload equipment. An estimate of the Spacelab Baseline Environmental Control System's contaminant removal capability was required to allow determination of the need for a supplemental trace contaminant removal system. Results from a test program to determine this removal capability are presented.

This report presents ground-level runway wind statistics for the Edwards AFB, California area. Crosswind, tailwind, and headwind reversal percentage frequencies are given with respect to month and hour for the two major Edwards AFB runways. Also presented are Edwards AFB bivariate normal wind statistics for a 90 degree flight azimuth for altitudes 0 through 27 km. Wind probability distributions, synthetic vector wind profiles, and statistics for any rotation of axes can be computed from the five given parameters: u, v, S(u), S(v), and R(uv).

This document presents the engineering report and science payload III test report and summarizes the experiment objectives, design/operational concepts, and final results of each of five scientific experiments conducted during the third Space Processing Applications Rocket (SPAR) flight flown by NASA in December 1976. The five individual SPAR experiments, covering a wide and varied range of scientific materials processing objectives, were entitled: Liquid Mixing, Interaction of Bubbles with Solidification Interfaces, Epitaxial Growth of Single Crystal
Film, Containerless Processing of Beryllium, and Contact and Coalescence of Viscous Bodies.

TM-78138 October 1977

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 77. It also includes papers of MSFC contractors.

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The information in this report will be of value to the scientific and engineering community in determining what information has been published and what is available.

TM-78139 September 1977

A statistical summary is presented of vertical wind speed data recorded at NASA's 150-Meter Ground Winds Tower Facility on Merritt Island, Kennedy Space Center, Florida. One year of continuous around-the-clock vertical wind speed measurements processed by the Automatic Data Acquisition System (ADAS) is classified as a function of tower level (10, 18, 60, and 150 meters) and period of reference [day, month, season: winter (October through March) and summer (April through September), and annual].

Intensity, frequency, time of occurrence, prevailing conditions, etc., of the daily maximum vertical gusts (i.e., updraft and downdraft) are determined. The results are compared with the vertical gusts associated with the daily maximum horizontal gust. The intent of this summarization of vertical wind speed data is to provide a general description of wind flow in the lower 150 meters of the atmosphere for the identification of hazards involved in wind shear encounters relative to ascent and descent of the Space Shuttle and conventional aircraft.

TM-78140 September 1977

The Image Data Processing System (IDAPS) at the Marshall Space Flight Center has been used to analyze radiographs of metal samples to qualitatively and quantitatively map compositional variations across the samples. When the X-ray radiographs are of samples having thickness variations, corrections must be made to accomplish compositional analysis. A correction technique is described for cylindrical samples and is applied to radiographs of SPAR Experiment 74-18. Uncorrected and corrected images are shown.

TM-78141 November 1977

A technique for simulating atmospheric turbulence that accommodates variability of turbulence properties along an aerospace vehicle trajectory is developed. The technique involves the use of Dryden spectral forms in
which the defining parameters are the standard deviations ($\sigma$) and integral scales ($L$) of turbulence. These spectra are expressed as nondimensional functions of the nondimensional frequency $\Omega = \omega L/V$ where $\omega$ is dimensional radian frequency and $V$ is the true air speed of the aerospace vehicle. The nondimensional spectra are “factored” by standard techniques to obtain nondimensional linear recursive filters in the time domain whereby band-limited white-like noise can be operated upon to obtain nondimensional longitudinal, lateral, and vertical turbulence velocities, $u/\sigma_u$, $v/\sigma_v$, and $w/\sigma_w$, respectively, as functions of nondimensional time, $tV/L$, where $t$ is time. Application of the technique to the simulation of the Space Shuttle Orbiter entry flight phase is discussed.

A program implementation model is presented which covers the in-space construction of certain large space systems from extraterrestrial materials. The model includes description of major program elements and subelements and their operational requirements and technology readiness requirements. It provides a structure for future analysis and development.

The work described was motivated by unexpected results from SPAR experiments directed at obtaining fine dispersions of metal systems that in a 1-g environment tend to segregate very rapidly. The SPAR samples exhibited segregation also. The physical processes occurring in fluid samples, such as the SPAR samples before solidification, are shown to be insufficient to produce a well-mixed liquid by the time solidification was initiated. This would result in solidified samples with the type of segregation noted in the SPAR samples. Experimental evidence and analytical arguments are presented.

An investigation is made into the feasibility of placing 120 Satellite Power System (SPS) rectifying antenna (rectenna) sites across the U.S. In the investigation, an initial attempt is made to put two land sites in each state using several land site selection criteria. When only 69 land sites are located, it is decided to put the remaining sites in the sea and sea site selection criteria are identified. An estimated projection of
electrical demand distribution for the year 2000 is then used to determine the distribution of these sites along the Pacific, Atlantic, and Gulf Coasts. A future study will also attempt to include the Great Lakes in this distribution.

As a result of this study, a methodology for distributing rectenna sites across the country and for fine-tuning exact locations is developed, and recommendations on rectenna design and operations are made. This developed methodology will be used in the reevaluation of the rectenna sites identified in this preliminary study. It is suggested that the design recommendations be considered in future rectenna design studies.

TM-78147 December 1977
N78-15628

This report describes the AVE VI Experiment and presents tabulated rawinsonde data at 25-mb intervals from the surface to 25 mb for the 22 stations participating in the experiment. Soundings were taken between 0000 GMT May 27 and 1200 GMT May 28, 1977. The methods of data processing and the accuracy are briefly discussed. Synoptic charts prepared from the data are presented together with an example of contact data.

TM-78148 November 1977
N78-15728

Under the Office of Applications' Data Management Program, an algorithm evaluation activity was initiated to study the problems associated with image processing by assessing the independent and interdependent effects of registration, compression, and classification techniques on Landsat data for several discipline applications. The objective of the activity was to make recommendations on selected applicable image processing algorithms in terms of accuracy, cost, and timeliness or to propose alternative ways of processing the data.

As a means of accomplishing this objective, an Image Coding Panel was established with members from several NASA Centers who represented different types of image processing interests. The Panel established the evaluation criteria, selected the data sets and algorithms, performed the analyses, and presented the results which were documented in the panel summaries. This report describes the conduct of the algorithm evaluation by Marshall Space Flight Center under approved RTOP 656-21-02-02 and in support of the Image Coding Panel.

TM-78149 December 1977
N78-15544

A digitized multispectral image, such as Landsat data, is composed of numerous four dimensional vectors, which quantitatively describe the ground scene from which the data are acquired. One of the purposes of this report is to investigate the statistics of unique vectors that occur in Landsat imagery and determine if that information can provide some guidance on reducing image processing costs. A second purpose of this report is to investigate how the vector statistics are changed by various types of image processing techniques and determine if that information can be useful in choosing one processing approach over another.

Commercial O-rings made from 13 different rubber compounds were tested for physical properties when they were received from the manufacturer and after 7 and 12 years of shelf aging. No gross changes were observed in tensile strength, elongation, or compression deflection characteristics.

This report discusses investigations of several problems of gravitation, including some aspects which are related to the Stanford University/Marshall Space Flight Center gyroscope experiment. In addition, the question of the existence of black holes is considered. While black holes like those in Einstein’s theory may not exist in other gravity theories, trapped surfaces implying such black holes certainly do. The theories include those of Brans-Dicke, Lightman-Lee, Rosen, and Yang. A similar two-tensor theory of Yilmaz is investigated and found inconsistent and nonviable. The Newman-Penrose formalism for Riemannian geometries is adapted to general-gravity theories and used to implement a search for twisting solutions of the gravity theories for empty and nonempty spaces. The method can be used to find the gravitational fields for all viable gravity theories. The rotating solutions are of particular importance for strong field interpretation of the Stanford/Marshall gyroscope experiment. Inhomogeneous cosmologies are examined in Einstein’s theory as generalizations of homogeneous ones by raising the dimension of the invariance groups by one more parameter. The nine Bianchi classifications are extended to Rosen’s theory of gravity for homogeneous cosmological models.

The origination of the Solar Heating and Cooling Commercial Demonstration Program by the Energy Research and Development Administration and the subsequent activities of the Marshall Space Flight Center of the National Aeronautics and Space Administration in the technical evaluation of proposals, contracts definitions, and program management details are defined and discussed.

During the period from initial site selection to present, a significant amount of experience has been gained which should be published to assist others in avoiding these problems. The significant problems are summarized in both technical and management aspects of the program.

It is concluded that the program has significantly stimulated additional solar effort by the program participants. It is also concluded that the use of conventional construction industry organizations with design/competitive bid procedures and standards has maintained a cost effective program.

The collector controller is examined as a functioning control system that drives the Northrop collector from east to west to follow the Sun then back to the east at sundown in readiness for the next sunrise. The major components are examined separately with particular emphasis placed on an analysis of the electronic drive circuit.
Results are presented from hardware testing and analysis with recommended changes to improve the system.

**Effect of Hydraulic Fluid (MIL-H-83282) on Selected Commercial O-Ring Compounds.**
T. E. Wood and W. P. Stone. Materials and Processes Laboratory. N78-18213

This report presents elastomeric materials compatibility data in MIL-H-83282 synthetic hydraulic fluid. Acrylonitrile and fluorocarbon compounds were evaluated at various temperatures and time intervals in samples of the fluid obtained from three qualified suppliers.

It was concluded that both polymers can function in the MIL-H-83282 hydraulic fluids within the conditions defined by this study. Hydraulic fluid from each manufacturer was similar in its effect upon each given O-ring material, with one exception. Similarly, there were no striking differences in the resistance of O-rings of the same generic rubber type when provided by the different manufacturers.

**Satellite Power System Work Breakdown Structure Dictionary.**

A multiple dimension work breakdown structure (WBS) tailored to the unusual requirement of the Satellite Power System (SPS) project is displayed, and each of the WBS terms is defined. The system logic is discussed, and the interrelationship of the various elements of the WBS is described. The resulting WBS, while primarily structured to the unique cost, economic and programmatic requirements, is recommended for general use by all parties involved in the definition and analyses of the SPS project.

**Equal Period Orbit Determination for the Solar System Planets.**
Wilbur H. Funston. Data Systems Laboratory. N78-18092

Rendezvous and docking maneuvers by spacecraft often make use of equi-period orbits. For example, a spacecraft in circular orbit about the Earth’s Moon may put an observation module into an elliptical orbit which lowers the perigee for a closer observation of the lunar surface. Use of equi-period orbits will bring the observation module back to rendezvous with the other module which has remained in circular orbit. There will be one rendezvous opportunity each revolution.

This report presents the determination of a set of equations for equi-period orbits work and a set of figures for quick reference.

**Vibration Effects on the Space Shuttle Main Engine High Pressure Oxidizer Turbopump Bellows.**
James A. Harp. Materials and Processes Laboratory. N78-19190

A welded metal bellows was subjected to a series of vibration tests in a 400 psi oxygen environment to evaluate the effects of the bellows convolutes rubbing on the damper ring in the High Pressure Oxidizer Turbopump of the Space Shuttle Main Engine.

The bellows was subjected to approximately 2 million cycles at 0.007 in. double amplitude displacement during this series of tests, at a frequency of 400 Hz.
Instrumentation of the test specimen revealed no significant heat buildup caused by the rubbing of the bellows convolutes on the damper ring.

A final destruct test was made to determine if a fire would result if the bellows ruptured in the 400 psi oxygen environment, thus exposing a fresh metal surface. The vibration input was changed to 0.8 in. double amplitude displacement of 20 Hz to intentionally rupture the bellows. Failure occurred after 2.5 sec (50 cycles); no fire or heat buildup was encountered.

The purpose of this report is to present additional and improved techniques for the manufacture of Gravity Probe B gyroscopes. Improvements discussed include the redesign of the housings, new techniques for indentation of the electrode surfaces, and a new rotor ball lapping machine. These three items represent a significant improvement in operation of the gyroscope and also make possible the fabrication of a gyroscope which will meet flight requirements.


Although the possibility of using the reduced gravity of space as a means to enhance the performance of certain electrophoresis devices has been considered for several years, there has been no serious attempt to quantitatively compare electrophoresis performance on the ground with that anticipated in space. The computer mathematical models of various proposed electrophoresis systems that have been devised do not lend themselves to parameter optimization as do analytical expressions. Moreover, there has been no attempt to quantitatively determine the limits imposed on ground-based operation by thermal convection. This report derives approximate expressions which will allow estimation of performance enhancement in reduced gravity and also will direct optimization of the various design parameters for a continuous flow electrophoresis system.

The Space Shuttle Solid Rocket Booster (SRB) forward and aft skirts were designed with fracture control considerations used in the design data. Fracture control is based on reliance upon nondestructive evaluation (NDE) techniques to detect potentially critical flaws.


This report presents ground-level runway wind statistics for the Edwards AFB, California area. Crosswind, headwind, tailwind, and headwind reversal percentage frequencies are given with respect to month and hour for the two major Edwards AFB runways. Also presented are Edwards AFB bivariate normal wind statistics for a 90 degree flight azimuth for altitudes 0 through 27 km. Wind probability distributions and statistics for any rotation of axes can be computed from the five given parameters: \( u \), \( v \), \( S(u) \), \( S(v) \), and \( R(uv) \). This document supersedes NASA TM-78136 and should be used in place of it.

In the aerospace industry, welds on aluminum in the thicknesses (0.500 to 1.375 in.) such as those encountered on the SRB skirts are normally welded from both sides to minimize distortion. This presents a problem with the potential presence of undefined areas of incomplete fusion and the inability to detect these potential flaws by NDE techniques. To eliminate the possibility of an undetectable defect, weld joint design was revised to eliminate blind root penetrations. Weld parameters and mechanical property data were developed to verify the adequacy of the new joint design.

TM-78162 March 1978
An Evaluation of Grease Type Ball Bearing Lubricants Operating in Various Environments (Status Report No. 3). E. L. McMurtrey. Materials and Processes Laboratory. N78-20335

Because many future spacecraft or space stations will require mechanisms to operate for long periods of time in environments which are adverse to most bearing lubricants, a series of tests is continuing to evaluate 29 grease type lubricants in R-4 size bearings in five different environments for a 1 year period. Four repetitions of each test are made to provide statistical samples. These tests have also been used to select four lubricants for 5 year tests in selected environments with five repetitions of each test for statistical samples. At the present time, 65 test sets have been completed and 23 test sets are underway. Two (5 year) tests have already been started in (1) continuous operation and (2) start-stop operation, with both in vacuum at ambient temperatures. To date, in the 1 year tests, the best results in all environments have been obtained with a high viscosity index perfluoroalkylpolyether grease.

TM-78163** March 1978

The Marshall Space Flight Center (MSFC) was requested by the Energy Research and Development Agency (ERDA) to assess the general suitability of the design and materials and to investigate certain failure modes of the Owens-Illinois (O-I) Sunpak solar energy collector system. The primary problem was the violent fracture of collector tubes, with attendant scattering of glass fragments, under boilout conditions.

This report presents the data and information generated during the materials analysis segment of this effort. These data were obtained during pressure testing of the individual tubes, performance testing of a complete array of tubes on the MSFC solar simulator apparatus, and in other investigations as noted. The information herein represents only the data directly associated with materials analysis and is not a comprehensive presentation of all the data compiled during the MSFC test program.

TM-78164 February 1978

A simplified stochastic model of spacecraft motion is developed. The model is based on the assumption that the net torque vector due to crew activity and rocket thruster firings is a statistically stationary Gaussian vector process. The process has zero ensemble mean value, and the components of the torque vector are mutually stochastically independent. Each component of the torque
Vector is characterized by a constant, nonzero, spectral density function in the frequency interval $\omega_1 < |\omega| > \omega_0$ with zero spectral density for all other values of $\omega$. The linearized rigid-body equations of motion are used to derive the autospectral density functions of the components of the spacecraft rotation vector which are shown to be proportional to $\omega^{-2}$ over the interval $\omega_1 < |\omega| < \omega_0$ and zero for all other values of $\omega$. The cross-spectral density functions of the components of the rotation vector vanish for all frequencies so that the components of rotation are mutually stochastically independent. The autospectral and cross-spectral density functions of the induced gravity environment imparted to scientific apparatus rigidly attached to the spacecraft are calculated from the rotation rate spectral density functions via linearized inertial frame to body-fixed principal axis frame transformation formulae. The autospectral and cross-spectral densities of the induced gravity vector components are equal to nonzero constants over the frequency interval $\omega_1 < |\omega| < \omega_0$; however, the cross-spectral density functions are less than zero, thus indicating negative correlation between any two unlike induced gravity components in the principal axis frame of the vehicle. The induced gravity process is a Gaussian one with zero mean value. Transformation formulae are used to rotate the principal axis body-fixed frame to which the rotation rate and induced gravity vectors are referred to a body-fixed frame in which the components of the induced gravity vector are stochastically independent.

Rice's theory of exceedances is used to calculate expected exceedance rates of the components of the rotation and induced gravity vector processes. Application of the assumption that the number of exceedances of rotation rate and induced gravity over a given duration time $T$ are Poisson distributed permits calculation of the risks associated with the components of the rotation rate and induced gravity vectors exceeding specified critical values at least once as a function of experiment duration time.

TM-78165** . . . . April 1978

Details of the Marshall Space Flight Center (MSFC) solar simulator construction and operating characteristics are presented. Actual measured values from simulator checkout tests are detailed. Problems encountered during initial startup are discussed and solutions described. Techniques utilized to evaluate collector performance from simulator test data are given. Performance data generated in the simulator are compared to equivalent data generated during natural outdoor testing. Finally, a summary of collector performance parameters generated to date as a result of simulator testing are given.

TM-78166 April 1978

Solar active regions observed during the period of Skylab observations (May 1973-February 1974) have been examined for properties that varied systematically with location on the Sun, particularly with respect to the location of coronal holes. Approximately 90 percent of the optical and X-ray flare activity occurred in one solar hemisphere (136-315 heliographic degrees longitude). Active regions within 20 heliographic degrees of coronal holes were below average in lifetimes, flare production, and magnetic
complexity. Histograms of solar flares as a function of solar longitude have been aligned with Hα synoptic charts on which active region serial numbers and coronal hole boundaries have been added.

TM-78167 April 1978
Space Processing Applications Bibliography. N78-23115

This document is a bibliography of articles, papers, and reports which discuss various aspects of the use of the space environment for materials science research or for commercial enterprise. Since the use of the space environment for materials science is a relatively new undertaking, it is the intent of this document to provide a consolidated reference for those new to the field.

The references are arranged chronologically, and several cross references are provided, as well as instructions for procurement of references.

TM-78168 April 1978
Shear Strength of Fillet Welds in Aluminum Alloy 2219. Charles V. Lovoy. Materials and Processes Laboratory. N78-21495

Fillet welds in aluminum alloy 2219 (2319 filler) are used in the fabrication and assembly of components for the Solid Rocket Booster (SRB) forward and aft skirts, External Tank (ET), and other support equipment. The fillet weld size is normally specified on the engineering drawing and is a theoretical dimension. In this report fillet size is discussed in terms of theoretical or design dimensions versus as-welded dimensions, drawing attention to the inherent conservatism in the design load sustaining capabilities of fillet welds.

Problems associated with inspection of fillet welds are addressed and a comparison is drawn between defect counts obtained by radiographic inspection and by visual examination of the fracture plane.

Fillet weld quality is related lineally to ultimate shear strength. Correlation coefficients are obtained by simple straight line regression analysis between the variables of ultimate shear strength and accumulative discontinuity summation. Shear strength allowables were found to be equivalent to 57 percent of butt weld “A” allowables ($F_{tu}$).

TM-78169 May 1978
Design and Operation of a Solar Heating and Cooling System for a Residential Size Building. N78-25546

The first year of operation of the Marshall Space Flight Center's Solar House is discussed. Selected design information, together with a brief system description, is included. The house is equipped with an integrated solar heating and cooling system which uses fully automated state-of-the-art equipment. Overall performance for the first year is summarized. In addition, information pertaining to modifications made to improve performance is provided, and problems encountered during operation are discussed.

Evaluation of data from the first year of operation indicates that the MSFC solar house heating and cooling system is capable of supplying nearly 100 percent of the thermal energy required for heating and approximately 50 percent of the thermal energy required to operate the absorption cycle air conditioner. The lower percentage of energy provided for the cooling mode as compared to the heating-mode is due to the significantly higher temperature needed to operate the air conditioner, requiring the solar collector to operate at low efficiencies due to the higher inlet temperatures. Operation of the facility in the cooling mode has shown the need for basic subsystem improvements such as
decreasing the operating temperature of the
daire conditioner and/or improving collector
performance.

TM-78170 March 1978

Air Analysis of Maximum Horizontal
Wind Speeds and Associated Parameters
Recorded at NASA’s 150-Meter Ground
Winds Tower Facility at Kennedy Space
Center, Florida. Margaret B. Alexander.
Space Sciences Laboratory. N78-24743

This report presents statistical summaries
of the daily maximum horizontal wind speed and
associated parameters from data recorded
at the National Aeronautics and Space
Administration’s 150-Meter Ground Winds
Tower Facility on Merritt Island, Kennedy
Space Center, Florida. One year of con­
tinuous horizontal wind speed measurements
processed by the Automatic Data Acquisition
System is classified as a function of tower
level (10, 18, 60, and 150 meters) and period
of reference [day, month, season: winter
(October through March) and summer (April
through September), and annual]. Tabula­
tions were made of the daily maximum
horizontal wind speed, time of occurrence,
and five associated parameters: mean hori­
zontal wind speed, maximum vertical gusts
(i.e., updraft and downdraft), and mean and
instantaneous directions. Analyses using these
data included means, extremes, standard
deviations, and frequency distributions.
Comparisons of intensity of maximum hori­
zontal wind speeds determined in this year of
data are made with maximum values recorded
at Kennedy Space Center during another
non-hurricane-occurrence year (1967) and
with values during 1966 through 1972 when
six hurricanes affected the area after the
Ground Winds Tower Facility became opera­
tional in December 1965. The intent of this
report is to provide additional information for
the general description of wind flow in the
lowest 150 meters of the atmosphere for the
identification of hazards involved in wind
shear encounter relative to ascent and descent
of the Space Shuttle and conventional
aircraft.

TM-78171 April 1978

Electrets Used to Measure Exhaust
Cloud Effluents from Solid Rocket
Motor (SRM) During Demonstration
Model (DM-2) Static Test Firing. Michael
Susko. Space Sciences Laboratory.
N78-24281

The purpose of this experimental
research was to compare Marshall Space
Flight Center’s (MSFC) electrets with
Thiokol’s fixed flow samplers during the
Demonstration Model (DM-2) static test firing
at Thiokol’s static test site, January 18, 1978,
near Brigham City, Utah.

The measurement of the rocket exhaust
effluents by Thiokol’s samplers and MSFC’s
electrets indicated that the Solid Rocket
Motor (SRM) had no significant effect on the
air quality in the area sampled. Thiokol had
only one significant measurement. At Plant
78 (Site 12), approximately 6.43 km at a 330
deg heading from the static test stand, the
fixed flow air sampler obtained a trace of
contamination of 0.0017 mg/m³ (back­
ground) and 0.094 mg/m³ (test). Of this total
weight, 0.0017 mg/m³ was of chlorine.
Converting this to parts/million (ppm) gives
0.0006 ppm. At this site, from X-ray
spectroscopy, the electret had a background
count of 1667 and a test count of 2409,
resulting in an increase of 742 counts. One of
the additional electrets, E13, was closer to the
static test site, approximately 585 m at a
heading of 325 deg. The chlorine count from
the X-ray spectroscopy analysis on this
electret was 3576, an increase of 1909 counts.
Equating the counts of 742 to 0.0006 ppm,
1909 counts equals 0.0015 ppm. Again, there
was no measurement of significant rocket
exhaust at the test site.
The results show that the electrets (a passive device which needs no power) can be used effectively alongside existing measuring devices (which need power).

By placing electrets in areas where no power is available, measurements may be obtained. Consequently, it is a valuable complementary instrument in measuring rocket exhaust effluents in areas where other measuring devices may not be able to assess the contaminants.

TM-78172** May 1978

Marshall Space Flight Center personnel have worked for several years with the development and demonstration of solar heating and cooling systems in support of the Department of Energy. In this work, they have encountered numerous problems in the design, production, installation, and operation of the solar energy systems. Many of these problems have been seen in more than one system. This report describes the hardware problems, which range from simple to obscure and complex, and their resolution. It is intended to provide personnel in the solar energy field with information that will help prevent the installation of solar heating and cooling systems that will not operate satisfactorily or that will not last for the design lifetime.

TM-78173 May 1978
Spacelab Mission 1 Experiment Descriptions. Paul D. Craven, Editor. Space Sciences Laboratory.

This document presents brief descriptions of experiments and facilities planned for Spacelab 1. These experiments and facilities were selected from the responses to the Announcement of Opportunity for the first Spacelab mission.

TM-78174 April 1978

This report presents the results of the sequence of tests performed on the Space Shuttle Solid Rocket Booster thrust vector control subsystem by the Marshall Space Flight Center, Huntsville, Alabama. The tests were performed between July and December 1976.

The operational characteristics of the thrust vector control subsystem components, as determined from the tests, are discussed. Special analyses of fuel consumption, basic steady-state characteristics, GN₂ spin, and actuator displacement are presented which will aid in understanding the performance of the auxiliary power unit. The possibility of components malfunction is also discussed.

TM-78175 May 1978

This report presents the experiment description summaries for the first group of materials processing experiments planned for a Shuttle mission. The summaries give the objectives, the approach, the rationale for the use of space, and the anticipated results for each experiment. These experiments form the nucleus of the Materials Processing in Space program in the Shuttle era and provide the science requirements for the definition of the space processing facilities being developed for the Spacelab Module and Pallet.

TM-78176 June 1978
Weld peaking is usually undesirable in any welded structure. In heavy structures, the forces involved in the welding process become very large and difficult to handle. With the Shuttle's Solid Rocket Booster, the weld peaking resulted in two major problems: (1) reduced mechanical properties across the weld joint and (2) fit-up difficulties in subsequent assembly operation. Peaking from the weld shrinkage forces can be fairly well predicted in simple structures; however, in welding complicated assemblies, the amount of peaking is unpredictable because of unknown stresses from machining and forming, stresses induced by the fixturing, and stresses from welds in other parts of the assembly.

When excessive peaking is encountered, it can be corrected using the shrinkage forces resulting from the welding process. Application of these forces is discussed in this report.

TM-78177 May 1978
An Analysis of Maximum Horizontal Wind Speeds Recorded Since 1961 at Kennedy Space Center, Florida.
Margaret B. Alexander. Space Sciences Laboratory.

This report presents tabulations of maximum horizontal wind speed values recorded at the Kennedy Space Center since the Space Sciences Laboratory's Atmospheric Sciences Division began monitoring the winds in the area at Launch Complex 34 in 1961. Monitoring programs and beginning dates also include Launch Complex 37 in 1963, NASA's 150-Meter Ground Winds Tower Facility in 1965, Launch Complex 39A in 1967, and Launch Complex 39B in 1968. As expected, maximum wind speeds were recorded during the eight hurricanes which have affected the area — Cleo in August 1964 through Agnes in June 1972. Detailed tabulations and frequency distributions of daily maximum horizontal wind speeds recorded at NASA's 150-Meter Ground Winds Tower Facility at nine levels from December 1965 through March 1970 are also included.

TM-78179** July 1978

Responding to a request from Energy Research and Development Agency (ERDA), Marshall Space Flight Center (MSFC) conducted an in-depth assessment of problems encountered with the Owens-Illinois SUNPAK™ collector installed in several ERDA solar system demonstration sites. The assessment included analysis and independent tests of the collector in the MSFC Solar Simulator where the system failure conditions were duplicated. The assessment showed the basic design of the SUNPAK™ collector to be sound; however, material limitations dictate that near-term applications constraints be recognized by system designers. MSFC recommendations were presented to ERDA in March 1977. Subsequent retrofit activity by Owens-Illinois appears to have been effective in demonstrating the integrity of the SUNPAK™ collector.

TM-78180** August 1978

This is a continuation of the test program, that was previously reported (NASA TN D-8409, February 1977), to find suitable and effective inhibitors for solar heating and cooling systems. Inhibitors which appeared promising in the previous tests and additional inhibitors including several proprietary products were selected for evaluation. Evaluation of the inhibitors was based on corrosion protection afforded an
aluminum-mild steel-copper-stainless steel assembly in a hot corrosive water. Two inhibitors were found to be effective and show promise for protecting multimetallic solar heating systems.

TM-78181 July 1978

This report presents ground-level runway wind statistics for the Kennedy Space Center, Florida area. Crosswind, headwind, tailwind, and headwind reversal percentage frequencies are given with respect to month and hour for the Kennedy Space Center Space Shuttle runway. This document supersedes NASA CR-128995 and should be used in place of it.

TM-78182** July 1978

This document summarizes final results of Contract NAS8-32255 for the development of an air flat plate collector for use with solar heating, combined heating and cooling, and hot water systems. The contract was for final development, testing, and certification of the collector, and for delivery of a 320 ft² collector panel.

TM-78183 August 1978

This report supplements NASA TMX-73300 and NASA TM X-73393. These reports are compilations of bibliographies from the principal investigator groups of the Apollo Telescope Mount (Skylab solar observatory facility) that gathered data from May 28, 1973, to February 8, 1974. The analysis of these data is presently under way and is expected to continue for several years.

The publications listed in this report are divided into the following categories: (1) Journal Publications, (2) Journal Publications Submitted, (3) Other Publications, (4) Presentations – National and International Meetings, and (5) Other Presentations. An author index is included together with errata for the first report.

TM-78184 August 1978

The results reported in this study support several hypotheses concerning Landsat data that need to be verified further or disproved by examining additional data and by independent investigation performed by other Landsat data users. The hypotheses are as follows:

1) Landsat does not discriminate vegetation types, but mostly sees chlorophyl and canopy cover.

2) A majority of the features in the ground scene possess linearly proportional amounts of “color” from each spectral band.

3) The data are continuous and as a result there is no true separability of ground scene features in the data, but some features possess an excess of color in a particular band pair.

4) There are relatively few features present in the spectral data, and these do not correspond to the conventional definitions that are used.
Aside from seasonal effects, in a distributional sense all Landsat data are essentially the same. The only difference is the way the data are spatially arranged in the image.

This report gives the results and an assessment of the series of ocean environment tests that were conducted at Panama City and Kennedy Space Center, Florida, during the Spring and Summers of 1976 and 1977.

Temperature and size considerations of the tube-fin space radiator are characterized by charts and equations. An approach of accurately assessing rejection capability commensurate with a phase A/B level output is reviewed using the analytical techniques developed by Donald B. Mackey. A computer program, based on Mackey's equations, is also presented which sizes the rejection area for a given thermal load. The program also handles the flow and thermal considerations of the film coefficient.

The Materials and Processes Laboratory at the Marshall Space Flight Center recognized early in the Shuttle program that material performance on a long-term basis would be critical to the success of the Shuttle and its goal of reusable components. The laboratory instituted, in-house, a comprehensive series of materials tests simulating exposure of the refurbishable components of the propulsion system to expected flight and marine environments. These tests were subsequently expanded to include ocean environment exposure of these laboratory type samples. An Integrated Test Bed of 3.048 m (10 ft) diameter by 2.438 m (8 ft) high was also fabricated in support of this program. The Integrated Test Bed allowed large scale evaluation of principal manufacturing, insulating, cleaning and refurbishment methods.

The capabilities described in this report are being utilized in: (1) research and development of new technology, (2) education of individuals in the various disciplines and technologies in the field of microelectronics, and (3) fabrication of many types of specially designed integrated circuits, which are not commercially feasible in small quantities, for in-house research and development programs.
This report calculates the supercooling rate and solidification time for molten drops of niobium, copper, and lead. Calculations for both radiation and helium gas cooling are presented in order to estimate the influence that the presence of helium gas would have upon the cooling rate of falling drops in the Marshall Space Flight Center space processing drop tube.

**TM-78190 August 1978**

Instruments for Measuring the Amount of Moisture in the Air. Dale L. Johnson. Space Sciences Laboratory.

This report presents a summarization and discussion of the many systems available today for measuring moisture in the atmosphere. Conventional methods used in the field of meteorology and methods used in the laboratory are discussed. Performance, accuracies, and response of the instruments are presented as well as the advantages and disadvantages of each. Methods of measuring humidity aloft by instrumentation onboard aircraft and balloons are given, in addition to the methods used to measure moisture at the Earth's surface. Much of the information contained in this report has been summarized from books, papers, and documents available in the open literature which are included as references.

**TM-78191 August 1978**


This report presents the results of an evaluation of an apparatus built by the Jet Propulsion Laboratory under Advanced Applications Flight Experiment (AAFE) program funding. The results are expected to contribute to an improved design for a Fluid Experiments System (FES) planned for Spacelab 3. The detailed results are presented in four categories: (1) human factors, (2) electrical and mechanical, (3) optical performance, and (4) thermal performance.

*Blue cover reports printed at Langley.
**DOE/NASA reports.
The purpose of this experimental research was to investigate electrets, a new device used to detect the chemical composition of rocket exhaust effluents. In assessing the effectiveness of electrets, comparisons were made with hydrogen chloride measuring devices from chamber and field tests and computed results from the NASA/MSFC Multilayer Diffusion Model.

The experimental data used in this investigation were obtained from the 18 static test firings at Marshall Space Flight Center, Huntsville, Alabama, chamber tests at Arnold Engineering Development Center, Tullahoma, Tennessee, and the Viking I launch to Mars on August 20, 1975, from Kennedy Space Center, Florida.

The results show that electrets have multipollutant measuring capabilities, simplicity of deployment, and speed of assessment. The electrets compared favorably with other hydrogen chloride measuring devices. The summary of the measured data from the electrets and the hydrogen chloride detectors is within the upper and lower bounds of the computed hydrogen chloride concentrations from the NASA/MSFC Multilayer Diffusion Model.
material devices. Fundamental mechanisms of heat transfer within the phase change device are discussed. Performance in zero-g and one-g fields are examined as it relates to such a device. Computer models for phase change materials, with metal fillers, undergoing conductive and convective processes are detailed. Using these models, extensive parametric data are presented for a hypothetical configuration with a rectangular phase change housing, using straight fins as the filler, and paraffin as the phase change material. These data are generated over a range of realistic sizes, material properties, and thermal boundary conditions. A number of illustrative examples are given to demonstrate use of the parametric data. Also a complete listing of phase change material property data are reproduced herein as an aid to the reader.

TP-1088 November 1977

An exact expression relating the coordinates of a point on the incident ray, a point of reflection from an arbitrary surface, and a point on the reflected ray is first derived. The exact relation is then specialized for the case of grazing incidence, and first-order and third-order systematic analyses are carried out — first for a single reflective surface and then for a combination of two surfaces. The third-order treatment yields a complete set of primary aberrations for single-element and two-element systems. The importance of a judicious choice for a coordinate system in showing field curvature to clearly be the predominant aberration for a two-element system is discussed. The validity of the theory is verified through comparisons with the exact ray-trace results for the case of the telescope.

TP-1164 February 1978
Analysis of Data Systems Requirements for Global Crop Production Forecasting in the 1985 Time Frame. Sanford W. Downs, Paul A. Larsen, and Dietwald A. Gerstner. Data Systems Laboratory. N78-18497

Starting with the description for the Global Crop Production Forecasting objective as given in "Outlook for Space," Marshall Space Flight Center undertook the task to define the data systems concepts that would be needed to implement this objective in an orderly transition from experimental to operational status in the 1985 time frame. The objective was carefully examined with consideration of the data system implications. Cognizant personnel were interviewed; data processing facilities were surveyed; the impact of future technology development was assessed; pertinent documentation was studied; and previous and current activities in this objective area were evaluated. This investigation served as the foundation for quantifying the objective by obtaining from the most important users their projected information needs. These information needs were then converted into data system requirements, and the influence of these requirements on the formulation of a conceptual data system was analyzed. Any potential problem areas in meeting these data requirements were then identified in an iterative process whereby the scoped objective was further refined as the analysis continued and recommended solutions and alternatives were developed.

TP-1220 April 1978

A program has been underway to evaluate materials for advanced solar arrays which are required to provide power to weight ratios up to 100 W/kg. Severe mission environments together with the lack of
knowledge of space environmental materials degradation rates require the generation of irradiation and outgassing engineering data for use in the initial design phase of the flight solar arrays. Therefore, approximately 25 candidate array materials were subjected to selected mission environments of vacuum, UV, and particle irradiation, and their mechanical and/or optical properties were determined where appropriate.

TP-1225      May 1978

This report presents a summary of a work on nuclear waste disposal in space conducted by the George C. Marshall Space Flight Center, National Aeronautics and Space Administration, and the following contractors: Battelle, Inc.; Northrop Services, Inc.; and Science Applications, Inc. From the aggregate studies, it is concluded that space disposal of nuclear waste is technically feasible.

The preferred baseline is as follows:

Kind of waste considered — Domestic civilian.

Waste mix to be carried — All wastes excluding unburned uranium and reactor cladding hulls. Carrying plutonium is optional.

Waste form — Calcine or calcine in metal matrix.

Launch site — Kennedy Spaceflight Center or a remote complex.

Launch vehicle — Space Shuttle.
aluminum in fresh water were evaluated. These included combinations of borates, nitrates, nitrites, phosphates, silicates, and mercaptobenzothiazole. Eight of fifty inhibitor combinations evaluated gave excellent corrosion protection and compared favorably with sodium chromate, which has generally been considered standard for many years.

TP-1280    July 1978

The exhaust products from the HARPOON booster motors have been analyzed using both thermodynamic analysis and finite-rate chemistry. The resulting constituents are presented together with a discussion of the techniques employed.

TP-1313    August 1978

The possibility of space disposal of iodine waste from nuclear power reactors is investigated. The space transportation system utilized relies upon the Space Shuttle, a liquid hydrogen/liquid oxygen Orbit Transfer Vehicle (OTV), and a solid propellant final stage. The iodine is assumed to be in the form of either an iodide or an iodate, and calculations assume that the final destination is either solar orbit or solar system escape.

It is concluded that space disposal of iodine is feasible.

TP-1328    September 1978

A linear stability analysis of a baroclinic zonal current contained between two parallel rigid boundaries is presented. Curvature is included by performing the analysis on a \( \beta \)-plane and viscosity by allowing for the effects of Ekman layers on the rigid boundaries. A two-layer model is used. This calculation was carried out to assist in the design of a spherical model of the general circulation of the Earth's atmosphere for Spacelab. In the low-gravity environment on an orbiting vehicle, a dominant radial dielectric body force, analogous to planetary gravity, can be achieved over a volume of liquid held between two concentric spheres. The results show the Eady short wavelength cutoff, and long wavelength cutoffs due to Ekman damping and curvature.
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APPROVAL

FY1978 SCIENTIFIC AND TECHNICAL REPORTS,
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Compiled by O. L. White

The information in this report has been reviewed for technical content. 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.

J. T. SHEPHERD
Director, Administration and Program Support

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