LONG DURATION EXPOSURE FACILITY EXPERIMENT
M0003 DEINTEGRATION OBSERVATION DATA BASE

S. R. Gyetvay
J. M. Coggi
M. J. Meshishnek
The Aerospace Corporation
El Segundo, CA 90245

ABSTRACT

The four trays (2 leading edge and 2 trailing edge) of the M0003 materials experiment on LDEF contained 1274 samples from 20 subexperiments. The complete sample complement represented a broad range of materials, including thin film optical coatings, paints, polymer sheets and tapes, adhesives, and composites, for use in various spacecraft applications, including thermal control, structures, optics, and solar power. Most subexperiments contained sets of samples exposed on both the leading and trailing edge trays of LDEF. Each individual sample was examined by high resolution optical microscope during the deintegration of the subexperiments from the M0003 trays. Observations of the post-flight condition of the samples made during this examination were recorded in a computer data base. The deintegration observation data base is available to requesters on floppy disk in 4th Dimension for the Macintosh format. Over 3,000 color macrographs and photomicrographs were shot to complement the observation records and to document the condition of the individual samples and of the M0003 trays. The photographs provide a visual comparison of the response of materials in leading and trailing edge LDEF environments. The Aerospace Corporate Archives is distributing photographs of the samples and hard copies of the database records to the general public upon request. Information on obtaining copies of the data base disks and for ordering photographs and records of specific samples or materials are given in this paper.

INTRODUCTION

The Aerospace Corp. M0003 Experiment

Of the 57 experiments flown on the 86 experiment-holding trays arrayed around the LDEF, M0003 was one of the most comprehensive materials experiments. Experiment M0003 resided on four trays, two on the leading edge of LDEF and two on the trailing edge. This experiment, planned and integrated by the Aerospace Corporation Mechanics and Materials Technology Center, was designed to study the effects of the space environment on current and developmental spacecraft materials. The M0003 experiment was a collection of 20 subexperiments from the Aerospace Corporation Laboratories, Air Force and Navy Laboratories, and Department of
Defense (DoD) contractors, fielded under the sponsorship of the Air Force Space Systems Division and the Space Test Program. The 20 subexperiments are described in Table I; the current point of contact for each is given.

M0003 Trays And Samples

The M0003 hardware consisted of four encircling trays, two Experiment Power and Data Systems (EPDS), two Environment Exposure Control Canisters (EECCs), and several Li/SO\(_2\) batteries to satisfy power requirements. The trays were flown in pairs, one pair consisting of a 6-inch deep tray (carrying a data system and a canister) that was connected by wiring harness to a 3-inch deep tray (carrying mostly sample coupons). One tray pair was located on the LDEF leading edge and a similar pair was located on the trailing edge. Aerospace designated the trays as "L3", "L6", "T3", and "T6", according to the tray depth and leading or trailing edge location, before NASA had assigned the trays to an exact location on the LDEF. Subsequently, these trays were named by NASA according to their row and ring location and are more commonly known as "D9", "D8", "D3", and "D4", respectively. The Aerospace tray designations were ensconced in the unique identification code assigned to each subexperimenter sample for the coordination and data base accounting of the M0003 experiment integration and deintegration and these could not easily be changed.

The design of the M0003 trays was modular, allowing samples to be thermally coupled or decoupled from the tray and therefore, the LDEF structure. Each tray had six of the experiment-carrying modules, designated by Roman Numerals I through VI. The 1274 samples were mounted on anodized black aluminum hardware plates on the modules. The materials in the M0003 experiment included a variety of thermal control paints and coatings, polymers, optics, structural materials, and solar power materials. The M0003 sample complement is diagrammed by these material types in Figures 1 through 5. For brevity, not all samples types are shown in these diagrams.

For the 69 month duration of the LDEF exposure at Low Earth orbit, the four trays of samples experienced different environments which varied according to their location on LDEF; but all trays, leading and trailing edge, experienced the same number of thermal cycles, were exposed to roughly the same number of hours of UV exposure and received the same low levels of electron and proton irradiation. Only the leading edge trays, D8 (L6) and D9 (L3), were subjected to a significant atomic oxygen dose; these trays also received a greater number of hypervelocity impacts than did the trailing edge trays (Ref. 1, 2, 3).

Most of the subexperiments in M0003 contained duplicate sets of samples exposed on the leading and the trailing edge trays. A few had duplicate sets exposed for shorter durations in the canisters as well. Some subexperiments also included a set of "flight control" samples that were mounted within the modules and that were not directly exposed to the space environment, but were subject to the thermal vacuum cycling.

Environment Exposure Control Canisters

The canisters on trays D4 (T6) and D8 (L6) were programmed to open in three stages in order to obtain different duration exposures on some materials. Two weeks after the initiate
signal, the canisters opened to expose a large (\(\sim 3/4\) area) of samples. The next canister stepped movement occurred approximately 23 weeks after deployment and exposed another row of samples (1/8 additional area). The next canister stepped movement was at approximately 33 weeks and exposed the last row of samples (1/8 area) by opening to the canister's fullest extension. The canister drawer closed completely at 42 weeks after initiate and remained closed during the remainder of the LDEF mission. Thus, varying exposure times of 9, 19, and 40 weeks were obtained for some samples in addition to the full mission exposure of 69 months for identical samples on the other M0003 trays. The canisters were opened in a clean room at Aerospace roughly five months after LDEF retrieval. LDEF special investigation group (SIG) personnel were present during this event and sampled the canister gases and assisted in helium leak testing of the seals. The canisters were both essentially at atmospheric pressure and some leakage of the front seals was detected.

THE M0003 EXPERIMENT DEINTEGRATION

Following retrieval of the LDEF, the Aerospace Corporation was charged by the Space Test Program, with documentation of the handling and disassembly of the M0003 experimental trays and with providing support to the subexperimenters. The support included full photographic documentation of the trays, modules, and quarter-modules from the earliest stages of retrieval through the complete deintegration of the trays; photographic documentation of the condition of the individual samples; packaging and return of the samples to the subexperimenters; and providing flight data to the subexperimenters. The deintegration tasks were documented in a relational computer data base, 4th Dimension for the Macintosh.

Inspection at Kennedy Space Center

The deintegration tasks began with inspection of the M0003 trays at Kennedy Space Center following the removal of LDEF from the payload bay of the Shuttle Columbia to the SAEF (Spacecraft Assembly and Encapsulation) II clean room facility. Observations were recorded and NASA photographic surveys were made to document the condition of the trays and samples following their reintroduction into the earth environment (air, humidity, gravity, etc.).

Tray Disassembly at The Aerospace Corporation

The four M0003 trays were air-shipped to the Aerospace Corporation and unpacked and disassembled in a class 10,000 clean room. As test samples were removed from the trays, they were individually examined by optical microscopy and photographed, preserving the orientation of the samples as mounted on the LDEF. Many of the samples experienced space-induced damage effects such as crazing, surface roughening, discoloration, erosion, contamination staining, and hypervelocity impact crater formation. Not all samples exhibited discernible changes, however. Observations of the condition of the samples were made by a single examiner who maintained a consistent criteria for the qualitative descriptions of the condition of all the M0003
samples. Each sample was examined and photographed using optical microscopy at magnifications from 3X to 1000X. A Wild-Heerbrug stereomacroscope and a Zeiss Axioplan Pol research microscope were used for the examinations. Microscopy techniques used included bright field, dark field, and Nomarski differential interference contrast. The observations of the condition of the samples were entered in real time into the computer database. It should be noted that in-depth analysis of the effects of the space exposure on the samples was the prerogative of the subexperimenter and was not the role of the examiner or the deintegration team. The microscopy examination was performed to provide a record of the post-flight condition of all samples in the event that some subexperiments were not reclaimed by the original subexperiments.

All entries in the M0003 database were keyed on a simple database number and unique sample identification code assigned to each sample. How each is used is illustrated in the example in Figure 6. The database number for the sample in this example is #73. Encoded in the sample identification is the sample’s location on the trays, the module on which it was mounted, the subexperiment number, the sample location number on the module, and the identification code number given it by the subexperimenter. In the example, L3II-7-65-10, an optical coating specimen, was fielded on L3 (D9), the leading edge 3-in. deep tray, on module II. It was part of subexperiment 7 and was sample #65 on module II on D9. It was designated as "10" by the principal investigator of the subexperiment.

Photographic And Observation Documentation

Over 3,000 macrographs and photomicrographs were made at the Aerospace Corporation to document the effects observed on the M0003 trays and the individual samples. Overall photographs of the trays, modules, and quarter-modules, (front and back) were shot using large format print film in color and in black and white. An example of one such photograph, a view of the D9 (L3) tray before deintegration of the samples, is shown in Figure 7. As the individual samples were dismounted from the modules, the underlying layers of the module hardware were also photo-documented. In addition, photographs of side-by-side leading and trailing edge pieces of hardware were made for visual comparison of the differences in degree of contamination staining, erosion, discoloration, etc. Photomicrographs made during the optical microscopy examination were recorded on high resolution 35 mm color print film. An example of a series of photographs made of an optical sample is shown in Figure 8. This sample, identified by both database number and sample identification code is a ZnS optical thin film coating on a fused silica substrate. Photographs of this type and the accompanying observation records are available for specific samples by request to the Aerospace Corporation Corporate Archives. The observation record for this sample is shown in Figure 9. The ZnS coating buckled during the 69 months of exposure. In addition, ring-like features, discernible at 200 times magnification, were observed on the buckled surface.

OBTAINING DATA AND PHOTOGRAPHS

The M0003 Deintegration Observation Record Database is available to requesters on an 1.4 MB (HD) diskette in Macintosh 4th Dimension™ format. A user instruction text file is provided on the
disk. The text file includes the detailed examination criteria used in compiling the observation records. A copy of the Aerospace form for ordering records and photographs of samples is also included in this file. The database file contains various layouts for examining the contents of the database by location on the M0003 trays, by sample identification code, or by spacecraft application. Searches may be made by material type, damage effects, categories, or text strings. Observation records in the database file include the dimensions of the samples, the subexperimenter-supplied descriptions of their composition or configuration, the observations made at Kennedy Space Center, the observations made during the deintegration process at Aerospace Corporation, and the subexperiment contacts for additional information on the samples.

The photographic portion of the database is not included on the diskette. The Aerospace Corporate Archives maintains a copy of the entire database to coordinate requests for photographs of specific samples. Requests should be addressed to the Aerospace Corporate Archives, P. O. Box 92957, Mail Station M2/326, Los Angeles, CA 90009-2957, phone (310) 336-5319; FAX (310) 336-5912. The requester should be as specific as possible in stating the type of materials desired (e.g., color prints of full trays, black and white photographs of certain modules, color micrographs of a specific samples, data records, etc.). This service will be provided as long as resources allow.

REFERENCES


<table>
<thead>
<tr>
<th>Subexperiment number</th>
<th>Scope</th>
<th>Subexperiment Point of Contact</th>
<th>Organization/ Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Radar camouflage materials and electro-optical signature coatings</td>
<td>Charles Hurley</td>
<td>Univ. of Dayton Research Inst. 300 College Park Dayton, OH 45469-0001</td>
</tr>
<tr>
<td>-2</td>
<td>Laser optics</td>
<td>Linda De Hainaut</td>
<td>Phillips Lab/LIDA Kirtland AFB, NM 87117-6008</td>
</tr>
<tr>
<td>-3</td>
<td>Structural materials</td>
<td>Charles Miglionico</td>
<td>Phillips Lab/PL/VTSL Kirtland AFB, NM 87117-6008</td>
</tr>
<tr>
<td>-4</td>
<td>Solar power components</td>
<td>Terry Trumble</td>
<td>Wright Labs/POOC Wright Patterson AFB, OH 45433-6533</td>
</tr>
<tr>
<td>-5</td>
<td>Thermal control materials</td>
<td>Charles Hurley</td>
<td>Univ. of Dayton Research Inst. 300 College Park Dayton, OH 45469-0001</td>
</tr>
<tr>
<td>-6</td>
<td>Laser communication components</td>
<td>Randall R. Hodgson</td>
<td>McDonnell Douglas Astronautics Corp. Mail Code 1067267</td>
</tr>
<tr>
<td>-7</td>
<td>Laser mirror coatings</td>
<td>Terry M. Donovan</td>
<td>3481 Murdock Dr. Palo Alto, CA 94306</td>
</tr>
<tr>
<td>-8</td>
<td>Composite materials, electronic piece parts, fiber optics</td>
<td>Gary Pippin</td>
<td>Boeing Aerospace Co. Materials Technology Dept., MS 2E-01</td>
</tr>
<tr>
<td>-9</td>
<td>Thermal control materials, antenna materials, composite materials, and cold welding</td>
<td>Brian C. Petrie</td>
<td>Lockheed Missiles &amp; Space Co. Dept. 62-92, Bldg. 564</td>
</tr>
<tr>
<td>-10</td>
<td>Advanced composite materials</td>
<td>Gary L. Steckel</td>
<td>The Aerospace Corp. P. O. Box 92957, M2/242</td>
</tr>
<tr>
<td>-11, -12</td>
<td>Contamination monitoring, Radiation measurements</td>
<td>Eugene N. Borson, F. B. Sinsheimer</td>
<td>The Aerospace Corp. M2/270</td>
</tr>
<tr>
<td>-14</td>
<td>Quartz crystal microbalance</td>
<td>Donald A. Wallace</td>
<td>QCM Research 2825 Laguna Canyon Road P. O. Box 277</td>
</tr>
<tr>
<td>-15</td>
<td>Thermal control materials</td>
<td>Oscar Esquivel</td>
<td>The Aerospace Corp. M2/241</td>
</tr>
<tr>
<td>-16</td>
<td>Advanced polymer composites</td>
<td>Gary L. Steckel</td>
<td>The Aerospace Corp. M2/242</td>
</tr>
<tr>
<td>-17</td>
<td>Radiation dosimetry</td>
<td>Sam S. Imanoto, J. Bernard Blake</td>
<td>The Aerospace Corp. M2/260</td>
</tr>
<tr>
<td>-18</td>
<td>Thermal control paints</td>
<td>Christopher H. Jaggers</td>
<td>The Aerospace Corp. M2/271</td>
</tr>
<tr>
<td>-19</td>
<td>Electronic Piece Parts</td>
<td>Seymour Feuerstein</td>
<td>The Aerospace Corp. M2/244</td>
</tr>
<tr>
<td>-20</td>
<td>Tray Hardware</td>
<td>Michael J. Meshishinek</td>
<td>The Aerospace Corp. M2/271</td>
</tr>
</tbody>
</table>
Optics
192 Samples
(74 Leading Edge, 118 Trailing Edge)

Substrates
46 Samples
(19 LE, 27 TE)
SiC2
Mo
Cu
Sapphire
Au/Cu
ZnSe
Black Glass
794O S+Ge

Mirrors
76 Samples
(37 LE, 41 TE)
ThF4Ag on Mo
Al2O3Si/Ag on Mo
(AI2O3/ZnS)x/Al on Mo
ThF4znS onSiO2
Black Glass
Ir on C
Al on SiO2
Rh on C
Ag
Au
Ni
OSRs

Coatings
125 Samples
(49 LE, 76 TE)
MgF2 on SiO2
ThF4 on SiO2
SiOx Si on SiO2
NaF on SiO2
As2Se3 on SiO2
PbF2 on SiO2
Ni on Cu
ZnS ThF4
TiO2 SiO2 on SiO2
Al2O3 on CaF2

Figure 1. Diagram of Optics samples in database.

Structures
715 Samples
(353 Leading Edge, 362 Trailing Edge)

Ceramics
6 Samples
(5LE, 3 TE)
SnN4
ZrO2 Foam
Macor

Composites
682 Samples
(341 LE, 341 TE)
Metal Matrix(146 LE, 145 TE)
Glass Matrix
Thermoplastic Resin Matrix
(48 LE, 45 TE)
Polysulfone
Polyethersulfone
Thermoset Resin Matrix
(138 LE, 143 TE)
Epoxy
Polymide
Polyarylacetylene
Phenolic
Carbon-Carbon(2 LE, 2TE)
Wires (57 LE, 57 TE)

Metals
309 Samples
(155 LE, 154 TE)
Al (6061-T6)
Al (2024)
Ni
Cu
Mo
Mg
Ti + B Alloy
Invar

Figure 2. Diagram of Structure samples in database.
Figure 3. Diagram of Thermal Control samples in database.

Figure 4. Diagram of Polymer samples in database.
Figure 5. Diagram of Solar Power samples in database.

Figure 6. Diagram of M0003 database.
Figure 7. View of the D9 (L3) tray before deintegration of the samples.
Figure 8. Macrographs and micrographs of sample Database #73.

View A. Module macrograph - Module II on Tray D9.
View B. Sample macrograph of DB#73 (L311-7-65-10, ZnS coating on fused silica, .375 in. dia.).
View C. Low magnification micrograph of buckled coating on surface of DB#73.
View D. High magnification micrograph of annular features on buckled coating on DB#73.
LDEF M0003 Sample Observation

Sample ID: L3II-7-65-10
Database #: 73

<table>
<thead>
<tr>
<th>Tray: D9</th>
<th>Module: II</th>
<th>Experiment #: 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Coating, ZnS on SiO2 (SiO2 substrate, ZnS coating)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Width: 0.375 |
| Length: - |
| Thickness: 0.100 |
| Category: Coating, glass |
| Subcategory: Coated substrate |
| Application: Optics |
| Exposure: 69 months |
| Post-flight Condition: Buckled (+), delaminated |

Observations at KSC Before Deintegration:
SURFACE CRAKED, FLAKING

Observations at The Aerospace Corporation:
Date: Tuesday, May 15, 1990
The exposed coating appears uniformly buckled; some areas have buckled so severely that the coating has flaked. In the flaked areas, the residual surface (the substrate) is smooth. Another phase appears to have nucleated on the top of the buckled surface. This phase is manifested, in various stages of formation, as crescent-, ring- or circular-shaped features on the surface.

Point of Contact:
Terry Donovan
3481 Murdoch Dr.
Sanford, CA 94306
FAX: (-) 000-0000

Publications:

Mechanics and Materials Technology Center
THE AEROSPACE CORPORATION

Figure 9. Example of hard copy database observation record (DB#73).
COLOR PHOTOGRAPHS

Figure 3. Layered contaminant films from Tray C12.
(Color version of black and white photograph shown on page 1028.)

Figure 5. Outgassed material on LDEF structure near vents from interior.
(Color version of black and white photograph shown on page 1029.)
Figure 1. Photograph of black chromium plated solar absorber panel, experiment AO076, tray F9.
(Color version of black and white photograph shown on page 1106.)
AUTHOR INDEX

L-90-11206
## Author Index

<table>
<thead>
<tr>
<th>Author</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams, J.H., Jr.</td>
<td>247, 1551</td>
</tr>
<tr>
<td>Agüero, R.C.</td>
<td>665</td>
</tr>
<tr>
<td>Ahearn, J.S.</td>
<td>1285</td>
</tr>
<tr>
<td>Albrecht, A.</td>
<td>231</td>
</tr>
<tr>
<td>Allbrooks, M.K.</td>
<td>595</td>
</tr>
<tr>
<td>Alston, J.A.</td>
<td>1493</td>
</tr>
<tr>
<td>Amari, S.</td>
<td>513</td>
</tr>
<tr>
<td>Armstrong, T.W.</td>
<td>137, 163, 187, 195, 207, 221</td>
</tr>
<tr>
<td>Arthur, R.J.</td>
<td>79</td>
</tr>
<tr>
<td>Atkinson, D.R.</td>
<td>277, 595, 619, 1399</td>
</tr>
<tr>
<td>Auer, B.M.</td>
<td>1137</td>
</tr>
<tr>
<td>Bada, J.</td>
<td>453</td>
</tr>
<tr>
<td>Banks, B.A.</td>
<td>431, 1137</td>
</tr>
<tr>
<td>Beahm, L.P.</td>
<td>247</td>
</tr>
<tr>
<td>Beaujean, R.</td>
<td>239</td>
</tr>
<tr>
<td>Becker, L.</td>
<td>453</td>
</tr>
<tr>
<td>Benton, E.R.,</td>
<td>171, 181</td>
</tr>
<tr>
<td>Benton, E.V.</td>
<td>163, 171, 181, 187</td>
</tr>
<tr>
<td>Bergman, L.A.</td>
<td>1439</td>
</tr>
<tr>
<td>Bernhard, R.P.</td>
<td>541, 551</td>
</tr>
<tr>
<td>Berry, J.N.</td>
<td>1425</td>
</tr>
<tr>
<td>Best, S.</td>
<td>479</td>
</tr>
<tr>
<td>Blake, J.B.</td>
<td>147</td>
</tr>
<tr>
<td>Blakkolb, B.K.</td>
<td>1035, 1343</td>
</tr>
<tr>
<td>Blue, M.D.,</td>
<td>1333</td>
</tr>
<tr>
<td>Boberg, P.R.</td>
<td>247</td>
</tr>
<tr>
<td>Bobias, S.G.</td>
<td>87</td>
</tr>
<tr>
<td>Bohnhoff-Hlavacek, G.</td>
<td>1223</td>
</tr>
<tr>
<td>Bonnemason, F.</td>
<td>1401</td>
</tr>
<tr>
<td>Borg, J.</td>
<td>347</td>
</tr>
<tr>
<td>Borson, E.N.</td>
<td>1033</td>
</tr>
<tr>
<td>Bosch, J.</td>
<td>261</td>
</tr>
<tr>
<td>Bourassa, R.J.</td>
<td>13</td>
</tr>
<tr>
<td>Bourrieau, J.</td>
<td>157</td>
</tr>
<tr>
<td>Bowen, H.S.</td>
<td>1035</td>
</tr>
<tr>
<td>Bradley, J.</td>
<td>577</td>
</tr>
<tr>
<td>Brennan, P.J.</td>
<td>1455</td>
</tr>
<tr>
<td>Brinker, D.J.</td>
<td>1291, 1375</td>
</tr>
<tr>
<td>Brodzinski, R.L.</td>
<td>79</td>
</tr>
<tr>
<td>Brownlee, D.E.</td>
<td>577, 677</td>
</tr>
<tr>
<td>Bühler, F.</td>
<td>705</td>
</tr>
<tr>
<td>Bunch, T.E.</td>
<td>347, 453</td>
</tr>
<tr>
<td>Burns, F.</td>
<td>107</td>
</tr>
<tr>
<td>Cagle, J.A.</td>
<td>1511</td>
</tr>
<tr>
<td>Callen, W.R.</td>
<td>1403</td>
</tr>
<tr>
<td>Carabétian, Ch.</td>
<td>1355</td>
</tr>
<tr>
<td>Chaloupka, T.</td>
<td>479</td>
</tr>
<tr>
<td>Champetier, R.J.</td>
<td>1399</td>
</tr>
<tr>
<td>Chang, A.C.</td>
<td>827</td>
</tr>
<tr>
<td>Chapman, S.P.</td>
<td>1425</td>
</tr>
<tr>
<td>Chatzitheodoridis, E.</td>
<td>791</td>
</tr>
<tr>
<td>Coggi, J.M.</td>
<td>357, 1075, 1235</td>
</tr>
<tr>
<td>Christl, L.C.</td>
<td>1169</td>
</tr>
<tr>
<td>Colborn, B.L.</td>
<td>137, 163, 187, 195, 207, 221</td>
</tr>
<tr>
<td>Cooke, W.J.</td>
<td>667, 693</td>
</tr>
<tr>
<td>Coombs, C.R.</td>
<td>277, 595, 619</td>
</tr>
<tr>
<td>Crawford, G.</td>
<td>479</td>
</tr>
<tr>
<td>Cromer, T.F.</td>
<td>1015</td>
</tr>
<tr>
<td>Cromwell, B.K.</td>
<td>1001</td>
</tr>
<tr>
<td>Crutcher, E.R.</td>
<td>1023, 1187</td>
</tr>
</tbody>
</table>

**PRECEDING PAGE BLANK NOT FILMED** 1251
Kemp, W.T. 1399
Kenemuth, J.R. 1361
Keough, B. 1041
Kessler, D.J. 585
Kinard, W.H. 277
Kinser, D.L. 529
Klein, J. 231
Kosic, T.J. 1035
Laird, C.E. 111, 125
Lange, G. 513
Lauriente, M. 51
Le, T.D. 977
Lee, M. 957
Letton, A. 849
Lind, D.L. 705
Lind, M.D. 725
Linton, R.C. 1151
Lyon, I.C. 791
Mack, K.S. 313
Mackay, N. 417
Macklin, J. 453
Mallon, J.J. 963
Mandeville, J.-C. 303, 347
Manuelpillai, G. 493
Masarik, J. 87
Mason, J.B. 1257
Matthews, R. 877
McCreight, C. 1455
McDonnell, J.A.M. 417
McKibben, R.B. 1535
McIntosh, R. 1455
Mell, R.J. 1061, 1111
Merrow, J.E. 431
Meshishnek, M.J. 357, 1075, 1235
Middleton, R. 231
Migliorino, C.J. 905
Miller, E.R. 1061, 1111
Mirtich, M.J. 431
Misra, V. 677
Monarski, T.W. 1425
Moss, C.E. 87
Motley, W.R. III 667
Mulholland, J.D. 667, 693
Murr, I.E. 905
Mustico, A. 1389
Newman, P.J. 417
Newman, S.C. 1511
Nielsen, K.F. 725
Norwood, J.K. 1125
Oda, K. 171
O'Donnell, J.H. 867
Oliver, J.P. 667, 693
Olmez, I. 107
O'Sullivan, D. 261
Padden, R.J. 1425
Parnell, T.A. 69, 111, 125, 171, 187
Paschen, K.W. 357
Pender, C.W. 1001
Perry, A.T. 1511
Peters, P.N. 3, 1111, 1169
Pippin, H.G. 13, 1023, 1041, 1187
Pomery, P.J. 867
Radhakrishnan, G. 1269
Radicati di Brozolo, F. 347, 453
Raikar, G.N. 1169
Rasoul, F.A. 867
Reedy, R.C. 87
Reeves, J.H. 79
Ricks, D.A. 677
Rooney, W. 957
Rose, M.F. 479
Roybal, R.E. 905
1253