

IG-01-034

**AUDIT
REPORT**

**CONTROLS OVER THE USE OF PLASTIC
FILMS, FOAMS, AND ADHESIVE
TAPES IN AND AROUND THE SPACE SHUTTLE
ORBITER VEHICLES**

August 31, 2001



National Aeronautics and
Space Administration

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Acronyms

ESD	Electrostatic Discharge
GSOP	Ground Safety Operating Procedures
M&P	Materials and Processes
MAPTIS	Materials and Processes Technical Information System
NSTS	NASA Space Transportation System
OIG	Office of Inspector General
PFA	Plastic Film, Foam, and Adhesive Tape
SFOC	Space Flight Operations Contract
USA	United Space Alliance

W

August 31, 2001

TO: A/Administrator

FROM: W/Inspector General

SUBJECT: INFORMATION: Controls Over the Use of Plastic Films, Foams, and Adhesive Tapes In and Around the Space Shuttle Orbiter Vehicles
Report Number IG-01-034

The NASA Office of Inspector General (OIG) is performing an audit of the United Space Alliance's (USA's) safety procedures under NASA's Space Flight Operations Contract (SFOC).¹ As part of the audit, we reviewed USA's controls over the use of plastic films, foams, and adhesive tapes (PFA's) used in and around² the orbiter vehicles and other segments of the Space Shuttle such as the solid rocket boosters and main engines. As previously reported to you in Safety Alert 01-01, dated May 22, 2001, we found that USA was routinely using in and around the Space Shuttle orbiter vehicles, PFA's that had no record of being tested to ensure that the PFA's met NASA standards for flammability resistance, electrostatic discharge (ESD) rate, or compatibility with rocket fuel. In addition, neither the John F. Kennedy Space Center (Kennedy) nor USA safety personnel had approved the use of these materials, thereby creating a potential safety hazard to personnel, the orbiter vehicles, and other flight hardware and equipment.

¹ NASA awarded the SFOC to USA of Houston, Texas, on September 26, 1996. USA is a joint venture of The Boeing Company and Lockheed Martin to conduct the SFOC and is the prime contractor for NASA's Space Shuttle Program. USA performs work for SFOC under contract number NAS9-20000. The total contract cost plus fee is estimated at \$8.6 billion. The contract is a cost-plus-incentive-fee/award-fee type contract and has a period-of-performance of October 1, 1996, through September 30, 2002. The contract includes two, 2-year option periods, which potentially extend the period-of-performance through September 30, 2006.

² Revision A of NASA Space Transportation System 08242, "Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles," (NSTS 08242) defines "in and around" as "in contact with the orbiter's exterior surfaces or within approximately three feet of the orbiter's exterior mold line." The SFOC requires USA to conform to the NSTS 07700 series of documentation. NSTS 07700, "Space Shuttle Program Requirements and Description," Volume V, references NSTS 08242 and states that a detailed materials list shall be provided for all materials approved for use in and around the orbiter vehicle during ground operations.

We have addressed safety involving NASA contractors, including the control of PFA's at Kennedy's payload processing facilities, in four prior audit reports.³ A synopsis of those reports is in Appendix B.

Background

USA's Space Shuttle processing activities at Kennedy occur in several facilities. In each of those facilities, USA uses various PFA's to protect surfaces of the orbiter vehicles and other segments of the Space Shuttle. More specifically, USA covers sensitive electrical components with plastic film secured with adhesive tape to prevent contamination. USA also uses foam padding inside compartments of the orbiter vehicles to protect flexible hoses and cables from damage by technicians. The same foam covers the wings of the orbiter vehicle to prevent damage during processing.

Kennedy Handbook 1710.2, "Kennedy Space Center Safety Practices Handbook," requires that plastic films, foams, and adhesive tapes pass acceptance criteria for flammability resistance, ESD rate, and hypergolic compatibility.⁴ Kennedy and USA management have acknowledged the risks of using PFA's around Space Shuttle payloads and flight hardware. Such risks include fire ignition from ESD sensitive materials and fire propagation through materials that do not meet flammability standards. Since 1995, several fires involving PFA's that did not meet NASA standards have occurred in Kennedy facilities that house the orbiter vehicles and other hardware and equipment (including an incident as recently as April 2001), resulting in significant property damage. Because of those risks, NASA and USA have developed specific policies and procedures regarding the use and control of PFA's around space flight hardware.

Recommendations

We recommended that management improve the controls over the use of PFA's in and around the orbiter vehicles by developing one centralized list of PFA's approved for use in and around the orbiters, clarifying procedures for using materials not on the approved

³ We issued reports No. IG-01-017, "Space Shuttle Program Management Safety Observations," March 23, 2001; No. IG-00-035, "Contract Safety Requirements at Kennedy Space Center and Marshall Space Flight Center," June 5, 2000; No. IG-00-028, "Safety Concerns with Kennedy Space Center's Payload Ground Operations," March 30, 2000; and No. IG-99-047, "Safety Considerations at Goddard Space Flight Center," September 22, 1999.

⁴ Kennedy Handbook 1710.2, references the Kennedy Materials Sciences Division Intranet, which also includes foams as materials that must pass the acceptance criteria. The basic requirements are:
Flammability Resistance – the material should be self-extinguishing before 6 inches of the test sample is consumed, should not drip flaming particles, and should not permit fire to propagate to another object.
ESD – the material cannot hold a charge of more than 350 volts, 5 seconds after termination of the initial charge.
Hypergolic Compatibility – the material should not have an extreme reaction such as discoloration or temperature increase when exposed to hypergols (rocket fuel).

list, and requiring personnel from the Kennedy Shuttle Processing Directorate's, Shuttle Safety and Mission Assurance Division (Kennedy Shuttle Safety Office) to be more involved in the control and use of PFA's. We also recommended that management review a group of questioned PFA's listed in Appendix E of our report to ensure that the materials are being used safely. These recommendations will help ensure that NASA knows the flammability, ESD, and hypergolic compatibility characteristics for the PFA's used in and around the orbiters and exercises proper safety precautions based on those characteristics. These actions will help to reduce the risk of harm to personnel and damage to the orbiter vehicles and other space flight hardware and equipment.

Management Response and OIG Evaluation

Kennedy partially concurred with all the recommendations, but we are concerned that the proposed actions are responsive to only three of the five recommendations.⁵ Management responded that the administration and documentation of the control and use of PFA's needs improvement. Kennedy asserted that all PFA's used in and around the orbiter vehicles were used safely. Kennedy has established an inter-Center team to review and improve requirements, policies, and processes related to the use of PFA's at Kennedy. Kennedy reviewed the PFA's listed in Appendix E of our report and asserted that all of those materials were used properly.

Kennedy did not provide specific corrective actions regarding how the Kennedy Shuttle Safety Office will review all proposed USA Ground Safety Operating Procedure (GSOP) changes prior to implementation as required by the SFOC, determine whether potential hazards are present in operations, and approve and allow the use of materials that have failed required tests or have not been tested. We have asked management to provide specific corrective actions and implementation dates.

Although management concluded that it used all of the materials safely, that was not the case during our audit field work. When we initially presented our audit results, management did not know whether USA used the materials safely but stated that it would perform further research. More than 4 months after receiving our results, Kennedy concluded that USA used the materials safely even though Kennedy was never able to present evidence of materials testing results from any NASA Center or test facility. In our opinion, management should know at all times whether materials in or around the orbiter vehicles are used in a safe manner.

⁵ Management asserted that appropriate corrective action was taken in response to an official mishap report attributing a 1995 fire in Kennedy's Orbiter Processing Facility to improper use of PFA's. However, since 1995, at least two additional mishaps involving PFA's have occurred in Kennedy facilities that house the Space Shuttle orbiters and other hardware and equipment. In August 1998, a fire in USA's Kennedy Logistics Support Facility started when a spark ignited gases in a plastic bag that held lithium batteries. In April 2001, vapors from a bottle containing a waterproofing agent ignited in the Orbiter Processing Facility during the use of materials that had a high potential for ESD. Additional corrective actions are warranted to ensure proper control of PFA's.

Management also commented extensively on our findings (see Appendix F). We respond to those comments in Appendix G of the report.

Details on the status of the recommendations are in the report's recommendation section.

[original signed by]

Roberta L. Gross

Enclosure

Final Report on Audit of Controls Over the Use of Plastic Films, Foams, and Adhesive Tapes In and Around the Space Shuttle Orbiter Vehicles

FINAL REPORT
AUDIT OF CONTROLS OVER THE USE OF PLASTIC FILMS,
FOAMS, AND ADHESIVE TAPES IN AND AROUND THE SPACE
SHUTTLE ORBITER VEHICLES

W

August 31, 2001

TO: M/Associate Administrator for Space Flight
Q/Associate Administrator for Safety and Mission Assurance
AA/Director, John F. Kennedy Space Center

FROM: W/Acting Assistant Inspector General for Audits

SUBJECT: Final Report on Audit of Controls Over the Use of Plastic Films, Foams, and
Adhesive Tapes In and Around the Space Shuttle Orbiter Vehicles
Assignment Number A-00-041-01
Report Number IG-01-034

Enclosed please find the subject final report. Our evaluation of your response has been incorporated into the body of the report and is included in its entirety in Appendix F. We consider management's proposed corrective actions responsive for recommendations 1, 4, and 5. We request that management provide additional comments on recommendations 2 and 3 by October 30, 2001. The additional comments should provide the specific corrective actions and implementation dates in relation to how the Kennedy Shuttle Safety Office will (1) review all proposed Ground Safety Operating Procedure (GSOP) changes prior to implementation as required by the Space Flight Operations Contract (SFOC), (2) determine whether potential hazards are present in operations, and (3) review and approve Material Use Permits or variances that allow the use of materials that have failed required tests or have not been tested. The recommendations will remain open for reporting purposes until corrective actions are completed. Please notify us when action has been completed on the recommendations, including the extent of testing performed to ensure corrective actions are effective. The final report distribution is in Appendix H.

We appreciate the courtesies extended to the audit staff. If you have questions concerning the report, please contact Mr. Kevin J. Carson, Deputy Assistant Inspector General for Audits, at (301) 286-0498, or Mr. Karl Allen, Audit Program Manager, at (202) 358-2595.

[original signed by]

Alan J. Lamoreaux

Enclosure

cc:

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B/Acting Chief Financial Officer

B/Comptroller

BF/Director, Financial Management Division

G/General Counsel

H/Associate Administrator for Procurement

JM/ Director, Management Assessment Division

QS/Director, Safety and Risk Management Division

AA/Acting Director, Lyndon B. Johnson Space Center

NASA Office of Inspector General

IG-01-034
A-00-041-01

August 31, 2001

Controls Over the Use of Plastics Films, Foams, and Adhesive Tapes In and Around the Space Shuttle Orbiter Vehicles

Introduction

The OIG is performing an audit of USA's Safety Procedures under NASA's SFOC. USA is responsible for the day-to-day operation and management of the U.S. Space Shuttle fleet. USA's work affects the safety of NASA's astronauts, the Space Shuttle orbiters and other flight hardware, personnel, and equipment. In conducting our audit, we reviewed USA's controls over the use of PFA's in and around the orbiter vehicles and other segments of the Space Shuttle such as the solid rocket boosters and main engines. We identified several weaknesses with the control of PFA's and are bringing these observations to management's attention as we continue with our overall audit of USA's safety program.

Our overall audit objective is to evaluate USA safety procedures for NASA's SFOC. The specific objective related to this report was to determine whether Kennedy properly controlled potentially unsafe materials used in contract performance. Appendix A contains further details on the audit objectives, scope, and methodology.

Results in Brief

Kennedy management has acknowledged the safety risks of not properly controlling the use of PFA's in NASA facilities and requires all such materials to be evaluated for flammability resistance, ESD rate, and hypergolic compatibility characteristics. However, USA is routinely using in and around the orbiter vehicles and other segments of the Space Shuttle PFA's for which those characteristics are not known. Neither the USA Safety Office nor the Kennedy Shuttle Safety Office have approved these materials for use. Further, USA's procedures for the safe handling and use of PFA's in and around the orbiter vehicles were not effective in that USA (1) allowed a Materials and Processes (M&P) engineer, rather than a safety professional, to make key safety decisions regarding the use and testing of PFA's; (2) changed its procedures concerning PFA's rather than comply with established testing and safety requirements; and (3) continued to use

materials that had contributed years earlier to a fire in the Kennedy Orbiter Processing Facility.⁶ This lack of control over the use of PFA's creates a potential safety hazard to personnel, the orbiter vehicles, and other flight hardware and equipment.

Background

USA's specific responsibilities include Space Shuttle modification, testing, checkout, launch and landing activities at Kennedy, and flight operations at the Lyndon B. Johnson Space Center (Johnson). USA's Space Shuttle processing activities at Kennedy occur in several facilities, including the (1) Vehicle Assembly Building;⁷ (2) three high bays of the Orbiter Processing Facility; (3) Hypergolic Maintenance Facility;⁸ and (4) Rotation, Processing, and Surge Facility.⁹ In each of these facilities, USA uses various PFA's to protect surfaces of the orbiter vehicles and other segments of the Space Shuttle.

The Kennedy Directors of Logistics Operations and Space Station and Shuttle Payloads recognized the risks associated with using PFA's in a June 1999 memorandum. The memorandum directed personnel to improve safety procedures in two Kennedy processing facilities and emphasized the need to properly control PFA usage as follows:

. . . it is important that the Materials and Processes (M&P) engineers control the use of PFA's and solvents in [the Operations and Checkout Building and the Space Station Processing Facility]. . . Compliance with the rules for the use of materials that meet the requirements for flammability resistance, electrostatic discharge, odor, offgassing, breakthrough resistance, and fluid compatibility is mandatory to ensure safety, contamination control, and mission success.

Control of PFA's In and Around Space Shuttle Orbiter Vehicles

We identified PFA's that are either in use or approved for use in and around the orbiters for which USA has not properly identified the flammability resistance, ESD rate, and hypergolic compatibility characteristics. USA did not have any of the PFA's tested for those characteristics as required, and Kennedy and USA safety professionals have not approved the PFA's for use. This condition exists because of (1) inadequate USA procedures for ensuring the testing and safe use of PFA's, (2) inadequate oversight by the Kennedy Shuttle Safety Office, and (3) incomplete material

⁶ The Orbiter Processing Facility consists of three high bays, two low bays, and administrative space where USA conducts post-landing orbiter vehicle inspections, testing, and refurbishment and installation and checkout of the payload for the next mission.

⁷ USA uses the Vehicle Assembly Building for (1) integration and stacking of the Space Shuttle vehicle, (2) external tank checkout and storage, (3) contingency storage, (4) payload canister operations, and (5) solid rocket booster handling.

⁸ The Hypergolic Maintenance Facility consists of three buildings and all facilities required for USA to process and store the hypergolic-fueled modules for the orbiter's reaction control system, orbital maneuvering system, and auxiliary power units.

⁹ USA uses this facility to isolate hazardous operations associated with solid rocket motor rotation and processing capabilities and to conduct solid rocket motor receiving, rotation, and inspection.

approval and testing records. As a result, materials USA is using in or near the orbiter vehicles may not meet NASA standards for flammability resistance, ESD rate, and hypergolic compatibility. This situation creates a potential fire hazard and a safety risk to personnel, the orbiter vehicles, and other flight hardware and equipment.

Requirements for Safe Use of PFA's

The SFOC establishes the responsibilities for ensuring safe operations at Kennedy's Space Shuttle processing facilities as follows:

Safety Responsibilities at Kennedy's Space Shuttle Processing Facilities

<u>Organization</u>	<u>Safety Responsibilities as Defined by the SFOC</u>
USA	Develop and implement (1) an approach in which ground operations and maintenance activities are assessed for hazards and (2) a process in which NASA and other noncontractor personnel and property are protected from injury or harm as a result of exposure to those hazards.
NASA (Kennedy Shuttle Safety Office)	Perform surveillance, audits, and technical insight of contractor safety and mission assurance activities; prepare and maintain a ground operations safety surveillance plan; and review and approve variance requests.

Numerous NASA-wide and Kennedy-specific requirements address the testing and control of PFA's and other materials. Appendix C provides details on these requirements.¹⁰ NASA and Kennedy policies generally require that all PFA's used near the orbiter vehicles be tested and evaluated for NASA's standards for flammability resistance, ESD rate, and hypergolic compatibility characteristics. Use of the PFA's must then be controlled based on those characteristics. Materials that meet NASA standards are placed on approved lists.¹¹ Materials that do not meet those

¹⁰ Attachment J-11 to the SFOC refers to applicable NASA policies and procedures. Specifically, the SFOC incorporates, by reference, NASA-STD-6001 and Kennedy Handbook 1710.2. Appendix C of this report contains additional requirements regarding PFA testing and control. These additional requirements are also incorporated, by reference, into the SFOC contract.

¹¹ Several sources identify the PFA's approved for use in and around the Space Shuttle orbiter vehicles: (1) Appendix C of NSTS 08242, "Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles"; (2) Appendix I of USA's GSOP 5400; (3) the Kennedy Materials Science Division's Intranet; and (4) the George C. Marshall Space Flight Center's (Marshall) online Materials and Processes Technical Information System (MAPTIS), which contains test data for PFA's tested at other NASA locations such as Marshall or NASA's White Sands Test Facility.

standards can be used only after obtaining a Materials/Equipment Usage Permit (Material Use Permit)¹² or a safety variance,¹³ both of which require USA and Kennedy safety office approval.

Based on the safety responsibilities as described in the SFOC and NASA and Kennedy policies on the testing and control of PFA's, the process flow for the safe use of PFA's in and around the Space Shuttle orbiter vehicles is depicted in Figure 1.

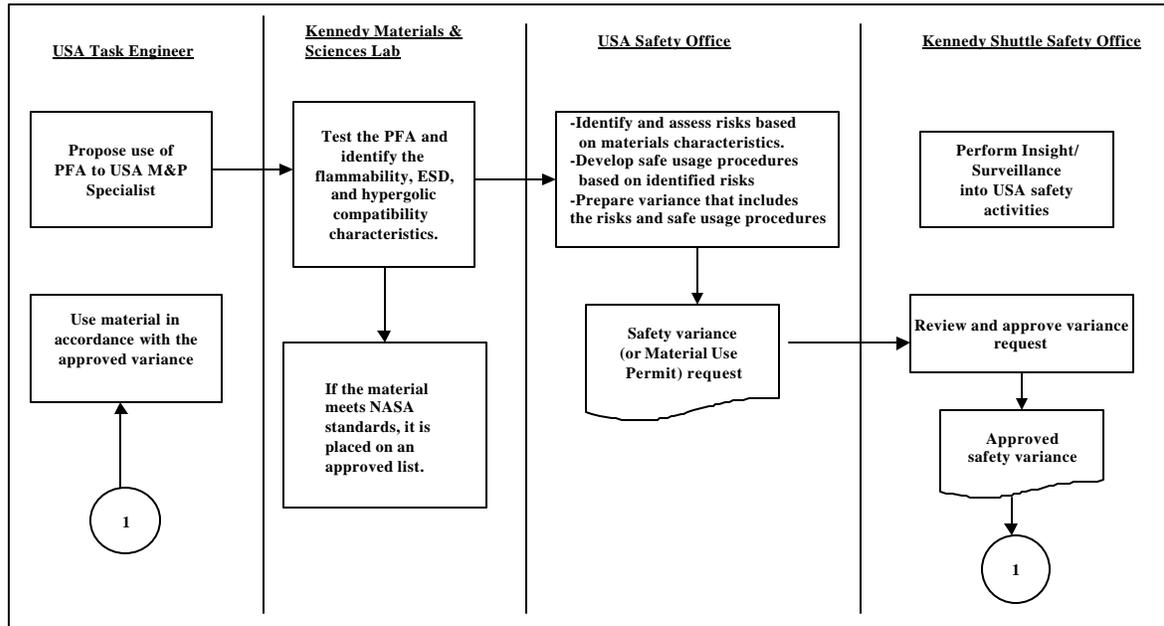


Figure 1. Process flow for the use of PFA's In and Around the Space Shuttle Orbiter Vehicles.

PFA's With Unknown Flammability, ESD, and Hypergolic Compatibility Characteristics

Through our observations¹⁴ and review of the lists of materials approved for use in and around the orbiters, we identified 30¹⁵ PFA's that were either in use or approved by

¹² A Material Use Permit is a standard document that allows USA Task Engineers to use a certain type of material, on a temporary or permanent basis, subject to the restrictions described in the document.

¹³ NASA Handbook 1700.1, "NASA Safety Policy and Requirements Document," defines a variance as documented and approved permission to perform some act contrary to established requirements.

¹⁴ From July through October 2000, we toured six of the nine Kennedy facilities USA used for Space Shuttle processing activities: the Vehicle Assembly Building; Hypergolic Maintenance Facility; Rotation, Processing, and Surge Facility; and high bays 1, 2, and 3 of the Orbiter Processing Facility.

¹⁵ The Kennedy Materials Science Lab could not provide testing data for Mystik 7000 tape (shown in Figure 2). The Lab tested the Mystik 7000 tape in 1995 after a fire occurred in the Orbiter Processing Facility. The Kennedy mishap file stated that the material failed ESD tests and, along with ACLAR plastic film, was a contributing factor to the fire. Although we listed Mystik 7000 tape in Appendix E, we did not include it in our count of 30 PFA's.

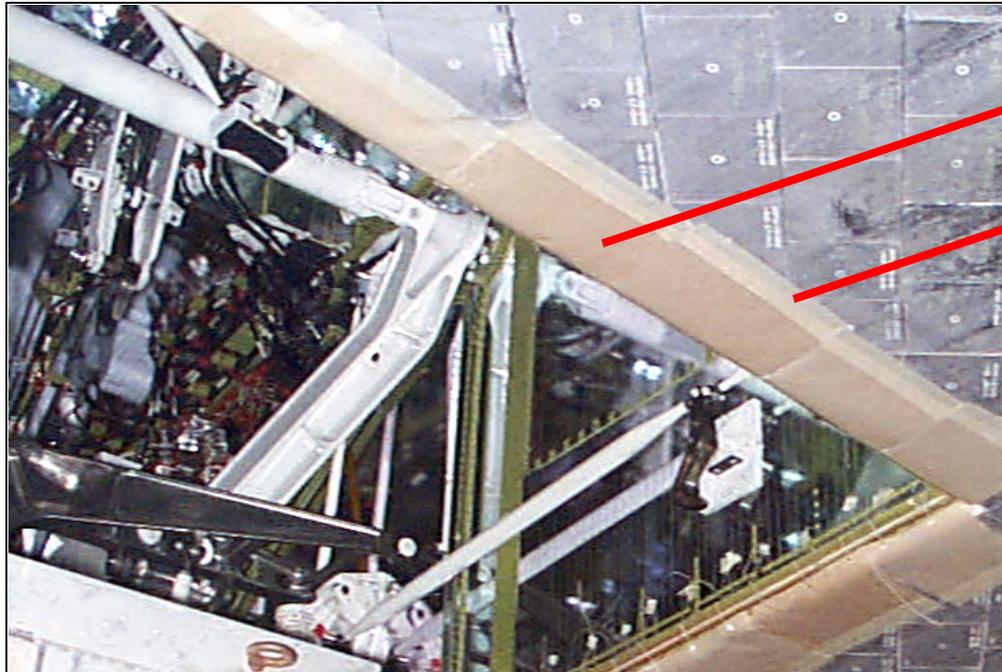
NASA or USA for general use in and around the orbiter vehicles¹⁶ even though USA had no record of test data and flammability, ESD rate, and hypergolic compatibility characteristics. We discussed each of the 30 PFA's with safety, M&P, and Space Shuttle program personnel from both USA and Kennedy and reviewed available testing records and determined that:

- The Kennedy Materials Science Lab¹⁷ had not tested the 30 PFA's for flammability, ESD rate, and hypergolic compatibility.
- Marshall's online Materials and Processes Technical Information System (MAPTIS) contained no evidence to support that 16 (53 percent) of the PFA's had been tested for flammability resistance, ESD rate, or hypergolic compatibility at any other NASA location. The test results in MAPTIS for the remaining 14 PFA's did not state whether the materials had passed or failed required tests.
- Neither USA nor Kennedy had any record of Kennedy or USA safety office review and approval for 29 of the 30 materials.

Figure 2 shows an example of the use of these materials.

¹⁶ During our tours of the six Space Shuttle processing facilities, we observed technicians using various PFA's in and around the orbiter vehicles and other components of the Space Shuttle and large quantities of PFA's stored in these facilities for USA's future use. The PFA's we observed in use were: (1) plastic films covering sensitive flight hardware components to prevent contamination; (2) adhesive tapes securing plastic films to items of flight hardware; and (3) polyvinyl foam insulating and protecting cables, work stands, and surfaces of the orbiter vehicles, such as the wings. Appendix D of this report shows examples of such usage. NASA approved 24 of the PFA's by including them in Appendix C of NSTS 08242. Through the Material Use Permit process, Kennedy and USA M&P personnel approved four of the PFA's. We observed the remaining two materials, Armalon fabric (shown in Figure 2) and RE22 tape (shown in Figure D-3 in Appendix D), affixed to the outer surfaces of Orbiter Vehicle-105.

¹⁷ The Kennedy Materials Sciences Lab, a branch of the Materials Sciences Division, is identified by NSTS 08242 as the organization responsible for materials testing at Kennedy.



**Armalon
fabric**

**Mystik
7000**

**Figure
2.**

Armalon fabric is adhered to outer tile of Orbiter Vehicle-105 (Endeavor) with Mystik 7000 tape. We took this photograph in the Orbiter Processing Facility on October 17, 2000. A USA engineer specialist identified these materials as Armalon fabric and Mystik 7000 tape.

Neither the Armalon fabric nor the Mystik 7000 tape shown in Figure 2 are on the Kennedy Materials Science Lab's list of approved materials¹⁸ and are not included in Appendix C of NSTS 08242 as approved for general use in and around the orbiter vehicles. USA did not obtain a Material Use Permit allowing the use of either material. The Kennedy Materials Sciences Lab previously identified the Mystik 7000 tape as a contributing factor to a fire that occurred near one of the orbiter vehicles in 1995 (see page 11 for details).

Without test data for these PFA's, USA management is unable to identify the specific flammability resistance, ESD rate, and hypergolic compatibility properties for each material, making it impossible to effectively manage the associated risks. A full description of the PFA's, testing information, and Material Use Permit data is provided in Appendix E of this report.

Control Over the Use of PFA's

¹⁸ Armalon is a trade name and, without additional information, we were unable to determine whether the Kennedy Materials Science Lab or other NASA locations have tested the specific material in use. MAPTIS contained flammability, toxicity, and thermal vacuum stability test data for Mystik 7000 tape; however, the test results do not clearly state whether the tape passed or failed required tests.

The inadequate control over the use of PFA's in and around the orbiter vehicles resulted from (1) inadequate USA procedures for ensuring the safe use of PFA's, (2) Kennedy Shuttle Safety Office's limited oversight of USA's use of PFA's, and (3) incomplete NASA PFA approval and testing records.

USA Safety Procedures for the Use of PFA's. USA did not have adequate procedures in place to ensure the safe use of PFA's in and around the orbiter vehicles as required by the SFOC. USA (1) had unclear procedures regarding when to use a Material Use Permit or a safety variance and allowed M&P personnel, rather than safety professionals, to make decisions regarding the safe control and use of PFA's and (2) significantly changed its material safety procedures without notifying NASA.

- **Use of a Material Use Permit or a Safety Variance.** Where circumstances dictate, USA may use PFA's not on the approved lists by obtaining a Material Use Permit, safety variance, or both.¹⁹ The requirements for safety office involvement and the preparation of a risk assessment²⁰ differ significantly between a Material Use Permit and a safety variance as shown in the following:

Key Differences Between a Material Use Permit and a Safety Variance

<u>Document</u>	<u>Kennedy or USA Safety Office Involvement.</u>	<u>Risk Assessment</u>
Material Use Permit	Only if the USA M&P engineer specialist determines that safety office involvement is necessary.	Not required
Safety Variance	Kennedy and USA safety office approval is required.	Required

While the requirements of the Material Use Permit and safety variance process differ, USA's procedures are unclear regarding when one procedure is more appropriate than the other. According to USA procedures, a USA M&P representative is responsible for approving or disapproving a Material Use Permit when an organization wishes to use a previously

¹⁹ As an example of the use of both a Material Use Permit and a variance, on February 13, 1996, Kennedy and USA signed Material Use Permit 96-005, allowing the use of Fromelt Saf-T-Vu plastic film. The film does not meet the safety requirements regarding flammability resistance, as established by Appendix I of USA's GSOP 5400 and Chapter 7 of the Kennedy Safety Handbook. In 1999, Kennedy and USA also issued safety variance 99-028 for the same material.

²⁰ A risk assessment is a process of identifying all risks involved in a certain operation and the likelihood of those risks occurring. NASA Procedures and Guidelines 8715.3, "NASA Safety Manual," dated January 24, 2000, states that the primary purpose of risk assessment is to identify and evaluate risks to support decisionmaking regarding actions to ensure safety and mission success.

unapproved PFA in and around the orbiter vehicles.²¹ The USA M&P engineer specialist determines whether the proposed use of the material poses a hazard. The M&P engineer specialist does not seek Kennedy or USA Safety Office involvement and does not submit the material to the Kennedy Materials Science Lab for testing unless the engineer specialist determines that hazards are present. In addition, USA's Material Use Permit process does not require the requesting organization to prepare a risk assessment for use of the PFA.

In contrast to the Material Use Permit process, USA's safety variance procedures require the organization wishing to use a previously unapproved PFA to prepare and submit for Kennedy and USA Safety Offices' approval, a safety variance and associated risk assessment.²² Although USA's GSOP 5400²³ states that deviations from safety requirements must be submitted as a safety variance, USA often used Material Use Permits for this purpose. As a result, we could not clearly ascertain USA's policy for obtaining a Material Use Permit rather than a safety variance in order to use an unapproved PFA. USA did not consistently apply the Material Use Permit and variance process and, therefore, did not obtain safety office approval and did not prepare risk assessments to support its decisions to use unapproved materials in Kennedy's Space Shuttle processing facilities. USA should have clear, uniform procedures for using previously unapproved PFA's, including defining when it is appropriate to use a Material Use Permit or a variance. The procedures should also identify the review and approval requirements of both the Kennedy Shuttle Safety Office and USA Safety Office for Material Use Permit or variances.

- **USA's Changed Material Safety Procedures.**²⁴ In a September 28, 2000, meeting with USA M&P and safety officials, we made reference to Revision C of GSOP 5400, the then current version of the document. During that meeting, we pointed out that GSOP 5400 required risk assessments and tests of all PFA's. On October 3, 2000, USA made changes to Revision C of GSOP 5400, stating that as a result of our audit, changes were necessary to clarify existing policies. By modifying the document, USA omitted the two sections that required risk assessments, including tests of flammability resistance, ESD rate, and hypergolic compatibility, prior to using any

²¹ Since 1990, Kennedy or USA M&P personnel have prepared and approved 114 Material Use Permits of which 11 are related to PFA's.

²² From January 1, 1998, through July 13, 2000, Kennedy and USA safety officials approved 99 safety variances, of which 3 were related to PFA's.

²³ GSOP 5400 is the USA document that specifies and establishes safety policies and procedures required during operations and maintenance activities at USA-designated areas of Kennedy.

²⁴ Because the SFOC is a performance-based contract, USA may change its operating procedures without seeking or receiving NASA approval unless such change increases the risk beyond an acceptable level or directly violates a NASA or Kennedy requirement. USA, however, must submit to the Kennedy Shuttle Safety Office, a rationale and risk assessment for changes to operating procedures. Two weeks after USA revised its materials safety procedures, the Kennedy Shuttle Safety Office had not yet received notification of the changes and was unaware that USA had instituted new procedures.

plastic film and adhesive tape.²⁵ In effect, USA changed its procedures concerning PFA's rather than comply with the testing and risk assessment requirements. Additionally, USA had not notified Kennedy Shuttle Safety Office officials of the significant changes in USA material safety procedures. USA should reestablish the requirements on PFA testing and risk assessments in GSOP 5400 to ensure that it is compliant with NASA and Kennedy safety policies and SFOC requirements.

As required by the SFOC, USA should have documented safety procedures in place for assessing ground operations and maintenance activities for hazards such as untested PFA's and for protecting personnel and property from those hazards.

Kennedy Shuttle Safety Office Oversight of USA. The NASA Kennedy Shuttle Safety Office was not actively involved in overseeing USA's PFA usage as stipulated in the SFOC. The Kennedy Shuttle Safety Office's surveillance procedures did not include steps for gaining insight into USA's material selection and usage. Kennedy Shuttle Safety Office personnel were unaware that (1) the USA M&P engineer specialist frequently approved Material Use Permits without consulting either the USA or Kennedy Shuttle Safety Offices, (2) USA did not have the Kennedy Materials Science Lab test all PFA's, and (3) USA made significant changes to its materials safety procedures. Also, Kennedy Shuttle Safety Office personnel erroneously believed that, at a minimum, USA tests all new, unapproved PFA's for flammability resistance. As required by the SFOC, the Kennedy Shuttle Safety Office personnel must perform surveillance and gain better insight into USA's use and control of PFA's by reviewing all variances, Material Use Permits, and procedure changes. Improved insight will help ensure the safe use of PFA's.

Approved Material and Test Records. There is no centralized list of approved materials and no test records for some materials in use in and around the orbiter vehicles. We identified several, often conflicting, sources of approved materials and requirements regarding material selection, testing, and control. Appendix I of USA's GSOP 5400 and Chapter 7 of the Kennedy Safety Practices Handbook state that current approved adhesive tape and plastic film lists are on the Kennedy Materials Science Division Intranet. However, USA M&P personnel also refer to Appendix C of NSTS 08242, "Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles"; Material Use Permit and safety variance files; and the MAPTIS when selecting PFA's for use in Kennedy's Space Shuttle processing facilities. As a result, there are at least five sources used for identifying approved materials, whereas Kennedy policy references only the Kennedy Materials Science Division Intranet as the source of approved materials. In addition, our review of MAPTIS showed that it did not clearly indicate whether

²⁵ Prior to the changes of October 3, 2000, Appendix I and Section 2.21 of GSOP 5400, Revision C, required users to obtain test data from the Kennedy Materials Science Lab before using a PFA in order to verify the material's performance and to aid in material selection. In contrast, the revised version of Revision C and Revision D of GSOP 5400, dated November 15, 2000, state that PFA testing is required only during the Material Use Permit process if material uses are hazardous or controlled. Also, the revised Appendix I specifies that only selection of PFA's for use in and around the orbiter vehicles shall comply with the Material Use Permit approval process, which does not require a safety assessment and does not require approval by the Kennedy or USA Safety Offices.

materials had passed or failed required tests. The Director, John F. Kennedy Space Center, should establish one centralized list of materials approved for use in and around the orbiter vehicles, with reference to all associated testing records.

Effects of Inadequate Control Over PFA's

Without active Kennedy Shuttle Safety Office and USA Safety Office involvement, USA has neither conducted an assessment of risk nor developed appropriate safety procedures for the use of PFA's. This hinders USA's and NASA's ability to effectively manage the potential risks and hazards associated with the use of PFA's.

A Kennedy Materials Science Lab official, who is responsible for conducting required tests of PFA's and other materials, stated that using PFA's that have never been tested could be catastrophic from a safety standpoint. He opined that USA should, at a minimum, request tests of flammability resistance for new or unapproved PFA's intended for use in and around the orbiter vehicles. He also stated that Kennedy and USA Safety Offices should be involved in the process of determining whether a PFA or its proposed use is potentially hazardous.

USA acknowledged the potentially unsafe nature of PFA's by stating in GSOP 5400, Revision D, the following warning regarding ESD rate, flammability resistance, and improper use of adhesive tapes and plastic films:

If a flammable adhesive tape is used to join two thin sheets of plastic that meet flammability requirements, and if the tape accidentally ignites, it (and its adhesive) can act as a path to quickly propagate the flame from one edge to the other of the normally self-extinguishing plastic film. . . . When pulling tape from its roll or any surface to which the tape is adhered, pull slowly to minimize electrostatic charge build-up.²⁶

Fires involving PFA's have occurred in Kennedy facilities that house the Space Shuttle orbiters and other hardware and equipment.

- In August 1998, a fire in USA's Kennedy Logistics Support Facility started when a spark ignited gases in a plastic bag that held lithium batteries.²⁷ The fire damaged 196 items including cables, components, batteries, and test equipment and resulted in \$133,568 in damages.
- In May 1995, a fire occurred in the Orbiter Processing Facility as a direct result of PFA's that did not meet ESD standards. The fire caused damage to Orbiter Vehicle-105's thruster and surrounding tiles and endangered three technicians. According to the official mishap report, five

²⁶ GSOP 5400 states that Kennedy Materials Science Lab tests of some tapes showed that voltages in excess of 10,000 volts (at 30-percent relative humidity) result when a user pulls the tape from its roll. The voltage can remain for a significant time. Under some circumstances, surface rubbing of affixed tape can result in buildup of voltages in excess of 20,000 volts.

²⁷ USA's Kennedy Logistics Support Facility houses about 500 NASA and contractor personnel and 190,000 Space Shuttle hardware parts.

of the seven PFA's involved in the mishap, including Mystic 7000 tape, failed ESD tests conducted by the Kennedy Materials Science Lab after the fire.²⁸

The two fires clearly indicate a need to ensure that all PFA's used in Kennedy's Space Shuttle processing facilities are adequately tested and approved for use by the appropriate safety professionals. The Kennedy Shuttle Safety Office should appropriately assess whether the materials listed in Appendix E of this report are properly used and controlled.

Summary

The orbiter vehicles along with the workforce that helps to maintain them and the supporting infrastructure are core elements of the Agency's mission. NASA must do everything reasonably possible to protect these capabilities. As the NASA Administrator stated in his January 1999 message on safety, NASA must become informed risk takers by identifying, understanding, and managing risk in all that is done. As shown through prior mishaps, inadequate control of PFA's in the facilities that house the orbiters and other components of the Space Shuttle can be very risky. NASA must effectively manage those risks by first identifying the characteristics of the PFA's through testing and then performing assessments to ensure that the materials are used safely based on the identified characteristics. To help achieve this, NASA and USA must have clear procedures in place that include involvement by the appropriate safety professionals.

Recommendations, Management's Response, and Evaluation of Response

The Director, John F. Kennedy Space Center, should:

- 1. Clarify the procedures for using Material Use Permits and safety variances for PFA's that are not on the approved list. The procedures should include appropriate NASA or USA safety office review and approval of all Material Use Permits and variances.**

Management's Response. Partially concur. An inter-Center team will review existing requirements for the use of PFA's. The team will provide recommended documentation

²⁸ Mishap investigators concluded that the most probable cause for ignition of the hypergolic fuel present was the generation of an electrostatic spark between a technician's tool and the fuel feedline fitting. The PFA's used for hypergolic fuel spill protection passed the electrostatic charge to the technician's suit, gloves, and tool. The mishap report stated that it is possible for a technician's protective suit to generate voltages of sufficient magnitude to produce an electrostatic arc from a tool held by that technician. The report further stated that the situation is further complicated when PFA's are present that generate a significant electrostatic charge that can dissipate at a dangerous level.

changes to clarify or enhance the requirements, roles, and responsibilities for the use of PFA's for all programs at Kennedy. The complete text of management's response is in Appendix F.

Evaluation of Management's Response. Management's planned action is responsive to the recommendation. Our concern is that USA did not consistently apply the Material Use Permit and variance process and, therefore, did not obtain USA or Kennedy Safety Office involvement in its decisions to use unapproved materials in Kennedy's Space Shuttle processing facilities. The inter-Center team's recommendations should include clear procedures for ensuring either USA or Kennedy Safety Office approval for the use of PFA's that are not on an approved list, at Kennedy Space Shuttle processing facilities, whether it be by way of a Material Use Permit or a variance. The recommendation is resolved, but will remain undispositioned and open for reporting purposes until corrective actions are completed.

NASA management also provided extensive comments on the finding that we address in Appendix G.

2. Request USA to revise GSOP 5400 to reestablish the requirements for PFA testing that were removed from Revision C on October 3, 2000, and obtain Kennedy Shuttle Safety Office review of all proposed GSOP changes prior to implementation as required by the SFOC.

Management's Response. Partially concur. The inter-Center team will review GSOP 5400 for compliance with NSTS 08242 and Kennedy Handbook 1710.2 requirements for the use of PFA's. All required documentation changes will be implemented to assure compliance with NASA requirements (see Appendix F).

Evaluation of Management's Response. Management's planned action is not responsive to the recommendation. Kennedy did not specifically address corrective actions to ensure that the Kennedy Shuttle Safety Office reviews all proposed GSOP changes prior to implementation. The audit determined that USA made significant changes to GSOP 5400 regarding the testing and control of PFA's without notifying the Kennedy Shuttle Safety Office. Section A of the SFOC states that, "the contractor shall keep NASA continually informed about all concerns and issues, particularly those related to safety and mission success." Instituting a procedure that requires the Shuttle Safety Office to review all proposed changes to USA's GSOP would ensure compliance with the SFOC and improve surveillance over USA's operations. Therefore, we request that management provide additional comments that address whether the Kennedy Shuttle Safety Office will review all proposed GSOP changes prior to implementation by USA. The additional comments should also include an estimated completion date for planned corrective actions. The recommendation is unresolved and will remain undispositioned and open for reporting purposes.

3. Direct Kennedy Shuttle Safety Office personnel to be more actively involved in the safe use of PFA's by (a) determining whether potential hazards are present in

operations, (b) reviewing and approving Material Use Permits or variances that allow the use of materials that have failed required tests or have not been tested, and (c) increasing surveillance of PFA usage in and around the orbiter vehicles and other elements of the Space Shuttle.

Management's Response. Partially concur. Kennedy has added a periodic internal audit of the PFA process for the Shuttle that is scheduled to be performed in July 2001. Internal and independent verification audits will have a special focus on the use of PFA's (see Appendix F).

Evaluation of Management's Response. Management's planned action is not fully responsive to the recommendation. Kennedy did not specifically address corrective actions to ensure that the Kennedy Shuttle Safety Office becomes more actively involved in the safe use of PFA's by (1) determining whether potential hazards are present in operations and (2) reviewing and approving Material Use Permits or variances that allow the use of materials that have failed required tests or have not been tested. As discussed in the report, the USA M&P engineer specialist (who is not a safety engineer) had sole responsibility for determining whether the proposed use of a specific PFA posed a hazard. The M&P engineer did not seek Kennedy or USA safety office involvement and did not submit materials to be tested unless he determined that hazards were present. Having a safety engineer review the proposed use of any PFA's not on an approved list would help ensure the safe use of all PFA's in Kennedy's Space Shuttle processing facilities. Therefore, we request that management provide additional comments on how it will ensure that the Kennedy Shuttle Safety Office determines whether potential hazards are present in operations and reviews and approves all Material Use Permits or variances that allow the use of materials that have failed required tests or have not been tested. The additional comments should also include an estimated completion date for planned corrective actions. The recommendation is unresolved and will remain undispositioned and open for reporting purposes.

4. Develop one centralized and approved list of PFA's approved for use in and around the orbiter vehicles in Kennedy's Space Shuttle processing facilities.

Management's Response. Partially concur. The inter-Center team will assess and provide recommendations to assure timely access to PFA materials evaluations and/or test results performed at the NASA Centers (see Appendix F).

Evaluation of Management's Response. Management's planned action is responsive to the recommendation. During the audit, we identified five sources for identifying materials approved for use in and around the orbiter vehicles. The five sources were the (1) Appendix I of USA's GSOP 5400, (2) Chapter 7 of the Kennedy Safety Practices Handbook (both state that current approved adhesive tape and plastic film lists are on the Kennedy Materials Science Division Intranet), (3) Appendix C of NSTS 08242, (4) Material Use Permit and safety variance files, and (5) the MAPTIS. If Kennedy and the Space Shuttle Program recognize NSTS 08242 as the definitive list of PFA's approved for use in and around the orbiter vehicles, then the inter-Center team should ensure that this is known by all personnel involved with PFA use. The inter-Center team should further ensure that the list of approved PFA's in NSTS 0842 has a clear audit trail to all associated

Material Use Permits, variances, and testing records. The recommendation is resolved, but will remain undispositioned and open for reporting purposes until corrective actions are completed.

5. Direct the Kennedy Shuttle Safety Office to perform appropriate assessments on the use and control of the materials listed in Appendix E of this report.

Management's Response. Concur. Appendix E has been reviewed and all 30 items have been verified to be authorized for use by NSTS 08242 or referenced subtier documents (see Appendix F).

Evaluation of Management's Response. The action taken by management is responsive to the recommendation. Kennedy stated in its response to the draft report that the test records for materials tested by other NASA Centers were not readily accessible. We request that Kennedy provide us the test records when they become available. The recommendation is resolved, but will remain undispositioned and open for reporting purposes until corrective actions are completed.

Appendix A. Objectives, Scope, and Methodology

Objectives

The overall audit objective is to evaluate the United Space Alliance (USA) safety procedures for NASA's Space Flight Operations Contract (SFOC). The specific objective related to this report was to determine whether potentially unsafe materials used in contract performance are properly controlled.

The remaining objectives, which will be discussed in separate reports, are to determine whether:

- NASA is performing effective oversight of USA's safety program and
- safety responsibilities between USA and NASA are clearly defined.

Scope and Methodology

To accomplish our objectives, we:

- Discussed materials testing, control, and approval procedures with John F. Kennedy Space Center (Kennedy) Materials Science Lab personnel and NASA and USA Materials and Processes (M&P) and safety officials.
- Reviewed the NASA, Kennedy, and USA requirements for materials testing, control, and approval procedures.
- Toured the Vehicle Assembly Building; Hypergolic Maintenance Facility; Rotation, Processing, and Surge Facility; and high bays 1, 2, and 3 of the Orbiter Processing Facility during the period July through October 2000.
- Queried the USA safety variance database and identified and reviewed all safety variances issued by USA from January 1, 1998, through July 13, 2000.
- Compared the plastic films, foams, and adhesive tapes (PFA's) we observed in use with various sources of approved PFA's and test results. The various sources of approved PFA's and test results were the Kennedy Materials Science Lab Intranet, all Material/Equipment Usage Permit (Material Use Permits) issued to date, USA safety variances for 1998 through 2000, and test data in Marshall's Materials and Processes Technical Information System (MAPTIS).
- Compiled a list of 30 PFA's that the Kennedy Materials Science Lab has not tested for flammability resistance, electrostatic discharge (ESD) rate, or hypergolic compatibility but that USA used in and around the orbiter vehicles.

Appendix A

Management Controls Reviewed

We reviewed management controls relative to procedures for controlling the use of potentially unsafe materials in and around the Space Shuttle orbiter vehicles. We determined that controls need to be strengthened to ensure that the Kennedy and USA safety offices are actively involved in overseeing PFA usage through a definitive procedure for control of such materials during Space Shuttle processing under the SFOC. This issue is discussed in detail in the finding section of the report.

Audit Field Work

We conducted field work from July 2000 through May 2001 at NASA Headquarters and Kennedy. We performed the audit in accordance with generally accepted government auditing standards.

Appendix B. Summary of Prior Audit Coverage

“Space Shuttle Program Management Safety Observations,” Report Number IG-01-017, March 23, 2001. As part of the ongoing audit of the United Space Alliance (USA’s) safety procedures under NASA’s Space Flight Operations Contract (SFOC), we evaluated NASA’s oversight of USA’s safety program. We identified several weaknesses pertaining to NASA’s management control structure for providing oversight of USA’s safety operations under the SFOC. Specifically, we found that:

- the Johnson Safety, Reliability, and Quality Assurance Office was not providing the required support to the Manager, Space Shuttle Program Safety and Mission Assurance for oversight of USA’s safety activities;
- NASA’s contractor surveillance plans did not address all contract requirements for safety;
- USA’s Management Plan had not been updated commensurate with the changes to the contract; and
- USA can improve its reporting to NASA of close calls and mishaps.

Increased management attention to these areas will not only help ensure that NASA has an adequate control structure in place to provide oversight of USA’s safety operations under the SFOC, but will also provide better control of more than \$13 million in annual Space Shuttle Program funds. We recommended that Johnson ensure that (1) surveillance plans address all contract requirements for safety, (2) USA’s SFOC Management Plan is kept current, and (3) USA promptly and accurately reports all required close call and mishap information to NASA’s reporting system. Johnson did not agree with all of the findings, but concurred with the recommendations. NASA implemented corrective actions to improve the overall management of safety for the Space Shuttle Program.

“Contract Safety Requirements at Kennedy Space Center and Marshall Space Flight Center,” Report Number IG-00-035, June 5, 2000. The NASA Administrator stated in a January 19, 1999, message that safety is the Agency’s highest core value. On February 26, 1999, the Administrator emphasized the need for NASA contractors to be supportive of and accountable for safety. The overall objective of the audit was to evaluate the safety procedures of NASA contractors. We found that NASA was not applying existing basic safety provisions such as required contract safety clauses, contractor safety plans at contract award, and Center safety office involvement in the procurement process to 15 out of 25 contracts that we reviewed at Kennedy and Marshall. As a result, NASA contractors including some involved in hazardous operations may not be supporting the same safety goals as NASA. We recommended that Kennedy and Marshall management identify all open contracts that either involve potentially hazardous operations or exceed \$1 million and determine whether those contracts have the required safety clauses and contractor safety plans. NASA concurred with our recommendations and implemented corrective actions to ensure that all applicable contracts contained the required safety documentation.

Appendix B

“Safety Concerns with Kennedy Space Center’s Payload Ground Operations,” Report Number IG-00-028, March 30, 2000. In February 1999, the House of Representatives Committee on Science requested that the NASA Office of Inspector General (OIG) address concerns related to the safety functions of Kennedy’s Payload Ground Operations Contract performed by McDonnell Douglas Aerospace, Space and Defense Systems, a subsidiary of The Boeing Company (Boeing). In response to this request, we reviewed the contractor’s operations to determine whether (1) safety responsibilities between Boeing and NASA had been clearly defined; (2) hazardous materials were being used in Kennedy’s processing facilities; and (3) hazardous materials, if used, were properly controlled. The audit identified that ground workers were using potentially hazardous materials in Kennedy processing facilities without exercising proper control and safety precautions. This condition existed because (1) Boeing safety personnel had not performed adequate, contract-required inspections of the facilities; (2) Kennedy and Boeing safety personnel had not reviewed Material Usage Agreements that authorized the use of noncompliant materials; and (3) Kennedy and Boeing safety personnel did not perform risk analyses to support the materials usage agreements. As a result, NASA lacks assurance that associated risks are adequately identified, documented, reviewed, and mitigated. Improper use of these materials is potentially hazardous to ground workers and increases the risk of damage to Space Shuttle payloads, including International Space Station hardware and equipment. We recommended that management (1) direct the contractor to perform analyses to support the use of all materials that do not meet requirements for flammability and electrostatic discharge, (2) clarify instructions for preparation of Materials Usage Agreements, and (3) increase surveillance of the contractor’s safety office inspection procedures. NASA concurred with each recommendation and implemented a number of procedures to control all noncompliant materials.

“Safety Considerations at Goddard Space Flight Center,” Report Number IG-99-047, September 22, 1999. While conducting a broad evaluation of NASA’s safety program, we identified issues requiring immediate management attention that could affect the safety of Goddard Space Flight Center (Goddard) employees. Specifically, we determined that (1) Goddard’s various safety offices were not consolidated into one organization with a full-time director; (2) the mishap reporting process did not ensure that the causes of all mishaps were properly addressed and that all mishaps and related information were adequately reported; and (3) contractor’s safety records were not evaluated prior to contract award, as required by the NASA Safety Manual. We recommended that the Goddard Center Director (1) evaluate the effectiveness of the ongoing safety initiatives, (2) ensure that all mishaps are reported accurately and in a timely manner and that the root causes are identified, and (3) establish procedures for reviewing contractor safety records before contract award. Management concurred with each recommendation.

Appendix C. Materials Testing, Approval, and Control Requirements

The following policies are applicable to NASA's requirements for testing, using, and controlling plastic films, foams, and adhesive tapes:

NASA Space Transportation System 08242, "Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles,"

(NSTS 08242) Revision A, May 6, 1994. This standard contains lists of non-flight materials and equipment approved for use as well as materials prohibited for use in and around the orbiter vehicles. The standard also defines the NASA responsibilities for control of the specified materials and equipment and establishes a procedure for effecting temporary or permanent changes to the approved materials and equipment lists contained therein. Specifically, paragraph 4.1 of the standard states that a United Space Alliance (USA) Materials and Process (M&P) representative shall prepare a Material/Equipment Usage Permit (Material Use Permit) when a requesting engineer wishes to use an unapproved PFA in and around the orbiters.

Where circumstances dictate, materials and equipment not on the approved lists or quantities in excess of those specified may be used on a temporary basis by means of a MUP [Material Use Permit].

NASA-STD-6001, "Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion," February 9, 1998. This standard establishes requirements for evaluation, testing, and selection of materials that are intended for use in space vehicles, associated ground support equipment, and facilities used during assembly, test, and flight operations. Materials intended for use in these situations must meet the requirements of this document. The intent of the standard is to preclude unsafe conditions related to flammability, odor, offgassing, and fluid compatibility. The standard requires, at a minimum, tests of materials for flammability resistance.

Materials used in habitable areas of spacecraft, including the materials of the spacecraft, stowed equipment, and experiments, must be evaluated for flammability, odor, and offgassing characteristics. **All materials used in other areas must be evaluated for flammability characteristics [emphasis added].**

The standard further supports required risk assessments prior to the use of untested materials, specifically:

Systems containing materials that have not been tested or do not meet the criteria of the required tests must be verified to be acceptable in the use configuration by analysis or testing.

KSC [Kennedy Space Center]-LO-8060.1, "KSC [Kennedy Space Center] Materials Processes and Control Program," July 15, 1997. This document establishes the policy and steps to be followed by all organizational elements at Kennedy in the selection of

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materials. Section 2.3 states that the Director of the Kennedy Safety and Mission Assurance organization is responsible for ensuring that only approved materials are used, including those used by contractors. Furthermore, the document states that engineers are responsible for selecting materials to be used in and around the orbiter vehicles in accordance with NSTS 08242. The document also identifies the Kennedy Materials Science Lab, a branch of the Materials Science Division, as the organization responsible for materials testing at Kennedy.

Kennedy Handbook 1710.2, “Kennedy Space Center Safety Practices Handbook,” Revision D, November 1, 1998. The purpose of the handbook is to establish consolidated safety requirements to define the parameters and boundaries required during design, operations, and maintenance activities at Kennedy. The provisions of the handbook apply to all organizational elements at Kennedy, to their associated contractors and subcontractors, and to other Government agencies and their contractors operating at Kennedy. The handbook requires that when an organization cannot meet a safety requirement, it shall provide a request for a variance to the Kennedy Safety Office.²⁹ Chapter 7, “Use of Plastic Films and Adhesive Tapes in Space Shuttle/Payload Processing Areas,” contains provisions for use and testing of materials in and around the orbiters. The chapter states, “Adhesive tapes and plastic films used in Kennedy Space Center flight hardware processing facilities shall only be used for operations where they meet the acceptance criteria for their specified use.” The chapter further states that current, approved adhesive tape and plastic film lists are maintained by the Kennedy Materials Science Lab and are available by accessing the Materials Science Division's Intranet.

Kennedy Handbook 1700.7, “Space Shuttle Payload Ground Safety Handbook,” Revision C, August 19, 1999. The handbook aligns existing Department of Defense and NASA ground safety criteria and establishes requirements for ground processing of Shuttle payloads and associated ground support equipment. Section 4.3.9, “Ground Support Equipment Materials,” pertains to the approval, use, and control of PFA’s by stating that flammable materials and static-producing materials shall be kept to a minimum in all payload-processing areas. Furthermore, plastic films shall be selected from the Launch Site Safety Office approved plastics list. The organization wishing to use a plastic film that is not on the approved list must submit to the Launch Site Safety Office a sample of the material for test/evaluation and approval.

²⁹ Kennedy Handbook 1710.2, Chapter 1, Section 106, “Variances,” states that when a requirement of the Handbook cannot be met, an organization shall request a variance from the Director, Safety and Mission Assurance. Although Section 106 does not specifically state that the Kennedy Director of Safety and Mission Assurance shall approve the variance, Section 103 states that the Kennedy Center Director has tasked the Director, Safety and Mission Assurance to ensure compliance with the Kennedy safety program. Under Kennedy’s recent reorganization, the Office of Director, Safety and Mission Assurance no longer exists and has been replaced by the Associate Director, Safety and Mission Assurance under the Safety, Health and Independent Assessment Directorate.

Use of flammable materials and static-producing materials shall be kept to a minimum in all payload-processing areas. If any plastic film is to be used, the material shall be selected from the LSSO [Launch Site Safety Office] approved plastics list. . . . If a plastic film is not on the approved list, a sample (minimum 1 square yard) shall be submitted to the LSSO for test/evaluation and approval.

USA’s Ground Safety Operating Procedures (GSOP) 5400, Revision C, January 20, 2000.

As stated in the introduction to Volume I of GSOP 5400, Revision C, “supplements Kennedy Space Center Safety, Reliability, Maintainability, and Quality Assurance Programs, and Kennedy Handbook 1710.2, “Kennedy Space Center Safety Practices Handbook” where necessary.” Furthermore, the document establishes safety policies and procedures required during operations and maintenance activities at USA-designated areas of Kennedy. Appendix I states that current approved adhesive tape and plastic film lists are maintained by the Kennedy Materials Science Lab and are available by accessing the Materials Science Division's Intranet. In addition, the appendix states:

Adhesive tapes and plastic films used in Kennedy flight hardware processing facilities shall only be used for operations where they meet the acceptance criteria for their specified use.

Revision C of USA’s GSOP 5400, Section 2.21, “Use of Flame Retardant, Anti-static Plastic Films/Tapes in STS [Space Transportation System]/Payload Processing Areas,” states:

All thin plastic films and adhesive tapes used in the STS and Payload areas must be approved by the Kennedy Space Vehicle Safety and Reliability Division. The listing source for safety-approved plastic films and adhesive tapes for unrestricted and restricted use appears in Appendix I of this volume. Use of thin plastic film or adhesive tape other than those listed for controlled use, will depend on a safety assessment of testing results and use application.

GSOP 5400 further provides that organizations desiring to modify the list of approved PFA’s must submit a safety assessment to the Kennedy Safety Office. Sections 2.21.1 and 2.21.2 state that the required safety assessment should consist of tests that measure the material’s safety characteristics. Specific measurements shall include flammability resistance, ESD rate, and hypergolic compatibility.

USA’s Standard Practice Instruction, SP-001(2)K, “Nonflight Materials and Equipment Control During Orbiter Ground Operations,” August 17, 1999. The purpose of this document is to implement material and equipment requirements and limitations stated in NSTS 08242, provide control procedures for ground operations, and describe the method to process Material Use Permits for temporary or permanent changes to existing materials and equipment lists. Specifically, the document states that if a

Appendix C

material is not in the NSTS 08242 list of approved materials and is required for performing work, requestors must obtain usage approval from a USA M&P engineer. As stated in Section 6.3, USA M&P engineers are responsible for (1) approving or disapproving Material Use Permits and (2) determining whether the Material Use Permit involves hazardous materials.³⁰ M&P engineers are required to submit Material Use Permits to USA's Safety Office for concurrence only if hazardous materials are involved. This document does not require a requesting organization to prepare a risk assessment.

USA's Standard Practice Instruction, SP-003(2)K, "Nonflight Materials and Equipment Control During External Tank/Solid Rocket Booster Operations," March 2, 1999. The purpose of this document is to specify nonflight materials and equipment requirements and limitations and to provide procedures for controlling materials and equipment in and around the external tank and solid rocket boosters during ground operations. The document states that any use of plastic sheet materials and tapes and spark- or heat-producing devices in and around the external tank and solid rocket boosters is to comply with GSOP 5400 requirements.

USA's Standard Practice Instruction, SF-507(8)K, "Safety Variances," December 14, 1999. This document establishes responsibilities and procedures for requesting, processing, and approving safety variances. The document requires that when an organization cannot meet an established safety requirement, the organization should request a temporary safety variance from both the Kennedy and USA Safety Offices. The request for the safety variance must include a detailed risk assessment that will be reviewed and approved by both the Kennedy and USA Safety Offices.

³⁰ Materials may be hazardous due to flammability, ignition source, toxicity, corrosion, or chemical reaction. Hazardous materials may also involve limitations on their use such as location, quantity, proximity to other materials or heat sources, need for protective equipment, or provisions for monitoring or handling.

Appendix D. Examples of PFA Usage In and Around the Orbiter Vehicles

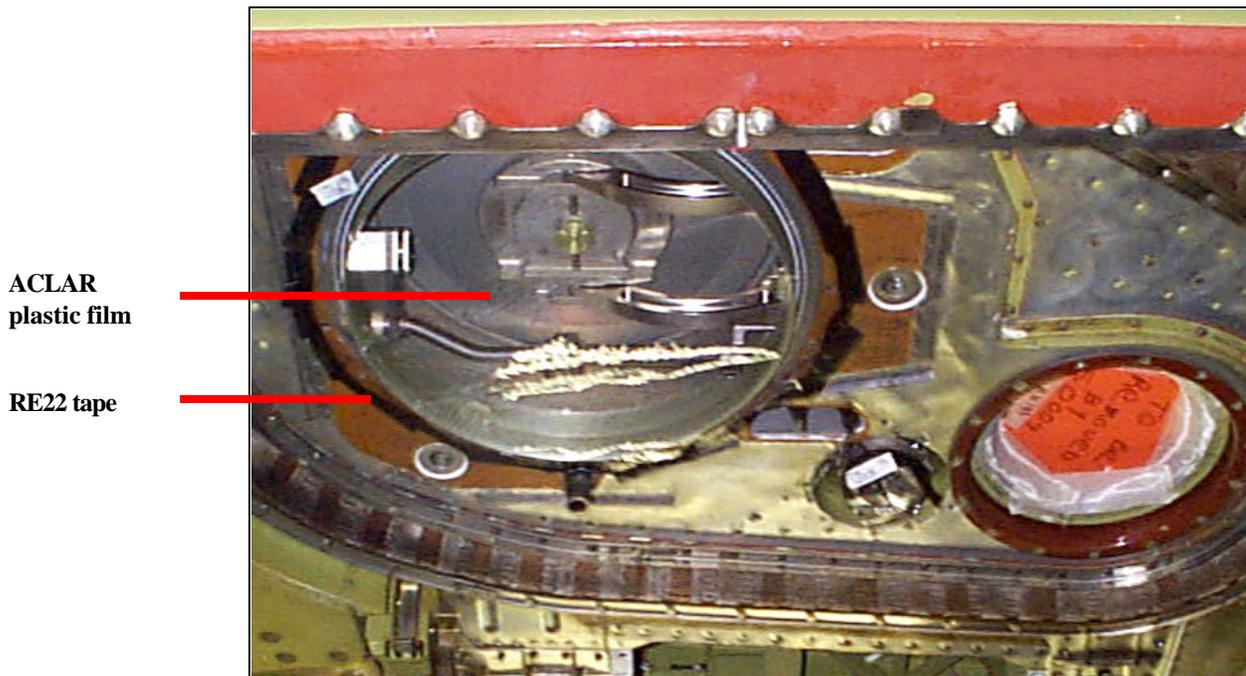


Figure D-3. ACLAR plastic film¹ covering LO2 17” disconnect and adhered to Orbiter Vehicle-105 with RE22 tape,² October 17, 2000.

¹ A United Space Alliance (USA) Materials and Process (M&P) engineer specialist identified this material as ACLAR plastic film. The Kennedy Materials Science Lab has tested ACLAR, 22A, 22C, and 33C. The film passed flammability tests, but based on the results of the electrostatic discharge (ESD) rate test, Kennedy determined that ACLAR is not permitted where ESD buildup or discharge is required to be minimal. Also, the lab cautions users to consider the material’s hypergol (rocket fuel) compatibility (the material’s reaction when exposed to hypergols) prior to use near hypergolic fuels. ACLAR plastic film is included in Appendix C of NSTS 08242, “Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles,” as approved for general use in and around the orbiter vehicles. However, its usage is limited to covering line connections and line closures and wrapping leaking hydraulic lines. Marshall’s Materials and Processes Technical Information System (MAPTIS) contained flammability, flash/fire, mechanical impact, and toxicity test data for ACLAR 22A. MAPTIS also contained flammability and mechanical impact test data for ACLAR 22C. However, the test results do not clearly state whether these films passed or failed. MAPTIS contained no test data for ACLAR 33C.

² A USA M&P engineer specialist identified this material as RE22 tape. The Kennedy Materials Science Lab has not tested RE22 tape, and the lab has not received a request for testing. As a result, this tape is not on the lab’s list of approved PFA’s. The tape is also not in Appendix C of NASA Standard 08242, “Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles,” (NSTS 08242) as approved for general use in and around the orbiter vehicles, and there is no current Material Use Permit approving the use of RE22 tape. MAPTIS contained no test data for this tape.

Appendix D

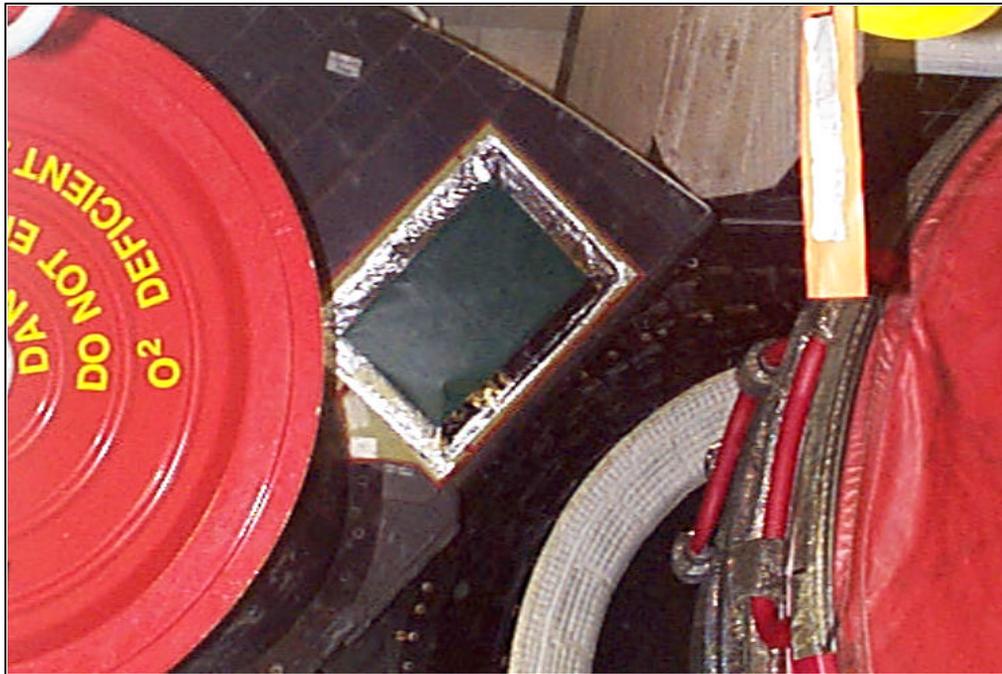


Figure D-4.

Lectrolite Duotone green/black plastic film¹ held to Orbiter Vehicle-105 Orbital Maneuvering System pod by 3M 363 tape,² October 17, 2000.

¹ A USA M&P engineer specialist identified this material as Lectrolite Duotone green/black plastic film. The Kennedy Materials Science Lab has tested this film. The film passed flammability resistance, ESD rate, hypergolic ignition, and breakthrough resistance tests and is approved for use in all Kennedy flight hardware processing facilities. The USA M&P engineer specialist stated that Lectrolite Duotone green/black film has the same properties as Lectrolite Duotone blue/black film. However, in April 1996, USA requested and Kennedy approved a safety variance for this material, stating that it consistently failed flammability tests. Lectrolite plastic film is included in Appendix C of NSTS 08242 as approved for general use in and around the orbiter vehicles, and there are no limitations on its usage. MAPTIS contained no test data for Lectrolite film.

² A USA M&P engineer specialist identified this material as 3M 363 tape. The Kennedy Materials Science Lab has tested the tape. The tape passed flammability resistance, ESD rate, and hypergolic compatibility tests and is approved for use in all Kennedy flight hardware processing facilities. The 3M 363 tape is not included in Appendix C of NSTS 08242 as approved for general use in and around the orbiter vehicles. MAPTIS contained flammability, flash/fire, toxicity, odor, thermal vacuum stability, and cure test data for Scotch 363 tape. Scotch is a registered trademark of the 3M Company.

Foam on
orbiter wing



Figure

D-5.
Ensolite
natural
foam*

covering wing of Orbiter Vehicle-105, October 17, 2000.

* A USA M&P engineer specialist identified this material as Ensolite natural foam. The Kennedy Materials Science Lab has tested this foam. The foam passed flammability tests, but is not permitted where electrostatic buildup or discharge is required to be minimal. The lab also cautions users to consider the foam's test reaction to hypergols (rocket fuel) prior to use near hypergolic fuels. Ensolite foam is included in Appendix C of NSTS 08242 as approved for general use in and around the orbiter vehicles. MAPTIS contained flammability, flash/fire, toxicity, odor, and thermal vacuum stability test data for Ensolite foam. However, the test results do not clearly state whether these films passed or failed.

Appendix E. Material Test Results

No.	Material & Manufacturer	Marshall Material and Processes Technical Information System (MAPTIS) Test Data	Audit Observations
Plastic Films			
1	<i>Saran 8</i> Dow Chemical	No test data available through MAPTIS.	Listed in Appendix C of NASA Standard 08242, "Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles," (NSTS 08242) as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
Foams			
2	<i>Eccosorb AN-73</i> Emerson & Cummings	MAPTIS contained thermal vacuum stability test data only for Eccosorb AN series foam. No flammability data available.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
3	<i>Eccosorb AN-77</i> Emerson & Cummings	MAPTIS contained thermal vacuum stability test data only for Eccosorb AN series foam. No flammability data available.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
4	<i>Omar 100</i> Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
5	<i>Polyfoam 2060 (BIR-60-E)</i> Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
Adhesive Tapes			
6	<i>L-T-80</i> Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
7	<i>3M 4008</i> 3M Co.	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
8	<i>3M 4046Y</i> 3M Co.	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.

No.	Material & Manufacturer	MAPTIS Test Data	Audit Observations
9	3M 4408 3M Co.	MAPTIS contained flammability and flash/fire test data for Scotch 4408 tape, a registered trademark of 3M Co.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
10	Permacel 222 Permacel/Nitto Denko	MAPTIS contained flammability, toxicity, and thermal vacuum stability test data.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
11	CHR K-250 Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
12	CHR K-350 Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
13	Permacel 252 Permacel/Nitto Denko	MAPTIS contained flammability, flash/fire, toxicity, odor, thermal vacuum stability, and cure test data.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
14	CHR M66 Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
15	Mystik 6402 Allied Signal	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
16	3M 800 3m Co.	MAPTIS contained flammability, toxicity, and odor test data for Scotch 800 tape, a registered trademark of 3M Co.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
17	3M 4016 3M Co.	MAPTIS contained toxicity test data for Scotch 4016 tape, a registered trademark of 3M Co.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.

Appendix E

No.	Material & Manufacturer	MAPTIS Test Data	Audit Observations
18	<i>Mystik 7503</i> Allied Signal	MAPTIS contained flammability, flash/fire, toxicity, odor, thermal vacuum stability, and cure test data.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
19	<i>Mystik 7505</i> Allied Signal	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
20	<i>Mystik 7510</i> Allied Signal	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
21	<i>3M 60</i> 3M Co.	MAPTIS contained flammability, toxicity, odor, and thermal vacuum stability test data for Scotch 60 tape, a registered trademark of 3M Co.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
22	<i>3M 61</i> 3M Co.	MAPTIS contained flammability, flash/fire, mechanical impact, toxicity, odor, and thermal vacuum stability test data for Scotch 61 tape, a registered trademark of 3M Co.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
23	<i>3M 62</i> 3M Co.	MAPTIS contained flammability, toxicity, odor, thermal vacuum stability, and cure test data for Scotch 62 tape, a registered trademark of 3M Co.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
24	<i>CHR HM-650</i> Unavailable	No test data available through MAPTIS.	Listed in Appendix C of NSTS 08242 as approved for general use. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing.
25	<i>RB0159-002</i> Unavailable	No test data available through MAPTIS.	Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. Material Use Permit 94-007, dated June 27, 1994, specified use limited to aft fuselage and exterior use.

No.	Material & Manufacturer	MAPTIS Test Data	Audit Observations
26	<i>Mystik 7367</i> Allied Signal	MAPTIS contained flammability, flash/fire, volatile condensable material, toxicity, odor, thermal vacuum stability, and cure test data.	Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. Material Use Permit 95-013, dated June 14, 1995, specified use limited to payload.
27	<i>Permacel P-670</i> Permacel/Nitto Denko	MAPTIS contained flammability, toxicity, and thermal vacuum stability test data.	Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. Material Use Permit 97-006, dated March 12, 1997, specified use limited to crew compartment only.
28	<i>Kalex 15036 urethane adhesive</i> Unavailable	No test data available through MAPTIS.	Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. Not a true tape, but an adhesive substance used to seal the nozzle vented tube plug for processing and post landing leak checks. Kennedy and USA safety officials signed Material Use Permit 00-010, approving Kalex polyurethane adhesive, because its use poses potential hazards such as eye, skin, respiratory tract, and lung irritation.
29	<i>Mystik 7000</i> Allied Signal	MAPTIS contained flammability, toxicity, and thermal vacuum stability test data.	Observed in use on the tile near the landing gear of Orbiter Vehicle-105. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. NSTS 08242 references specification ML0601-9024, which controls operations for the orbiter's thermal protection system. ML0601-9024 authorizes the use of this material only in such operations.
30	<i>RE22</i> Unavailable	No test data available through MAPTIS.	Observed in use on Orbiter Vehicle-105. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. Not listed in Appendix C of NSTS 08242 as approved for general use.
31	<i>Armalon</i> Fairprene Industrial Products	MAPTIS contained flammability, flash/fire, mechanical impact, toxicity, odor, and thermal vacuum stability test data for one material matching the designation of Armalon and only mechanical impact test data for a second material named Armalon. Both materials are manufactured by Fairprene Industrial Products.	Observed in use on Orbiter Vehicle-105. Not tested by the Kennedy Materials Science Lab. The lab has not received a request for testing. NSTS 08242 references specification ML0601-9024, which controls operations for the orbiter's thermal protection system. ML0601-9024 authorizes the use of this material only in such operations.

Appendix F. Management's Response

National Aeronautics and
Space Administration
John F. Kennedy Space Center
Kennedy Space Center, FL 32899



Reply to Attn of: PH

JUN 18 2001

TO: QA-D/KSC Audit Liaison Representative
FROM: PH/Director of Shuttle Processing
SUBJECT: Draft Report on Audit of Controls Over the Use of Plastic Films, Foams, and Adhesive Tapes In and Around the Space Shuttle Orbiter Vehicles, Assignment Number A0004101

The findings and recommendations in the Office of the Inspector General draft audit report, dated May 22, 2001, regarding the controls over the use of plastic films, foams, and adhesive tapes in and around the Space Shuttle orbiter vehicles, have been carefully reviewed. Enclosed is the Shuttle Processing Directorate's (PH) response to the report and to the recommendations.

Michael E. Wetmore
for David A. King

Enclosure

cc:
PH-B/Mr. Phelps
PH-B/Mr. Phillips
PH-H/Mr. Kelley
PH-P/Mr. Higgins
USAlliance/USK-274/Mr. Osborne
USAlliance/USK-383/Mr. Adamek
USAlliance/USK-455/Mr. Rudolph
USAlliance/USK-572/Mr. Pickavance

Enclosure 1

Response
ToOffice of Inspector General
Draft Audit Report A0004101

Controls over the Use of Plastic Films, Foams, and Adhesive Tapes In and Around Shuttle
Orbiter Vehicles

 General Discussion

We concur with the Office of Inspector General (OIG) draft report that the administration and documentation of the control and use of plastic films, foams, and adhesive tapes (PFA) need improvement to remove apparent overlapping and conflicting requirements among NASA Standards, programs, and Kennedy Space Center (KSC) documents (e.g., KHB 1710.2, NSTS 08242, NASA-STD-6001, etc.). We also agree with the OIG that the testing results of materials authorized by other Centers are not readily accessible.

The draft report includes a process flow chart. We are enclosing for your consideration to include in your report a process flow chart (see chart in Backup) that depicts the process that is defined in NSTS 08242 and United Space Alliance (USA) SPI SP-001.

A review of the materials listed in the draft report revealed that all of them were being used safely, and all were authorized for ground processing usage by the Shuttle Program in NSTS 08242. An update to the materials matrix is included in the KSC response to recommendation 5, and a brief discussion of the draft report figures follows.

Some of the report's conclusions were apparently based on the premise that a material cannot be used in and around the orbiter if that material fails any of the material tests. However, a material that is unsafe to use in some applications may be the best selection to use in another application. For example, ACLAR film failed the electrostatic discharge (ESD) test. It would not be safe to use it where a spark could damage sensitive electronic components or start a fire. However, ACLAR is the best film to use to wrap clean mechanical components, due to ACLAR's unique ability to be cleaned and not generate debris particles. NSTS 08242 authorizes the use of ACLAR in this specific operation. KSC KHB 1710.2 and the Shuttle PFA process are based on the premise that materials are controlled based on their specific application.

Much is noted in the report about fire, static control, and hypergolic protection for catastrophic prevention purposes. Fire (flammability) control is performed through material sensitivity regulation rather than restraint of the resultant flame propagation. ESD effects are controlled by creating a path for the energy to be dissipated or by some form of isolation/insulation of the generated energy. Protection from hypergolic effects on materials is accomplished by isolation of materials that are hypergolic sensitive using materials that are not hypergolic sensitive, as with an enclosure or use of protective coverings. The materials listed in the report's figures are authorized for the specific illustrated use because they meet functionality requirements for the particular application, and the appropriate program safety office had reviewed their selection at the time.

See Appendix G,
OIG Comment 1

See Appendix G,
OIG Comment 2

See Appendix G,
OIG Comment 3

See Appendix G,
OIG Comment 4

See Appendix G,
OIG Comment 5

See Appendix G,
OIG Comment 6

Figure 2 depicts a landing gear door opening on the orbiter, and the edge tiles adjacent to the opening are being protected from handling damage using Armalon fabric attached to tile outer surface with Mystic 7000 tape. The materials are shown in proper use. Shuttle Program (orbiter project) selected these materials for use in such an application and approved their use in ML0601-904. Even though laboratory tests of Mystic 7000 tape and Armalon indicate a static (ESD) generation concern, in this particular application there is no static concern. Mystic 7000 tape and Armalon fabric installed as a padding edge protection for orbiter thermal protection system (TPS) material are also not a concern as they are properly used.

In response to the draft report statement that USA "continued to use materials that had contributed years earlier to a fire in the Kennedy Orbiter Processing Facility," the Accident Investigation Board Report for the fire includes reference to four tapes and one ACLAR bag that failed ESD tests. These materials were being used incorrectly. Appropriate corrective action was taken after the report was issued. These five materials are still in use; however, they are only used in approved applications documented in NSTS 08242 or sub-tier documents. Corrective actions taken since the 1995 fire include specifically identifying in the Work Authorizing Documents (WAD's), by stock number and name, the materials used in providing an isolating barrier to segregate the hypergolic operational areas from the rest of the orbiter. The Kennedy Material Science Lab maintains a list of tapes approved for hypergolic operations. These materials have passed flammability, ESD, and hypergolic compatibility criteria. Additional corrective actions included the revision of GSOP 5400 and the WAD's to include periodic application of anti-static spray to SCAPE suits.

Figure D-3 depicts an orbiter/ET liquid oxygen (LOX) umbilical (ET mating face shown) protected with ACLAR film secured with RE 2-2 tape. The ACLAR film is used as a clean covering on this LOX umbilical to protect it from contamination. The RE 2-2 tape is a low-residue, LOX-compatible tape used to secure the film. These materials are being properly used. In this application, ESD would have no detrimental affect on hardware or personnel. Both materials are approved for use in NSTS 08242. The RE 2-2 tape is included in the PPP-T-66 specification referenced in NSTS 08242.

Figure D-4 depicts an Orbital Maneuvering System (OMS) pod base shield area with a Lectrolite Duotone film covering secured with 3M 363 tape. These materials are hypergolic compatible, indicating that a hazardous SCAPE operation is about to occur or has occurred. Hazardous SCAPE operations are not uncommon around the OMS pod due to the potential presence of hypergolic propellants. These materials are being properly used, and NSTS 08242 specifies these materials (3M 363 was added by Materials Use Permit (MUP) 95-010 approved on 5-22-95) for hazardous operations.

Figure D-5 depicts the orbiter left-hand wing edge, which is protected by Ground Support Equipment (GSE) covers. These covers are lined with Ensolite foam, which is used as padding to protect the wing edge. These and all other GSE go through a design and certification process before use in or around an orbiter. This application is a proper use for this material, which is included in NSTS 08242. Static (ESD) and hypergolic properties of the foam are not a concern in this application.

See Appendix G,
OIG Comment 7

KSC Responses to OIG Draft Report Recommendations for Corrective Action:

Recommendation 1. The Director, John F. Kennedy Space Center, should clarify the procedures for using Material Use Permits and safety variances for PFA's that are not on the approved list. The procedures should include appropriate NASA or USA safety office review and approval of all Material Use Permits and variances.

KSC Response. Partially concur. USA uses Standard Practice Instructions (SPI's) to identify to the workforce the requirements and processes used during Shuttle processing. SPI's are developed to provide specific direction for compliance with higher level procedures and documentation. The Material Use Permit (MUP) process is defined in SPI SP-001, "Nonflight Materials and Equipment Control During Orbiter Ground Operations." This SPI states in the General Requirements Section, 5.0, paragraph 3, "If a nonflight material is not in the NSTS 08242 materials list and is required for performing scheduled work, approval must be obtained by processing a MUP (Materials Use Permit), (Reference: Appendix A)." MUP processing is described in paragraph 16a of the General Requirements, which states, "Deviations to the NSTS 08242 controlled materials and equipment lists can be obtained by processing a MUP if the material or equipment is not listed in NSTS 08242 or a quantity larger than the NSTS 08242 approved quantity is required for scheduled work in the controlled area." The SPI also defines the required signatures for approval of each MUP based upon the type(s) of materials involved. If the MUP involves the use of hazardous chemicals, materials or equipment, it must be submitted to the USA and NASA Shuttle Safety engineers for concurrence. This complies with the MUP process defined in NSTS 08242.

Although NSTS 08242 and the USA MUP process does not require USA or NASA Safety engineers to review and approve all MUP's, all processed MUP's are reviewed by the USA Safety engineer and the NASA M&P engineer to assure compliance with requirements.

SPI SF-507, "Safety Variances," defines the USA process for obtaining approval for not meeting identified safety precautions. Testing of materials used in hazardous operations prior to their use in and around the orbiter is a safety requirement, and when this cannot be met, a variance is required. A variance to these testing requirements would also affect the requirements of the KHB 1710.2, which requires the approval of the NASA system engineer as well as the NASA Shuttle S&MA Division Chief. These signature requirements are identified in the Responsibilities and Handling Section, 6.1b, of SPI SF-507 and again in Appendix A of this same SPI. The requirements for completion of the variance request are quite explicit regarding the information, assessment, and signature approvals. All safety variances require the review and approval of USA and NASA Shuttle Safety engineering in accordance with Appendix A.

All USA personnel receive training in general processing requirements and, more importantly in this case, in the specific requirements for safely and correctly accomplishing the assigned tasks. All personnel involved in the process of approving materials for use in and around the orbiter are required to fully understand the two referenced SPI's.

See Appendix G,
OIG Comment 8

See Appendix G,
OIG Comment 9

The point where NSTS 08242 applies and the requirements of KHB 1710.2 apply can be confusing. The materials that are used in and around the orbiter are controlled by NSTS 08242. Other PFA's used in the processing facility must meet, based on use, the requirements of the Kennedy safety requirements contained in KHB 1710.2. Materials that are approved for use by KHB 1710.2 that must be used in or around the orbiter would also require entry into NSTS 08242.

Action Required. An inter-Center team will review the existing requirements for the use of plastic films, foams, and adhesive tapes. The team will provide recommended documentation changes to clarify or enhance the requirements, roles, and responsibilities for the use of plastic films, foams, and adhesive tapes for all programs resident at KSC. Recommendations are due by July 30, 2001.

Recommendation 2. The Director, John F. Kennedy Space Center, should request USA to revise GSOP 5400 to reestablish the requirements for PFA testing that were removed from Revision C on October 3, 2000, and obtain Kennedy Shuttle Safety Office review [of] all proposed GSOP changes prior to implementation as required by the SFOC.

KSC Response. Partially concur. During the IG audit, it was discovered that the PFA section in the GSOP 5400 needed to be updated to reflect NASA and USA roles and responsibilities. NSTS 08242 defines "in and around" as inside and within 3 feet of the Space Shuttle orbiter vehicles. The elements of the NSTS 08242 or MUP approval process were not changed in the new revision of the GSOP 5400. The GSOP change referenced SPI SP-001 that implements the elements of NSTS 08242 or MUP. PFA requirements for areas outside of the orbiter 3-foot perimeter were clarified, while still meeting the requirements of KHB 1710.2.

USA has the authority to change their "how to" policy documents without NASA approval, as long as they do not violate a higher level of NASA safety requirement. In this case, changes released as GSOP Revision D did not violate a higher-level document. USA SPI SP-001 defines the processes that implement requirements found in KHB 1710.2, NSTS 08242, and the "how to" requirements in GSOP 5400. NASA signs all of the changes to SPI SP-001.

All changes to the GSOP 5400 are summarized and sent to the KSC NASA-wide electronic distribution system, and the official version of the GSOP 5400 is available via the KSC Web page. Any requirement changes to GSOP 5400 that result in process changes to MUP or safety variances review, assessments, and signature approvals are reflected in SPI changes, and NASA is required to sign these changes. NASA visibility and approvals of USA MUP process changes are currently in place.

Actions Required. As a part of the inter-Center team, GSOP 5400 will be reviewed for compliance with NSTS 08242 and KHB 1710.2 requirements for the use of plastic films, foams, and adhesive tapes. All required documentation changes will be implemented to assure the compliance with NASA requirements. Changes are due by July 30, 2001.

See Appendix G,
OIG Comment 10

See Appendix G,
OIG Comment 11

Recommendation 3. The Director, John F. Kennedy Space Center, should direct Kennedy Shuttle Safety Office personnel to be more actively involved in the safe use of PFA's by (a) determining whether potential hazards are present in operations, (b) reviewing and approving Material Use Permits or variances that allow the use of materials that have failed required tests or have not been tested, and (c) increasing surveillance of PFA usage in and around the orbiter vehicles and other elements of the Space Shuttle.

KSC Response. Partially concur.

3a and b. For PFA materials used in a hazardous environment, NASA Safety and Mission Assurance engineers are involved in the approval process. The USA internal process to implement the material control and limitation requirements of NSTS 08242 and KHB 1710.2 is defined in SPI SP-001, "Nonflight Material and Equipment Control During Orbiter Ground Operations." This SPI requires that all MUP's involving hazardous chemicals, materials, or equipment be submitted to and approved by USA Mission Assurance, Safety Engineering, and a NASA Shuttle Safety engineer.

The variance process is used to document the acceptance of the residual risk associated with using materials that have not passed a specific test requirement identified in KHB 1710.2, "Kennedy Space Center Safety Practices Handbook." SPI SF-507, "Safety Variances," defines the USA process for obtaining approval for safety variances. Safety variances require approvals of the NASA system engineer and the NASA S&MA Division Chief.

For approval of materials that represent a significant risk, NASA must provide signature approval of the MUP to use a material in a hazardous environment and provide signature approval of a variance to use a material that has not passed a specific requirement.

3c. Currently, NASA Shuttle M&P and Safety engineers perform surveillance of procedures and task execution activities assessing the proper use of materials and the implementation of safety requirements. NASA and USA have chosen continuous sampling on which to base assessments of performance. Sampling is used to determine process capability and stability as well as need for corrective action. To date, the NASA surveillance activities have not indicated any need for corrective actions. By adding periodic internal audits, our surveillance activities will be more robust.

Actions Required. A NASA Shuttle periodic internal audit of the PFA process has been added and is scheduled to be performed in July 2001. Internal and independent verification audits will have a special focus on the use of PFA's.

Recommendation 4. The Director, John F. Kennedy Space Center, should develop one centralized and approved list of PFA's approved for use in and around the orbiter vehicles in Kennedy's Space Shuttle processing facilities.

KSC Response. Partially concur. KSC and the Space Shuttle Program recognize NSTS 08242, "Space Shuttle Limitations for Nonflight Materials and Equipment Used In

See Appendix G,
OIG Comment 12

See Appendix G,
OIG Comment 13

See Appendix G,
OIG Comment 14

Appendix F

10

and Around the Space Shuttle Orbiter Vehicles," as the approved list of PFA's approved for use in and around the orbiter vehicles in KSC Shuttle processing facilities.

We recognize that gaining access to PFA materials evaluations and/or test results performed at other NASA Centers is not always timely. When PFA material is proposed to be used and is not authorized by NSTS 08242, a MUP must be processed, and if the required test data cannot be attained to support the MUP assessment, the PFA material is sent to the Kennedy Material Science Labs for required tests.

Actions Required. An inter-Center team will assess and provide recommendations to assure timely access to PFA materials evaluations and/or test results performed at the different NASA Centers. Recommendations are due by July 30, 2001.

Recommendation 5. The Director, John F. Kennedy Space Center, should direct the Kennedy Shuttle Safety Office to perform appropriate assessments on the use and control of the materials listed in Appendix E of this report.

KSC Response. Concur. Document NSTS 08242 and sub-tier documents contain lists of nonflight materials and equipment approved for use in and around the orbiter during ground processing. The materials listed in these documents are specified because they meet functionality requirements for the particular application, and the appropriate program safety office reviewed their selection at the time. These documents include some items with specific restrictions on their use. Appendix E has been reviewed, and all 30 items were verified to be authorized for use by NSTS 08242 or referenced sub-tier documents. Based on our review, none of the examples included in the report identified materials being used improperly. See the following matrix.

Matrix Item #	Material Description	Drawing Item	Inclusion in NSTS-08242
1	Saran 8	ML0601-9024	Y
2	Eccosorb AN-73		Y
3	Eccosorb AN-77		Y
4	Omar 100		Y
5	Polyfoam 2060 (BIR -60-E)		Y
6	LT-80 Tape	ML0601-9024	Y
7	3M 4008	ML0601-9024	Y
8	3M 4046Y	ML0601-9024	Y
9	3M 4408	ML0601-9024	Y
10	Permacel 222	ML0601-9024	Y
11	CHR K250 (Now St Gobain)		Y

See Appendix G,
OIG Comment 15

See Appendix G,
OIG Comment 16

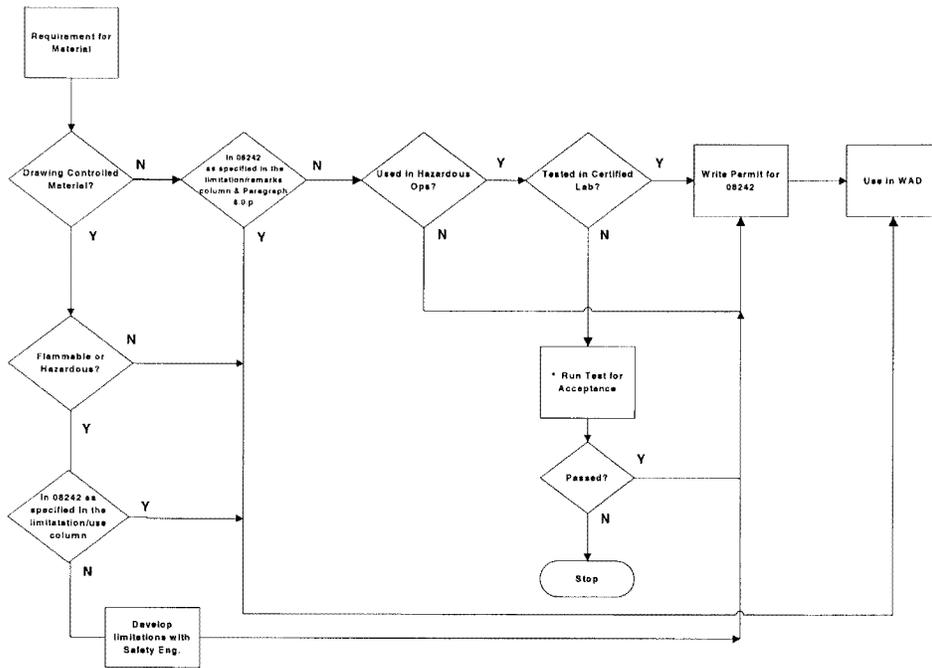
See Appendix G,
OIG Comment 17

12	CHR K350 (Now St Gobain)		Y
13	Permacel 252		Y
14	CHR M66 (Now St Gobain)	ML0601- 9024	Y
15	Mystik 6402		Y
16	3M 800		Y
17	3M 4016		Y
18	Mystik 7503	ML0601- 9024	Y
19	Mystik 7505		Y
20	Mystik 7510		Y
21	3M 60		Y
22	3M 61	ML0601- 9024	Y
23	3M 62		Y
24	CHR HM-650	ML0601- 9024	Y
25	RB0159-002 s/b RB0195...		Y
26	Mystik 7367		Y
27	Permacel P-670		Y
28	Kalex 15036		Y
29	Mystik 7000	ML0601- 9024	Y
30	RE-2 2	MK0116- 0011	Y
31	Armalon	ML0601- 9024	Y

Actions Required. Complete.

Appendix F

Flow Chart for Plastic Films, Foams and Adhesives
For use 'In and Around (3 ft) the Orbiter'



* Acceptance Criteria:

- If used in a 150 degree or higher environment – run flammability test per NASA-STD-6001
- If used in an ESD sensitive area – run ESD test per MMA-1985-79
- If used in a hypergolic environment – run flammability test per NASA-STD-6001, run ESD test per MMA-1985-79, and run Procedure for Casual Exposure to Hypergolic Fluids – MTB-175-88

Appendix G. Office of Inspector General Comments on Management's Response

John F. Kennedy Space Center (Kennedy) management provided the following comments in response to the draft report. Our responses to the comments are also presented.

Management's Comment. The draft report includes a flowchart for the use of plastic films, foams, and adhesive tapes in and around the orbiters. Kennedy enclosed (see Appendix F) for our consideration and inclusion in the report, a process flowchart that depicts the process that is defined in NASA Standard 08242, "Limitations for Non-flight Materials and Equipment Used In and Around the Space Shuttle Orbiter Vehicles," (NSTS 08242).

1. Office of Inspector General (OIG) Comments. The process flowchart in the body of the audit report (page 4) reflects our understanding of the process flow for the safe use of PFA's in and around the orbiter as required by the Space flight Operations Contract (SFOC) and NASA and Kennedy policies on the testing and control of PFA's. The process flow as depicted in management's flowchart does not completely meet SFOC requirements because (1) there is no testing data and results available for many of the materials listed in NSTS 08242 and (2) the Materials and Processes (M&P) engineer's decision as to whether a material would be used in a hazardous operation did not include input from a safety engineer.

Management's Comment. Kennedy's review of the materials listed in the draft report determined that all of them were used safely and that all were authorized for ground processing usage by the Shuttle Program in NSTS 08242.

2. OIG Comments. Although management responded that it used all of the listed materials safely, that was not the case during our audit field work. We identified 30 materials that United Space Alliance (USA) was using in and around the orbiter vehicles for which there was no record of testing data or Safety Office review and approval. On February 5, 2001, we presented this information to the Kennedy Director of Shuttle Processing to share with his staff. When we met with the Kennedy Director of Shuttle Processing on February 15, 2001, he did not know whether USA used the materials safely but stated that he would have to perform further research. More than 4 months later, management concluded that USA used the materials safely. However, Kennedy was unable to present any evidence of materials testing from any NASA Center or test facility. In our opinion, management should know at all times whether USA is safely using materials in or around the orbiter vehicles. There should be a clear audit trail of testing data, safe use requirements, and authorization for every material used in and around the orbiters. We found that no such audit trail existed.

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Management's Comment. Some of the report's conclusions were based on the premise that a material cannot be used in and around the orbiter if that material fails any of the material tests.

3. OIG Comments. We take exception to management's statement. The report clearly states that "Materials that meet NASA standards are placed on approved lists. Materials that do not meet those standards can be used only after obtaining a Materials/Equipment Usage Permit (Material Use Permit) or a safety variance, both of which require USA and Kennedy safety office approval."

Management's Comment. Much is noted in the report about fire, static control, and hypergolic protection for catastrophic prevention purposes.

4. OIG Comment. The report discusses two fires involving PFA's in Kennedy's Shuttle processing facilities in order to illustrate the potential effect of inadequate control of PFA's and the need for strong safety requirements. In addition to the two fires discussed in the report, another incident occurred in April 2001 in the Orbiter Processing Facility that provides further evidence of the need for improved fire and static control. According to the USA incident report on the April 2001 incident, vapors from a bottle containing a waterproofing agent ignited and could have caused serious injury to processing personnel and/or significant damage to major essential flight elements. The incident investigation team determined that a root cause of the incident was the use of materials that had a high potential for electrostatic discharge (ESD).

Management's Comment. Fire (flammability) control is performed through material sensitivity regulation rather than restraint of the resultant flame propagation.

5. OIG Comment. This statement conflicts with NASA and USA requirements. Both NASA and USA standards indicate that control of flame propagation must also be considered. NASA Technical Standard 6001, "Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion (NASA-STD-6001)," requires the upward flame propagation test on all materials used in space vehicles, ground support equipment, and facilities used during assembly, test, and flight operations. NASA-STD-6001 states that the purpose of the upward flame propagation test is, "to determine if a material, when exposed to a standard ignition source, will self-extinguish and not transfer burning debris, which can ignite adjacent materials." USA also acknowledged the need to control flame propagation of PFA's by stating in its Ground Safety Operating Procedures (GSOP) 5400, Revision D, "If a flammable adhesive tape is used to join two thin sheets of plastic that meet flammability requirements, and if the tape accidentally ignites, it (and its adhesive) can act as a path to quickly propagate the flame from one edge to the other of the normally self-extinguishing plastic film."

Management's Comment. The materials identified in the report's photographs are authorized for the specific use shown in those photographs because they meet functionality requirements for the particular application, and the appropriate program safety office had reviewed their selection at the time.

6. OIG Comment. Neither the Armalon fabric nor the Mystik 7000 tape shown in Figure 2 of the report are on the Kennedy Materials Science Lab's list of approved materials and are not included in Appendix C of NSTS 08242 as approved for general use in and around the orbiter vehicles. USA did not obtain a Material Use Permit allowing the use of either material, and there was no record of either USA or Kennedy Safety office approval for either material.

The Kennedy Materials Science Lab had not tested the RE22 tape shown in Figure D-3. The tape is not in Appendix C of NASA Standard 08242 as approved for general use in and around the orbiter vehicles, and there is no current Material Use Permit approving the use of RE22 tape. MAPTIS contained no test data for this tape and there was no record of either USA or Kennedy Safety office approval for the RE22 tape.

Management's Comment. Even though laboratory tests of Mystik 7000 tape and Armalon indicate a static (ESD) generation concern, in this particular application, there is no static concern.

7. OIG Comment. The Mystik 7000 tape failed ESD testing and was cited as a contributing cause to a fire in the Kennedy Orbiter Processing Facility. When we took the photograph of the Mystik 7000 tape, there were no documented procedures/ restrictions in place and authorized by either NASA or USA safety personnel to ensure the safe use of the material. The material was not listed in NSTS 08242 or approved through a Material Use Permit or safety variance.

Management's Comment. USA uses Standard Practice Instructions to identify to the workforce the requirements and processes used during Shuttle processing.

8. OIG Comment. The OIG is aware of the separate requirements for using a Material Use Permit as opposed to a variance. However, as stated in the report, USA's procedures were unclear regarding when one process is more appropriate than the other. In fact, we found at least one example of issuance of both a Material Use Permit and a safety variance for the same material (Fromelt Saf-T-Vu plastic film). Details on this example are provided in footnote 18 of the report. By not consistently applying the Material Use Permit and variance process, USA did not always obtain safety office approval and did not prepare risk assessments to support its decisions to use unapproved materials in Kennedy's Space Shuttle processing facilities. Only the USA Materials and Processes

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(M&P) engineer specialist determined whether the proposed use of a material posed a hazard. The M&P engineer specialist did not seek Kennedy or USA Safety Office involvement unless he determined that hazards were present.

In addition, Material Use Permits did not always provide specific instructions and restrictions for the use of PFA's that did not meet NASA requirements. For example, on March 18, 1996, the Kennedy Materials Sciences lab tested Kydex 100 thermoplastic sheets, and the material failed the ESD test. Although USA issued a Material Use Permit for Kydex 100 on January 24, 2000, the Material Use Permit log did not include any special instructions to ensure that the material is used only when ESD is not a concern. USA should have clear, uniform procedures defining when it is appropriate to use a Material Use Permit or a variance to ensure that all materials are used safely.

Management's Comment. Although NSTS 08242 and the USA material use process does not require USA or NASA safety engineers to review and approve all Material Use Permits, the USA safety engineer reviews all permits.

9. OIG Comment. Management did not provide support for this statement. The USA M&P engineer specialist responsible for preparing the Material Use Permits stated that he asks for safety engineer review only when he determines that the materials will be used in a hazardous operation. Our review of the Material Use Permit file supported the USA M&P engineer's statement. Specifically, we found a safety engineer's signature only on the Material Use Permits for materials the engineer specialist determined would involve hazardous operations.

Management's Comment. During the audit, it was discovered that the PFA section of GSOP 5400 needed to be updated to reflect NASA and USA roles and responsibilities.

10. OIG Comment. This statement is not factual. USA was not complying with its own safety procedures regarding the use and control of PFA's. When we brought this noncompliance to the attention of USA management during the audit, USA changed procedures concerning PFA's rather than comply with established testing and safety assessment requirements.

USA safety and M&P personnel stated that they were unaware of any NASA requirement that USA have all PFA's tested for flammability resistance, ESD rate, and hypergolic compatibility prior to general-purpose use in and around the orbiter vehicles. Those personnel told us that USA's position on PFA testing was that USA needed to test a PFA only for those hazards (flammability, ESD rate, hypergolic compatibility) that could be reasonably expected based on the specific use of each PFA. Furthermore, the USA M&P engineer specialist told us that he was unaware that the GSOP 5400 required USA to perform all three tests on all PFA's before use.

We subsequently met with USA safety and M&P personnel and gave them section 2.21 (pages 2-50 through 2-52) of GSOP 5400, which states that all thin plastic films and adhesive tapes used in the Space Transportation System (STS) and Payload areas must be approved by the Kennedy Space Vehicle Safety and Reliability Divisions of the Kennedy Safety Office. In addition, Section 2.21 states that the use and approval of a thin plastic film or an adhesive tape “depends on the results of its safety assessment. This assessment consists of tests which measure safety characteristics.” Furthermore, Section 2.21 states, “Specific measurements are flammability, electrostatic discharge rate, and hypergolic . . . compatibility.”

In response, the USA safety and M&P personnel stated that this particular section of GSOP 5400 could be confusing and could be interpreted incorrectly. The USA safety engineer stated that before the Space Flight Operations Contract (SFOC) was signed, GSOP 5400 was a NASA document and that, since USA had taken over ground operations of the Shuttle program, USA management has gradually altered the document to suit its needs. Section 2.21 was one section of the original NASA document that USA had yet to change to reflect its actual operating procedures. USA would revise Section 2.21 to better reflect current operational procedures regarding use and testing of PFA’s. However, during the audit, we found that USA quoted this section of GSOP 5400 in preparing a March 2000 safety variance for Lectrolite Duotone green/black film.

The USA safety engineer subsequently provided the revised sections of GSOP 5400 to the audit team. The revised GSOP 5400 omitted the two sections that required risk assessments, including tests of flammability resistance, ESD rate, and hypergolic compatibility, prior to using all plastic films and adhesive tapes. USA’s rationale for the change stated only that, “Redlines are necessary to clarify existing policies per NASA OIG audit.”

Management’s Comment. USA has the authority to change its “how to” policy documents without NASA approval, as long as USA does not violate a higher level NASA safety requirement.

11. OIG Comment. This statement is not completely correct. According to Kennedy Shuttle Safety Office officials, USA had the authority to change its “how to” policy documents without NASA approval, as long as USA did not violate a higher level NASA safety requirement or increase risk. In our opinion, omitting a requirement to perform risk assessments on PFA’s prior to their use, including tests of flammability resistance, ESD rate, and hypergolic compatibility, increases risk. USA should have promptly brought this change to the attention of the Kennedy Shuttle Safety Office.

Management’s Comment. For PFA materials used in a hazardous environment, NASA safety and mission assurance engineers are involved in the approval process.

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12. OIG Comment. Our concern, as detailed in the report, is the method for making the determination of hazardous use or whether a material is hazardous. We determined that only one individual, the USA M&P engineer specialist (not a safety engineer), determined whether the proposed use of the material posed a hazard. The M&P engineer did not seek Kennedy or USA Safety Office involvement and did not submit the material to the Kennedy Materials Science Lab for testing unless the engineer specialist determined that hazards were present. In contrast, Kennedy Shuttle Safety office personnel stated that they believed (1) USA submitted all Material Use Permits to the Kennedy Shuttle Safety Office for approval, no matter how the materials were to be used, and that (2) at a minimum, USA had all new and previously unapproved PFA's tested for flammability resistance to establish whether the material itself may be hazardous. In our opinion, and as reflected in this report, the Kennedy Shuttle Safety Office should make the determination as to whether potential hazards are present in operations that involve PFA's.

Management's Comment. Currently, NASA Shuttle M&P and Safety engineers perform surveillance of procedures and task execution activities assessing the proper use of materials and the implementation of safety requirements.

13. OIG Comment. In our opinion, the surveillance the NASA Shuttle M&P and Safety engineers perform can be improved. Specifically, Kennedy Shuttle Safety Office personnel were unaware that (1) the USA M&P engineer specialist frequently approved Material Use Permits without consulting either the USA or Kennedy Shuttle Safety Offices, (2) USA did not have the Kennedy Materials Science Lab test all PFA's, and (3) USA made significant changes to its materials safety procedures. Further, Kennedy Shuttle Safety Office personnel erroneously believed that, at a minimum, USA tests all new, unapproved PFA's for flammability resistance.

Management's Comment. Kennedy and the Space Shuttle Program recognize NSTS 08242 as the approved list of PFA's approved for use in and around the orbiter vehicles.

14. OIG Comment. Management's statement conflicts with the requirements referenced in the SFOC. NSTS 08242 and the Kennedy Materials Science Lab often differ on whether a material is approved for use in and around the orbiter. Although Kennedy stated that NSTS 08242 is the list of PFA's approved for use in and around the orbiter vehicles, that was not the case during the audit. Specifically, we identified several, often conflicting, sources of approved materials and requirements regarding material selection, testing, and control. For example, Appendix I of USA's GSOP 5400 and Chapter 7 of the Kennedy Safety Practices Handbook state that current approved adhesive tape and plastic film lists are on the Kennedy Materials Science Division Intranet. However, the USA M&P engineer specialist also referred us to (1) Appendix C of NSTS 08242, (2) Material Use Permit and safety variance files, and (3) MAPTIS when selecting PFA's for use in

Kennedy's Space Shuttle processing facilities. As a result, there were at least five sources used for identifying approved materials. On February 5, 2001, we presented this information to the Kennedy Director of Shuttle Processing. When we subsequently met with the Kennedy Director of Shuttle Processing on February 15, 2001, he was unable to identify a single approved list of PFA's approved for use in and around the orbiter vehicles. It was not until more than 4 months later that management concluded that NSTS 08242 was the approved list of PFA's approved for use in and around the orbiter vehicles. Kennedy should approve one centralized source of materials for use in and around the orbiter vehicles, with reference to all associated testing records to ensure that the materials are used safely.

Management's Comment. We recognize that gaining access to PFA materials evaluations and/or test results performed at other NASA Centers is not always timely.

15. OIG Comment. Management's statement is misleading. Of the 30 materials listed in Appendix E of the report, testing records for 16 of the materials did not exist. Further, the testing records that were available for the remaining 14 materials did not clearly show the results of the test.

Management's Comment. When PFA material is proposed to be used and is not authorized by NSTS 08242, a Material Usage Permit must be processed, and if the required test data cannot be attained to support the Material Usage Permit assessment, the PFA material is sent to the Kennedy Material Science Lab for required tests.

16. OIG Comment. Our audit work does not support management's statement. The USA M&P engineer specialist told us during the audit that PFA's are tested only when he determines that hazards may be expected in the use of the PFA. Furthermore, we identified at least one material (RB0159-002 pressure sensitive tape) not authorized by NSTS 08242 for which no test records existed. The USA M&P engineer specialist processed Material Use Permit 94-007, authorizing permanent use of this material. The USA M&P engineer specialist approved the Material Use Permit even though the Kennedy Materials Science Lab never tested the material. In addition, we could not locate test records from any other NASA Center or test facility for this material.

Management's Comment. Appendix E has been reviewed, and all 30 items were verified to be authorized for use by NSTS 08242.

17. OIG Comment. There is no support for this statement because management has not presented evidence of materials testing results for the materials from any NASA Center or test facility.

Appendix H. Report Distribution

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Report Title: Controls Over the Use of Plastic Films, Foams, and Adhesive Tapes In and Around the Space Shuttle Orbiter Vehicles

Report Number: _____ **Report Date:** _____

Circle the appropriate rating for the following statements.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
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