National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

JUL 5 2001

Reply to Attn of: JE

U.S. Environmental Protection Agency
Docket A-2000-18
OAR Docket and Information Center
401 M Street, SW
Room M-1500, Mail Code 6102
Washington, DC 20460

Subject: Notice of Data Availability; New Information Concerning SNAP Proposal on HCFC Use in Foams – 66 FR 28408 – May 23, 2001

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment to the Environmental Protection Agency (EPA) on the referenced notice of data availability. Our comments are provided in the enclosure. Ms. Anhar Karimjee, EPA point of contact for subject notice, permitted us to submit our comments at this time.

The purpose of this formal comment concerns the information received by EPA subsequent to September 11, 2000. NASA concurs with the conclusions drawn in Caleb Management Services' independent survey that none of the technical options currently available to the foam industry provides a complete solution to the problem of HCFC 141b phaseout. Furthermore, NASA does not agree with the assertions made by certain blowing agent manufacturers that blowing agents will be available for all spray and pour foam applications by 2005. Finally, NASA would like to note that space vehicle insulating foam use is a specialized sector that should have been identified by the independent survey.

NASA has requested EPA's Stratospheric Protection Division, Program Implementation Branch, to include in its upcoming proposed regulations concerning the allowance allocation system for HCFC consumption, and in its omnibus rule, an exemption process to provide for the continued production and importation of HCFC 141b for space vehicle uses beyond the January 1, 2003, deadline contained in 40 CFR 82.4. NASA understands that the proposals under consideration by the Program Implementation Branch provide for allowances for space vehicle uses up to January 1, 2010.

NASA therefore reiterates that the present rulemaking also recognize the unique requirements of space vehicles, and exempt from its provisions the use of HCFC 141b for space vehicle purposes.

If NASA can be of further assistance, please contact Ms. Maria Bayon at 202-358-1092.

Olga M. Dominguez
Director, Environmental Management Division

Enclosure

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NASA Comments to Notice of Data Availability: New Information Concerning SNAP Program on HCFC Use in Foams, Released 23 May 01 [66 FR 28408]

INTRODUCTION

This letter is in response to EPA's recent request for comments published May 23, 2001 in the Federal Register [66 FR 28408]. Comments were requested on additional technical information submitted to EPA in response to EPA's SNAP proposal on HCFC use in foams dated July 11, 2000 [65 FR 42653]. This information pertained to the availability and technical viability of alternatives to the use of HCFCs in all foam end uses and is contained in EPA's SNAP Docket number A-2000-18. All document numbers below refer to that docket.

The following are the comments of the Space Shuttle Program (SSP) regarding the quality, accuracy and completeness of EPA's information. EPA does not specifically identify space vehicle use of insulating foams as an end-use sector. However, it is an important and technically challenging application of foam insulation that has human safety and national security ramifications.

NASA reviewed the subject additional information and wishes to provide comments in three areas of concern: materials availability, materials and processes viability for aerospace end uses, and the elimination of HCFCs in foam end uses as of January 1, 2005.

BACKGROUND

Each of the major Space Shuttle elements requires a thermal protection system (TPS). The SSP requires spray and pour foam insulation systems to satisfy NASA requirements for TPS materials. These materials utilize a chemical blowing agent to provide the critical thermal protection and cell structure properties of the foam insulation. The primary blowing agent used is HCFC 141b.

In 1992, the SSP initiated research on the next generation of blowing agents and foams in anticipation of EPA's accelerated phaseout of HCFC 141b. A significant amount of testing and development work has been conducted since that time. Potential blowing agents that have been screened include water, CO_2, pentane, HFC 245fa, HFC 245ca, HFC 236ea, HFE 245, HFE 263, ClF_3, C_3F_7I, HFC 356, HFC 365, HFC 245fc, and HFC 227ea. As part of the steps taken to find alternatives and share NASA developed technology, development team members have attended more than 50 conferences or technical interchange meetings where they have delivered presentations or have worked with representatives of other companies in the area of alternative blowing agents. Many different sources of blowing agent information have been utilized including: aerospace companies, NASA, military services, chemical companies, universities, libraries, national laboratories, blowing agent manufacturing companies, and the EPA. This experience gives us a credible basis from which to assess the quality of EPA's additional information.

It is important to note that foam that meets Space Shuttle requirements is not typical commercial industry foam. Extreme environments are encountered during pre-launch, launch and space flight; SSP foams must withstand these environments while providing highly efficient performance. Shuttle TPS foams must meet the stringent technical criteria listed below:

- Cryogenic strain capability at -423• F under Space Shuttle flight loads
- Maintain structural material properties (tensile strength, bond adhesion, etc.) over a temperature range of -423• F to +300• F
- Maintain propellant quality
- Acceptable material recession rate when exposed to the aerothermal and radiant heating environment experienced during the Space Shuttle mission
- Prevent debris that would adversely impact the Orbiter by creating a Safety of Flight issue
- Density and thermal conductivity that are sufficient to provide adequate thermal insulation while minimizing weight
- Meet NASA Handbook 8060.1 flammability requirements
- Sufficient robustness to survive manufacturing and transportation activities

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- Shelf life stability
- Long-term cured foam stability
- Lot-to-lot manufacturing consistency
- Low toxicity

TECHNICAL DISCUSSION

The SSP is concerned about certain blowing agent suppliers' assertions to EPA that alternate blowing agents will be available for all spray and pour foam applications by 2005. The SSP is also concerned about the implications in Docket item number IV-D-61 that blowing agent availability is synonymous with foam availability for all foam end uses, "compounds like HFC 245fa will be commercially available in time for a smooth conversion from HCFC 141b during 2002". SSP experience to date does not support such claims.

Space Shuttle thermal protection systems require both spray and pour foams that meet the extreme technical requirements of manned space flight. SSP processes rely on liquid blowing agents with specific properties. The SNAP-approved blowing agents are significantly different and are not drop-in replacements. NASA would like to take this opportunity to share with EPA the results of Shuttle testing of two blowing agents specifically mentioned in SNAP Docket comment materials.

HFC 245fa

In a letter (Docket item number IV-D-61) to EPA dated February 9, 2001, Honeywell states that replacement blowing agents, such as HFC 245fa, exist for all applications of HCFC 141b blown foam and that alternate foam systems for all end uses "are or will be available at a reasonable cost by the beginning of 2003." The SSP has tested HFC 245fa, and finds that it is a promising potential alternative to HCFC 141b. However, there are sufficient processing challenges associated with it and other potential alternates that qualification testing for manned space flight could not be completed before January 2005.

To implement new materials, such as replacement insulating foams, on manned space vehicles, NASA requires extensive qualification and verification testing. Test results must then be compiled into a comprehensive database and the data analyzed. Because this is a lengthy process, NASA disagrees with the commenter's implication that all end use sectors should be able to implement satisfactory replacements for HCFC 141b blown foams by EPA's proposed deadline of January 1, 2005.

HFC 245fa has a significantly higher vapor pressure than that of HCFC 141b. This has resulted in the need for equipment modifications, including pressurized cylinders and refrigerated storage. The vapor pressure has also dictated the need for modified blend vessels, blending procedures, and pumping and metering equipment that in turn have required significant adjustments prior to producing a material that can be sprayed for testing. The need for pressurized application equipment also necessitates more frequent maintenance of seals, valves and pressure regulators.

The gaseous nature of HFC 245fa at ambient conditions also presents challenges in foam formulation processes. Blending accuracy on a weight percentage basis is difficult since the weight of the blend vessel fluctuates with internal pressures that rise as the gaseous blowing agent is added. To obtain blend accuracy required by the SSP, procedural changes are needed to vent and weigh the blend vessel in an iterative loop. Appreciable amounts of blowing agent are lost to the atmosphere during these cycles. This evaporative loss significantly affects specific gravity measurements that are critical to ensure accurate chemical stoichiometry.

Once blended, application of HFC 245fa blown foams requires significant process adjustments compared to current systems. The higher vapor pressure of HFC 245fa contributes to frothing, which complicates spraying and equipment flush procedures. Elevated feed pressures are required to preclude pump cavitation and inaccurate feed ratios. Spray gun modifications must be developed to optimize spray pattern distribution. SSP foam is applied to large acreage with tight thickness tolerances necessary to meet design requirements. The design thickness requirements become more difficult when using high vapor pressure blowing agents. The HFC 245fa comes out of solution with pressure spikes associated with rapid flow rate changes and causes unacceptable variations in foam thickness.

The exothermic chemical reaction of urethane insulations must be adjusted and tuned to accommodate changes in: heat of reaction, vapor pressure of blowing agent, and solubility of blowing agent in both the liquid materials and reacting polymer. Proprietary formulation changes are necessary to achieve targeted densities, reaction profiles, and material properties. The surfactant package, catalysts, reactive polyol blend and isocyanate index must all be properly adjusted.

The higher vapor pressure of the HFC 245fa results in more overspray (material that accumulates on adjacent areas during spraying) during the warm-up and spray activities. The larger amounts of overspray tend to discolor and degrade faster than the current spray materials resulting in heat buildup and potential for fire. The SSP has implemented special procedures to accommodate the safety concerns associated with fire protection.

Finally, HFC 245fa is not suitable for typical hand-mix and pour procedures used in SSP operations.

SSP experience with HFC-245fa has been limited to research and development in laboratory and small-scale settings. Full-scale production and implementation of TPS based on HFC-245fa would require facility, equipment, process and safety-related modifications at SSP production facilities.

Cyclopentane (Exxsol)

ExxonMobil Chemical Company makes the statement in their April 2, 2001 letter to EPA [Docket item number IV-D-76] that "the evidence is clear that a range of safe, technologically, and economically viable substitutes for ozone depleting substances have been identified, for all urethane foam sectors including rigid spray and pour polyurethane foam applications". As with NASA's HFC 245fa experience, this statement is not applicable to the SSP.

Exxsol blowing agents are significantly more flammable than HCFC 141b. This has resulted in the need for modifications to handling and processing equipment including electrical grounding systems, inert gas purges, extensive gas sensors to monitor for explosive limits, integration of the sensors with processing controls to ensure fail safe operations, and increased exhaust demands to comply with National Fire Protection Association (NFPA) standards. Class I Division 1 explosion proof equipment and facilities are the only proven method to ensure safety and continued Space Shuttle production.

The flammable nature of pentanes also presents challenges in foam formulation processes. Blending of liquid components must now be accomplished in closed systems to prevent migration of flammable vapors. Once blended, application of pentane blown foams requires significant process adjustments compared to current systems. Spray gun modifications must be developed to optimize spray pattern distribution and minimize foam overspray. Processing temperatures must be carefully controlled and monitored to avoid ignition sources.

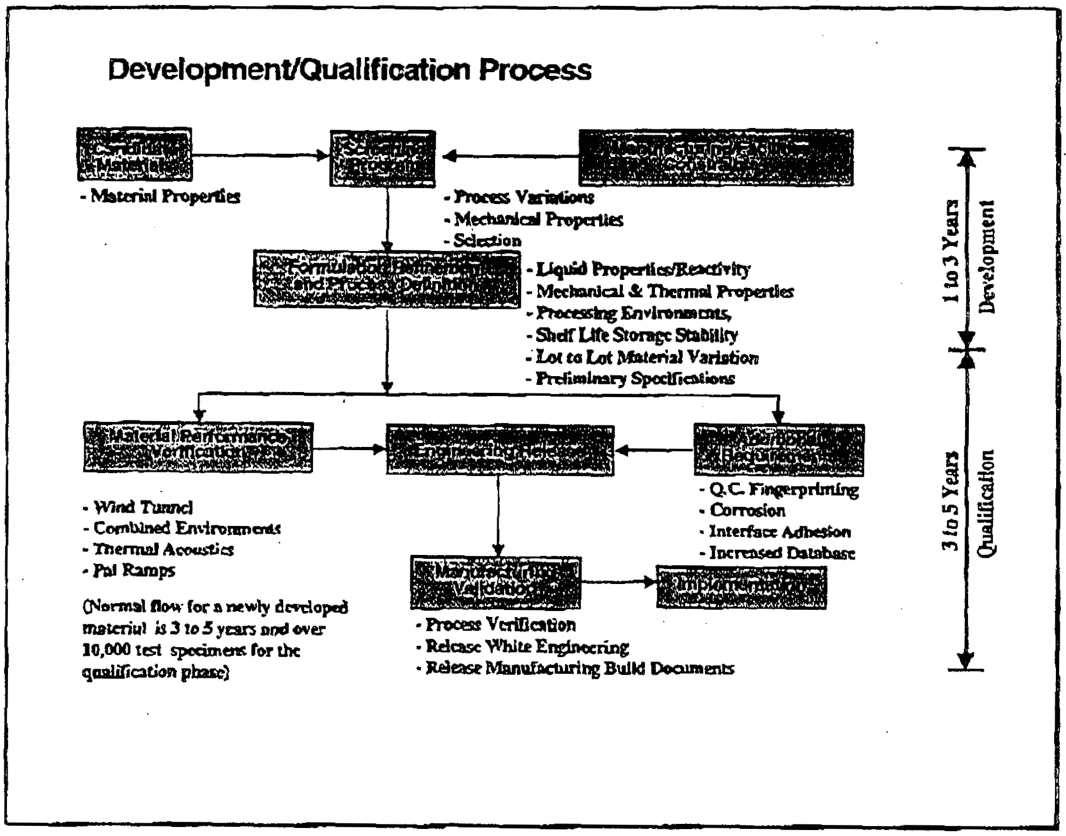
The flammability of the Exxsol blowing agents require extensive facilities improvements at multiple locations including the following NASA facilities: Michoud Assembly Facility (MAF) with multiple TPS production spray cells, Marshall Space Flight Center (MSFC) with multiple research and test spray cells, and Kennedy Space Center (KSC) where closeout and repair operations occur. In addition to NASA facilities, it would be necessary to upgrade contractor and subcontractor facilities to safely handle the flammable materials. Many of the SSP vendors of urethane-based insulations have indicated that they do not intend to use pentane blowing agents in their facilities. For these vendors to continue to supply the flight qualified systems, NASA would either have to invest in an In-House Blending Facility or negotiate the necessary legal obstacles for outside systems houses to license and blend proprietary insulation systems. Either of these solutions would require a significant amount of time to design and implement.

The SSP has developed special procedures to accommodate the safety concerns associated with fire protection for limited research and bench scale testing of flammable materials. The Exxsol blowing agents do offer a potential solution, but significant development is required. The exothermic chemical reaction of urethane insulations must be adjusted and tuned to accommodate changes in: the heat of reaction, vapor pressure of the blowing agent, and solubility of the blowing agent in both liquid materials and the reacting polymer. Proprietary formulation changes are necessary to achieve targeted densities, reaction profiles, and material properties. The surfactant package, catalysts, reactive polyol blend and isocyanate index must all be properly adjusted, tested and verified acceptable for Space Shuttle flight. In order to complete this work, extensive facilities upgrades are necessary.

A Blowing Agent Research Facilities team has reviewed all affected processes and completed an initial assessment of the costs of these upgrades. In addition to the extremely high cost, the number of facilities that must be upgraded dictates the need for more time to fully evaluate the cost and benefits of Exxsol and other flammable blowing agents.

TIMELINE ISSUES

The above paragraphs provide details on the problems encountered with just two blowing agent candidates during the testing required to select a replacement blowing agent and foam system. Human space flight safety is of paramount importance to NASA. Prior to implementation on the Space Shuttle, a new material must undergo a rigorous development and qualification program. These efforts can be time and resource intensive. A flow diagram of that process is shown below.



During development, cryogenic strain, radiant heating, physical property, density, and thermal conductivity materials testing is performed on potential foam systems. Development is an iterative process involving several blowing agent candidates and various foam formulations. Once a candidate is selected, the qualification phase begins. This phase greatly expands testing of the new foam system to include processing variations, lot-to-lot variability, shelf life, manufacturing capability, and design verification testing using various lots of material. Development of an extensive database is required before a product is ready for implementation on manned space flight hardware.

Upon successful completion of qualification tests, the selected foam must be validated in manufacturing processes before implementation. This entire process was completed in eight years for the four replacement foams containing HCFC 141b currently used on the Space Shuttle External Tank.

Given this previous experience in foam replacement, NASA concurs with a statement made in "Assessment of Alternative to HCFC 141b and Impact on The Spray and Pour Polyurethane Foam Industry", dated January 16, 2001 (Docket item number IV-D-55) that "... adoption of substitutes that are commercially viable, given the very distinct and challenging operating environment for any applications, is at least five to eight years away." Because of the rigorous testing requirements associated with the "distinct and challenging" operating environments of space flight, NASA believes that "five to eight years" is a more reasonable timeframe to develop and implement a viable substitute foam for the SSP. Shuttle acceptance of a new TPS material does not conclude until the material is successfully flown on flight hardware. Post-flight hardware assessments must be conducted to ensure adequate performance of the new TPS material.

Additionally, NASA concurs with a conclusion drawn in the Caleb Management Services study (Docket item number IV-D-78b) that there is a "lack of multiple technology choices in most sectors". The SSP agrees that promising candidate blowing agent replacements exist that may prove viable for Shuttle hardware. However, NASA would also like to add other candidate blowing agent alternatives to the SSP test program, specifically HFC 365mfc and hydrofluoroethers. HFC 365mfc is not available in the United States due to licensing agreements between the manufacturer and their US distributor. The hydrofluoroethers are Sevofluorane and Desfluorane. These products are only available by prescription because the FDA regulates them as commercial anesthetics.

Honeywell has Patent

CONCLUSION

Review of EPA's additional information reveals several areas of concern to the SSP. NASA's comments address materials availability, materials and processes viability for aerospace end uses, and the elimination of HCFCs in foam end uses as of January 1, 2005.

A number of SNAP-approved HCFC 141b foam blowing agent alternatives have proven inappropriate for use on Space Shuttle hardware. Additionally, there are other blowing agents of potential interest to the SSP that are not available in the United States. NASA does not agree that alternate blowing agents will be available for all spray and pour foam applications by 2005. NASA concurs that "the number of future transitions should be minimized and adequate timing allowed in the regulatory provisions" (Docket item number IV-D-78b).

NASA further concurs with the conclusions drawn by Caleb Management Services (Docket item number IV-D-78b) that none of the technical options currently available to the spray foam industry provides a complete solution to the problem of HCFC 141b phaseout. NASA believes that EPA would be acting prematurely to eliminate HCFCs in all foam end uses by January 1, 2005 on the basis of perceived material availability.