National Aeronautics and
Space Administration

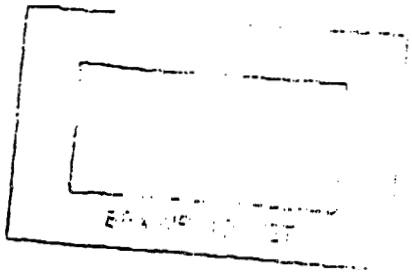
Headquarters
Washington, DC 20546-0001

IV-D-6

Reply to Attn of JE

SEP 8 2000

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



Ref: Proposed Rule: EPA Proposed Rule, Protection of Stratospheric Ozone; Listing of Substitutes for Ozone-Depleting Substances, 65 FR 42653.

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment to the Environmental Protection Agency (EPA) on the referenced proposed rulemaking. The purpose of this formal comment concerns the proposed January 1, 2005 date to discontinue use of HCFC-141b. As explained in the enclosure to this letter, NASA presently requires HCFC-141b for certain critical and essential foam end-uses for space vehicles. There are no substitutes available at this time for these HCFC-141b uses, nor will substitutes be ready for space vehicle uses by the proposed January 1, 2005 date.

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 concerning the 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 requests 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

cc:
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# NASA Comment and Request for Exemption From EPA Proposed Rule. Protection of StratosphericOzone; Listing of Substitutes for Ozone-Depleting Substances. 65 FR 42653

## Executive Summary

The next generation blowing agents represent a much greater technical challenge than the transition from CFC-11 to HCFC-141b for the Space Shuttle program. Blowing agent replacement is technically complex, and the changes involve significant program implementation risk. A thermal protection system (TPS) foam with an alternative blowing agent is not available at this point in time because foam manufacturers cannot provide an alternative that meets Space Shuttle requirements. The transition from a low ozone depleting potential (ODP) blowing agent, HCFC-141b, to a zero ODP blowing agent cannot be accomplished within the proposed phase-out timeline without jeopardizing the safety of NASA's human space flight program. Eliminating the usage of HCFC-141b as of 1/1/2005 would be premature, and would likely ground the space program. NASA thereby requests modification of the proposed rule to allow for the exemption of HCFC-141b utilized for space vehicle foam insulation. Continued use of HCFC 141b as a Space Shuttle TPS foam blowing agent until 2010 so replacements can be developed, qualified, and validated is critical to the NASA Space Program.

## Introduction

EPA established an accelerated schedule for the phase-out of HCFC-141b on December 10, 1993, 58 FR 65018, based on both sections 606(a)(1) and 606(a)(2). In the preamble, it states that "EPA believes it has the authority to take into account the technological achievability of a specific schedule in accelerating a phase-out schedule on the basis of scientific findings. Congress itself recognized the linkage between the need to phase out the production and consumption of ozone depleting chemicals to protect the environment and human health and the availability of substitutes for those chemicals". At that time, EPA believed that research into alternatives, "particularly for HCFC-141b in foam....is currently on-going and should result in the availability of substitutes by the dates contained on the HCFC phase-out schedule." However, this has not been the case for all end-uses. Progress has been made toward replacement materials, but there is nothing commercially available today that meets NASA Space Shuttle Program requirements. Although the ODP of HCFC-141b is substantially greater than any other of the HCFCs, and the accelerated phase-out would thereby ensure compliance

with the United States' obligations under the Montreal Protocol, the EPA is not required by law to phase out all uses. In the same Federal Register the statement was made that "the Agency believes that the use of HCFCs should be limited to only those applications where other environmentally acceptable alternatives do not exist". Recently EPA has proposed additional restrictions (65 FR 42653), citing that "non-ozone depleting substitutes are now available for all foam end-uses". The purpose of this formal comment is to demonstrate to EPA that NASA has certain essential uses for which there are no substitutes available at this time, nor will substitutes be ready for flight by the proposed 1/1/2005 date to discontinue use of HCFC-141b in our foam end-uses, and to request an exemption from the proposed rule for "space vehicles", as they are defined in 40 CFR 63.742.

**Purpose/Intended Use of the Product and Availability of Substitutes**

For over three decades the United States has led the world in the exploration and use of outer space. Access to and use of space are central for preserving peace and protecting United States national security as well as civil and commercial interests. The United States developed the Space Shuttle system to support these efforts by improving human access to space. The Space Shuttle is the first and only reusable space vehicle, and is the world's most reliable and versatile launch system. The Space Shuttle system consists of three major elements: a reusable manned Orbiter, two reusable Solid Rocket Boosters (SRBs), and an expendable External Tank (ET) containing cryogenic propellant for the Orbiter's main engines.

Each of the major Space Shuttle elements requires a thermal protection system. Since the inception of the Space Shuttle Program spray and pour foam insulation systems have been used to satisfy NASA requirements for materials that can withstand the rigors of launch environments while minimizing weight. These materials utilize a chemical blowing agent to provide the critical insulation and cell structure properties of the foam insulation. The blowing agents were originally CFC-11 and CFC 12, Class I ODCs.

Environmental compliance and pollution prevention have been and still are ongoing elements of the space program and the Space Shuttle production process. NASA was very proactive in pursuing alternatives for the Class I ozone depleting compound (ODC) blowing agents in order to comply with the 1990 Clean Air Act Amendments and the 1992 Montreal Protocol.

Replacement blowing agent investigations were initiated far in advance of the December 1995 Class I ODC phase-out. After screening a number of candidates, HCFC-141b was selected as the blowing agent meeting system requirements that was commercially available and proposed by foam manufacturers.

The External Tank requires the most foam insulation of the Space Shuttle elements. The majority of its surface is covered in 16750 square feet of four different HCFC-141b foam insulations that maintain the cryogenic propellant quality and protect the primary structure and its subsystem components to within design temperature limits during pre-launch, ascent, and re-entry phases. Orbiter uses are related primarily to the main propulsion system to prevent the formation of gas in liquid propellant lines, prevent the failure of quick disconnects due to ice formation, and prevention of damaging liquid air formation. Pour foams are used on the SRB for test hole repairs and on separation bolts. Typical annual usage of HCFC-141b in TPS foams is only 0.16% of the 15,537 metric ton HCFC cap established for 2004.

It is important to note that foam meeting Space Shuttle requirements is not typical industry foam used for furniture or insulation. Extreme environments are encountered during space flight. The requirements that the Space Shuttle HCFC-141b foams must meet are determined by the following:

**Prelaunch**

- Minimization of ice formation to prevent underlying vehicle structure damage
- Ensure liquid oxygen (LO2) and liquid hydrogen (LH2) specified temperatures at the Orbiter interface
- Maintenance of LO2 and LH2 boil off rates below vent valve capabilities
- Minimization of air liquefaction on the LH2 tank

**Ascent**

- Adhesion of insulation during lift-off in order to resist vibration and buffeting as the vehicle travels through the lower atmosphere, heat from aero-convective flow, the SRB and main engine plumes, SRB separation motor plume impingement, and autogenous tank pressurization gas

External Tank Reentry

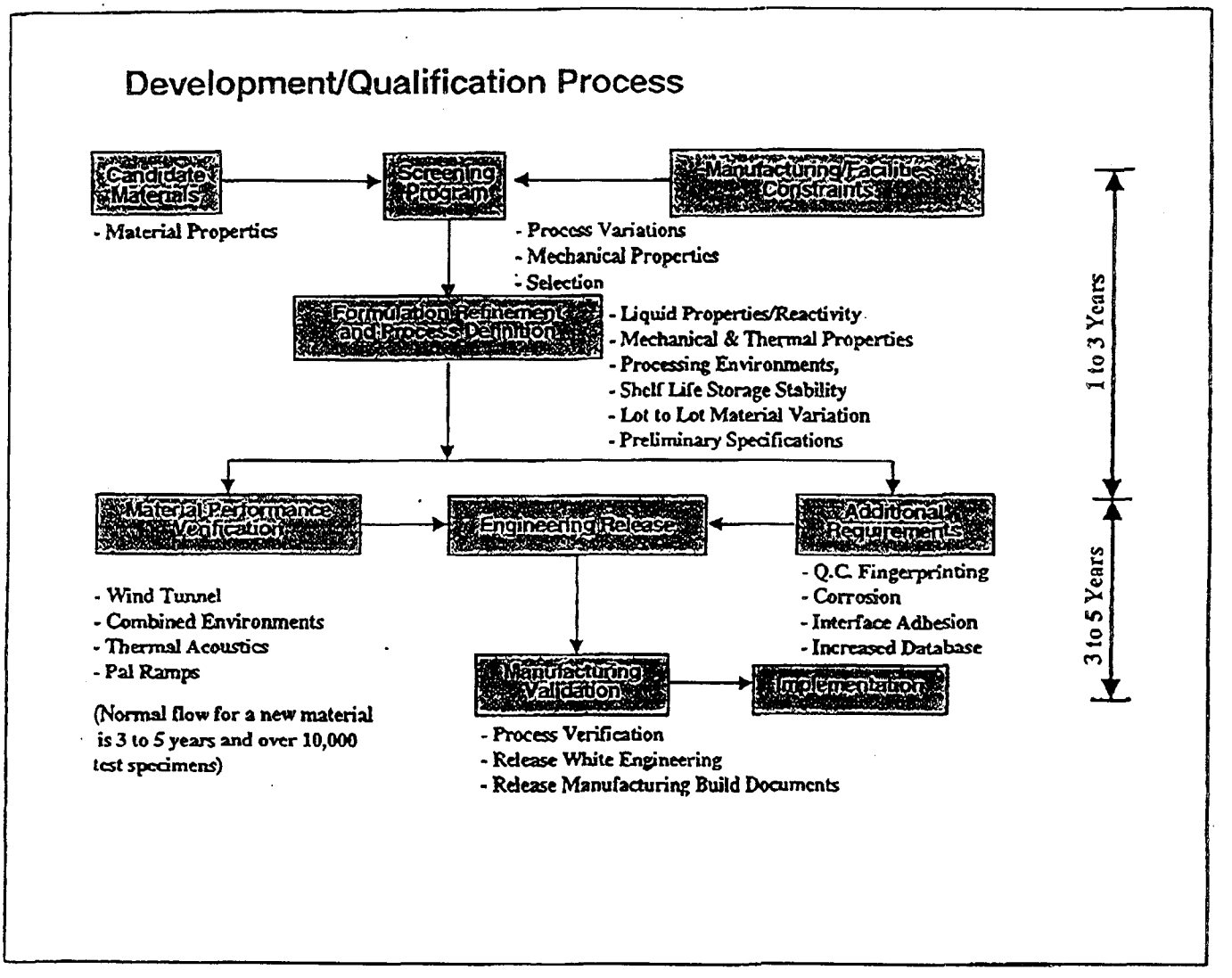
- Resists re-entry heating to maintain an ET debris footprint over an isolated ocean area, protecting the population and established shipping lanes.

TPS foams must meet the stringent technical criteria below in order to meet the above requirements:

- 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
- 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
- Sufficient robustness to survive manufacturing and transportation activities
- Shelf life stability
- Long-term cured foam stability
- Lot-to-lot manufacturing consistency
- Low toxicity

Human space flight safety is of paramount importance to NASA. Prior to implementation on the Space Shuttle system, a new material must undergo a rigorous development and qualification program. The blowing agent used in a replacement foam material can significantly affect any one or all of the above properties, thus the need and importance of development and qualification testing that must be performed to ensure the replacement material meets all of the requirements.

A flow diagram of that process is shown below.




Material testing consists of wind tunnel, cryogenic, radiant, physical property, density, and thermal conductivity. 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. Upon successful completion, 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.

Extensive efforts have been made by the Space Shuttle Program to develop the next generation of blowing agents and foams, with each of the major Space Shuttle elements working to identify replacement materials. A significant amount of research, testing and development work has already been conducted. Potential blowing agents that have been screened include water, CO2, pentane, bromine, HFC 245fa, HFC 245ca, HFC 236ea, HFE 245, HFE 263, CIF3, C3F71, 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.

NASA Headquarters has been working with EPA's Ozone Layer Protection's Implementation Branch since 1996 on development of a process that would allow space vehicle application for a waiver that would allow for continued production of HCFC-141b past the 1/1/2003 phase-out date until 2010. This would allow the time required for NASA programs to develop and successfully implement replacement TPS materials without compromising astronaut safety and Space Shuttle functionality.