

NASA'S APPROACH TO HALON ISSUES

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ABSTRACT

NASA **has** taken a strong stand in eliminating their dependence on halons and CFC's. The various NASA Centers were required **to** have a complete phase-out plan with all funding needs identified by April 1991. Kennedy Space Center (KSC) was designated **as** the focal point for all Halon/CFC reduction and eliminating efforts of the various NASA Centers. A committee chaired by KSC's Propellants Consumables Mangement Office has presented a Halon Phase-out Plan to NASA ~~Headquarters~~, with critical applications outlined. Critical applications include the Orbiter, the Launch Pads, and the Mobile Launch Platforms and will remain protected by halon until an acceptable alternative is available.

To accelerate the search for alternatives, NASA is funding a research project to identify replacement fire suppression agents and test them for various parameters including toxicity, decomposition products, and agent mixing. Small scale and full scale ~~fire~~ tests will be performed, as well **as**, development of hydraulic flow calculations. The project is well under way and looks very promising.

NASA has contracted for the design of a new halon recovery unit, which is expected to yield a greater than 90% recovery. It is scheduled to be complete sometime in 1992.

NASA has taken an active role in supporting industry and the National Fire Protection Association and has taken responsible actions towards their own dependence on halon. This paper **goes** into further details on each of NASA's reduction efforts.

INTRODUCTION

This paper presents an overview of the National Aeronautic and Space Administration's (NASA) halon plan and policies. It covers NASA's management of halon phase-out including funding of alternative agents research, Halon 1301 recycling equipment, research and monitoring of the stratosphere, and involvement with the National Fire Protection Association (NFPA).

POLICIES, PLANS & MANAGEMENT

Concurrent to the amendments of the Montreal Protocol and the Clean Air Act, NASA Headquarters instituted a policy to phase out usage of chlorofluorocarbons (CFC's) and halons. This policy was issued due to world-wide efforts to ban production of these compounds by the year 2000.

Kennedy Space Center's (KSC) Propellants Consumables Management Office was designated to be the Plan coordinator for all NASA Centers including Johnson Space Center, Langley Research Center, ~~Goddard~~ Space Flight Center, Stennis Space Center, Marshall Space Flight Center, Lewis Research Center, Ames Research Center, and Jet Propulsion Laboratory. In addition, KSC formed a CFC and Halon Working Group to develop a KSC Plan for complying with the NASA policy. The Plan outlines phase out timelines, resources, new technology, equipment requirements, bank management, and applications deemed critical for continued halon use. The Plan is updated annually. In addition, all NASA Centers took immediate action to eliminate unnecessary discharges and minimize any leakage.

NASA's interim policy includes: "Planning and preparation for phase out of the CFC's and Halons immediately with a goal of eliminating NASA consumption of these chemicals in all but critical applications by 1995, where critical is defined as both mission essential and applications that have no currently proven and available market alternative." Each NASA Center was directed to establish plans to meet or exceed the 1995 scheduled reduction and phase out of CFC's and Halons and designate any "critical" areas. KSC designated the Mobile Launch Platforms and Launch Pads critical for Halon use until alternatives become available.

KSC's Standard for Fire Protection Design document has already been modified to eliminate reference to Halon system design and states "In general, Halon systems shall not be installed at KSC." It is Center policy to require an engineering assessment, technical report, and Directorate approval for major modifications to existing Halon systems. In addition, the NASA

Safety Manual on Fire Protection is currently under revision to state that expansion or modification to any existing halon system or any new application will require approval from NASA Headquarters.

In the NASA policy released in 1990, it states "NASA will actively participate and support government and industry research and development efforts to identify and qualify CFC and Halon replacements that have NASA application." In concert with this, NASA released funds for research into alternatives to Halon.

ALTERNATIVES RESEARCH

As a result of the 1990 NASA policy and a requirement for halon in the critical launch locations, NASA issued a Call for Solicitations for research into development of non-ozone depleting fire suppressant gases under their Small Business Innovation Research (SBIR) Program. Hughes and Associates, a Maryland based company, received the contract to investigate alternatives.

Under Phase I of this SBIR program Hughes and Associates evaluated the feasibility of using perfluoroalkanes as Halon 1301 alternatives. The objective was to evaluate the feasibility of using perfluorocarbon agents against the range of required characteristics of a "clean", gaseous fire suppression agent. The characteristics include ozone depletion potential, fire suppression effectiveness, material compatibility, flow/discharge characteristics, mixing, decomposition behavior (during flame extinguishment), and toxicity. Perfluorobutane (C₄F₁₀) and Perfluoropropane (C₃F₈) appeared to be viable alternatives and will be studied further in Phase II. Small scale cup burner tests showed them to be effective fire suppressants in relatively low volumetric concentrations (68%). Literature indicates these compounds to be clean, stable, non-toxic, and non-ozone depleting.

Hughes and Associates is now underway with Phase II, a two year contract. The research under Phase II includes reduced scale testing, quantifying thermal decomposition, flow characterization, development of a two-phase flow model, full scale testing and validation, and evaluation of agent mixing.

A technology gap now exists on all alternative agents and precludes an informed selection of alternatives, effective use of alternatives due to a lack of engineering data and design methods, and evaluation of retrofit potential.

Phase II is expected to resolve the following technical barriers: 1) to compare perfluorobutane and perfluoropropane to other proposed alternatives, 2) to develop engineering methods and **data** to enable system design and retrofit evaluation, and 3) **perform** tests to evaluate the thermal decomposition products of these compounds. It will provide an independent source of data for comparison between the proposed alternatives.

3M Industrial Chemical Products Division plans to market the alternative agent, perfluorobutane, developed by Hughes and Associates under the trade name of PFC-410. Other organizations currently proposing alternative agents to Halon include E. I. du Pont de Nemours and Company, Inc. with FE-13 and **FE-25**, Great Lakes Chemical Corporation with FM-100 and **FM-200**, and Canadian based North American **Fire** Guardian Technology Inc. with NAFS-III.

RECYCLING

The Base Operations Contractor at KSC has designed a Halon 1301 recycling unit which is expected to be on-line in August 1992 with an efficiency approaching 99%. The designer is utilizing liquid nitrogen **as** the cooling fluid eliminating the need for a compressor. The halon will be liquefied, **as** it passes across cooling coils containing liquid nitrogen, and pumped to a storage tank. The nitrogen in the halon cylinder will be driven out of the halon **as** it passes through the condenser and vented.

During maintenance of halon cylinders, it is usually necessary to remove the halon from the cylinders. The halon recovery equipment currently in use results in a 20% loss of the halon to the atmosphere. The new unit represents a significant improvement and will allow KSC to achieve a **near** zero loss allowing longer lead time before changeout of the critical systems is necessary. It also provides KSC the opportunity to remove halon from the cylinders in systems that have been removed/replaced with sprinklers and retain the halon in large storage tanks until it can be disposed of properly and safely.

KSC has proposed that they be a Halon 1301 collection point for all NASA Centers. Kennedy Space Center is the largest user of Halon 1301 of all NASA Centers. Once the recycling unit is on-line, KSC can become a repository of Halon 1301 for all NASA Centers. This bank management proposal is now being considered by NASA Headquarters. Items that still need to be addressed before transference can begin include:

- 1) Transportation of halon cylinders over public roads between Centers. Halon cylinders require hydrostaticing on a routine basis, but this necessitates emptying the cylinder. NASA is **looking into** whether the hydrostat test might be waived for transportation in order to reduce unnecessary emissions.
- 2) Procedures **need** to be developed and funding responsibility needs to be assigned for container transfers to the bank storage location (**KSC**).
- 3) **Funding** responsibility of additional storage tanks **at** the designated storage location.
- 4) Empty cylinder disposition.
- 5) Ownership of container in transit should a problem occur.
- 6) **Funding** responsibility for additional floor tax/disposal fees **as** regulations **are** added or changed.
- 7) Procedures/funding responsibility of commodity transfers from the banked storage to requesting locations.

SATELLITE AND PAYLOAD ACTIVITIES

NASA has taken an active role in Space monitoring and research of the upper atmosphere. They have seven active **and** future projects, which are described below.

The NIMBUS-7 polar-orbiting satellite was launched in **1978** carrying the Total Ozone Mapping Spectrometer (TOMS). This instrument is able to provide high-resolution maps of stratospheric ozone and has traced in detail the annual development of the Antarctic "ozone hole". It has performed beyond its expected lifetime and has been joined by another **TOMS** which was attached to a Soviet satellite, the Meteor-3, and launched on August **15,1991**. A third **TOMS** will be launched aboard a Pegasus booster in **1993**, and the Japanese Advanced ~~Earth~~ Observations Satellite (**ADEOS**) will carry a fourth TOMS when it launches in **1995**.

On September **12,1991** NASA launched the Upper Atmospheric Research Satellite (UARS) to study the chemistry, dynamics, and energy of the upper atmosphere and the coupling between the upper and lower atmosphere. In the first two weeks of operation, UARS data confirmed existing ozonedepletion theories by providing three dimensional maps of ozone and chlorine monoxide **near** the South Pole during development of the **1991** ozone hole.

The Shuttle-based Atmospheric Laboratory for Applications and Science (ATLAS-1) mission was launched in April **1992** to study dismbution of ozone at various altitudes. This was the first in an **11-year** series of Shuttle-based Spacelab missions to study long-term interactions

between the atmosphere and the **Sun**. The missions are planned at about one year intervals. Three instruments aboard ATLAS **are** used in ozone monitoring. The Imaging Spectrometric Observatory (ISO) records light signatures in the airglow. The Atmospheric Trace Molecule Spectroscopy (ATMOS) and the Grille Spectrometer map trace molecules, including ozone, in the middle atmosphere by measuring the infrared radiation they absorb. The Millimeter Wave Atmospheric Sounder (MAS) makes simultaneous measurements of ozone concentrations, temperatures in the middle atmosphere, and trace molecules involved in the creation and destruction of ozone.

NASA began its second Airborne Arctic Stratospheric Expedition (AASE II) in October 1991. It was completed in March 1992 and included study over both the Arctic and Antarctic. The mission consisted of two airplanes, based in Maine and Alaska, which flew **on-board** instruments through the atmosphere. The instruments onboard gathered information on polar atmospheric chemical composition and kinetics, winds and clouds, and temperature.

The Shuttle Solar Backscatter Experiment (SSBUV) has flown four times and is scheduled for regular flights through the 1990's. It determines ozone levels by measuring reflected ultraviolet light, measures the total amount and height distribution of ozone in the upper atmosphere, and collects data to calibrate ozone-measuring instruments on other satellites.

The Stratospheric Aerosol and Gas Experiment (SAGE), first launched in 1979, provided ozone measurements using the solar occultation technique until 1981. SAGE II began operation in 1984 and is still in **use**. It provides high resolution of the Antarctic ozone, water vapor, and polar stratospheric clouds. SAGE recently observed large changes in lower stratospheric ozone in the **northern** polar **region** caused by energetic protons released from the **Sun** during intense solar flares.

Instruments to better understand the dynamics of the upper atmosphere, and in particular the ozone, will also be a part of NASA's Earth Observing System (EOS) spacecraft series. The EOS satellites **are** planned to be launched from expendable launch vehicles beginning in 1998 into Sun-synchronous polar orbits **so** that **all** parts of the globe can be viewed.

SUMMARY

NASA's critical applications include the mobile launch platforms and the launch pads. These **are** areas where shut-down of the power due to a fire and/or shorts due to application of

water could cause loss of life and/or payload. These special applications have resulted in NASA's keen interest in discovering alternatives and expediting their implementation. The National **Fire Protection** Association has formed a Technical Committee to write a National **Fire** Code which will guide fire professionals in the determination of fire suppression for **areas** where halon would have normally been the preferred method. A NASA employee is a member of that committee.

Although an unprecedented joining of world parties has occurred to address global environmental **protection**, the ozone depletion continues to be worse than expected each year. For decades, NASA has pioneered the study of the atmosphere in order to improve life on Earth. The agency has made environmental research a top priority and is continuing the ozone studies within Mission to Planet **Earth**, a coordinated series of ground-based, airborne, and space-based programs.

The **Montreal** Protocol is expected to be revised again in 1993, and NASA will continue to meet or exceed the Phase outs outlined in the Protocol. **Bank** management, recycling, elimination of leakage and discharges, alternatives research, and studies on Earth and from Space are all steps being taken by NASA in leading efforts to prevent a global crisis.