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THE EFFECT OF ENVIRONMENTAL INITIATIVES ON NASA SPECIFICATIONS AND STANDARDS ACTIVITIES

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ABSTRACT

The NASA Operational Environment Team (NOET) has conducted a survey of NASA centers specifications and standards that require the use of Ozone Depleting Substances (ODSs) (Chlorofluorocarbons (CFCs), Halons, and chlorinated solvents). The results of this survey are presented here, along with a pathfinder approach utilized at Marshall Space Flight Center (MSFC) to eliminate the use of ODSs in targeted specifications and standards. Presented here are the lessons learned from a pathfinder effort to replace CFC-113 in a significant MSFC specification for cleaning and cleanliness verification methods for oxygen, fuel and pneumatic service, including Shuttle propulsion elements.

INTRODUCTION

With the Copenhagen Amendment to the Montreal Protocol, all United States Government agencies and United States industries have had to greatly accelerate their phase-out of ozone-depleting chemicals (e.g. chlorofluorocarbons, chlorinated solvents). NASA organized a team in April of 1992, the NASA Operational Environment Team (NOET), to coordinate environmental compliance activities across the agency's programs. This NOET was chartered to disseminate information across all programs in an effort to eliminate any redundant replacement activities. Since the NOET needed to know just how extensive was NASA's usage of environmentally targeted materials, usage surveys were executed across the agency. It was discovered that many specifications, standards and procedures used at the various NASA centers call specifically for the use of targeted chemicals, such as CFC-113 (1,1,2-trichloro-1,2-trifluoroethane) and TCA (1,1,1-trichloroethane). Each of these specifications will need to be revised or replaced to allow NASA operations to continue in an environmentally compliant fashion. However, these specifications and standards generally have wide applicability, and the implications of revising these requirements are significant with potential cost impacts for the users. This paper will address the approach, methods, magnitude and scope of implementing environmental replacement technology in NASA specifications and standards. In addition, the discussion will show how the activities to replace CFC-113 and TCA in a widely utilized NASA Marshall Space Flight Center (MSFC) fluid system cleaning specification could be used as a pathfinder or model approach for the replacement of targeted materials in specifications and standards throughout the agency.

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DISCUSSION

The NOET approach to replacement of non-compliant specifications and standards is implemented through the Replacement Technology Team (RT^2) as a four phase program to: (1) identify current applications that use ODSs; (2) identify the performance requirements of those applications; (3) identify potential replacement compounds with equivalent characteristics; and (4) assure that specifications, standards and procedures are revised, where practicable, to permit the use of alternate compounds (reference 1).

The RT^2, which is a component of the NOET, is responsible for identifying potential alternative and replacement technologies and materials for non-compliant compounds. In addition, an objective of the RT^2 is to identify and revise specifications, standards and procedures that utilize individual or specific groups of non-compliant materials. RT^2 addressed the specifications and standards revision issue by requesting information from all NASA centers on any documents requiring the use of Class 1 or Class 2 ODSs. Responses to this information call were received in 1993 and were compiled to define the size and scope of the revision effort required by NASA. Over 300 specification/standard documents were identified in this survey from all the NASA centers. However, NASA was custodian for only about one-half or 144 of the documents identified, i.e. these specifications or standards were under the direct responsibility and control of NASA. . Therefore, other standards that were not under direct control of NASA were not part of this survey, e.g. Federal, Military, Industry or company standards. Table 1 identifies the number of NASA specifications that reference the use of ODSs and which ODSs these documents specify.

NASA Custodian	# of Documents	CFC 11	CFC 113	CFC 114	CFC 12	HCFC 21	HCFC 22	Halon 1301	CCL 4	TCA
ARC	0									
GSFC	0									
JPL	35		X							X
JSC	26	X	X	X	X	X	X	X	X	X
KSC	55		X	X	X	X	X	X		X
LaRC	1		X							
LeRC	1		X							X
MSFC	16	X	X	X						X
SSC	1		X							
HQ	9		X							X
Total	144	Note: CFC13, 111, 112, 115, 211-217, Halon 1211 and 2402 , and other Class 1 and 2 ODSs not shown were not reported in any NASA documents								

Table 1: ODSs Used In NASA Specifications and Standards

The most widely specified or utilized ODSs identified by this survey, in descending order of their frequency of the appearance in these specifications or standards were CFC-113, TCA, HCFC-21 (dichlorofluoromethane) and CFC-114 (1,2-dichloro-1,1,2,2-tetrafluoroethane). The primary use for these targeted chemicals in the specifications identified were cleaning, cleanliness verification, heat transfer/refrigeration, analytical methods, and reference standards.

NASA's Jet Propulsion Laboratory (JPL), Johnson Space Center (JSC), Kennedy Space Center (KSC), Langley Research Center (LaRC), Stennis Space Center (SSC), and MSFC identified fluid/propellant system precision cleaning specifications that require revision. These and similar specification revision activities to implement replacement technologies could benefit from cooperative efforts among NASA centers for consolidation into common NASA-wide specifications and standards. In fact, a plan for the development of a NASA-wide fluid and propellant system precision cleaning specification was adopted by NASA M&P Working Group at the second annual NASA Materials and Processes (M&P) Standards Committee meeting at JSC in April 1994. The draft of this specification is anticipated by April of 1995. This NASA-wide precision cleaning specification for fluid systems will build on the ODS replacement activities underway at each center by utilizing their environmentally compliant specification revisions as the basis for development of a NASA-wide standard. Examples of NASA specifications that have been or are being updated with alternate cleaning materials and processes are: KSC-C-123, "Specification for Cleanliness of Fluid Systems"; MSFC-SPEC-164, "Specification for Cleanliness of Components for Use in Oxygen, Fuel and Pneumatic Systems"; JSCM 5322, "Contamination Control Program Requirements Manual"; and SSC Standard 79-001, "SSC Facility Cleanliness Requirements for Propellant, Gas and Hydraulic Systems".

The results of this survey were not necessarily intended to encompass all the specifications and standards used by NASA prime contractors and subcontractors. This relationship is very complicated, making it difficult to identify whether certain requirements are actually tied to a NASA specification , standard or derived requirement. In addition, some subcontractors consider their internal standards to be proprietary. Typically, these contractor specifications are internal company or industry standards, and specify the design, development, manufacturing and testing requirements for hardware systems. As a result, these specifications could easily specify a significant number of materials, substances and chemicals, of which the numbers of specifications and standards utilizing targeted ODSs should far exceed those reported here by the NASA centers.

NASA Custodian	Handbook	Plan	Procedure	Requirement	Specification	Standard	Total
ARC	54	4	1	5	43	18	125
GSFC	57		2	12	7	21	99
JPL	448	181	17	104	289	78	1117
JSC	398	10	2	40	118	136	704
KSC	170	5	8	3	153	62	402
LaRC	135	2	4	3	99	122	365
LeRC	85	7	26	12	307	260	697
MSFC	437	3	26	10	645	200	1321
HQ	48				2		50
Totals	1832	212	86	189	1663	897	4880

Table 2: ESDB Contents

It has been noted that this survey was intended to take into account primarily those specifications and standards which are baselined, controlled, maintained, and approved for use by each NASA center. These specifications and standards are generally contained in a NASA Engineering Standards Data Base (ESDB), which is a part of the Materials, Processes and Environmental Engineering Network (MPEEN) residing on a VAX cluster at NASA's MSFC. The ESDB is a reference index of NASA baseline specifications and standards which provides the following information:

document number and release date; document title; Federal stock classification number; custodian (who maintains document); discipline (area of use); user (NASA center); metric compatibility; and abstract. The total number of specifications and standards contained in the ESDB is 4880, with Table 2 showing the breakdown by NASA center and type of document. Therefore, approximately 6% of the standards contained in the NASA ESDB utilize ODSs. When considering only those specifications and standards for which NASA is custodian and maintains control, fewer than 3% of the standards in the ESDB contain ODSs that NASA can directly replace by revising the standard to implement alternative technologies.

As a example, at NASA's Marshall Space Flight Center (MSFC), only 16 of the 1321 total approved and baselined MSFC standards contained Ozone-Depleting Substances (ODSs). Table 3 identifies these NASA MSFC standards, the corresponding ODSs, and gives indication of how the chemicals are used. However, several of these documents have broad use or are imposed on major programs and contracts, such as the MSFC Shuttle propulsion elements. As a result, any modifications to the requirements in these standards could have significant impacts to the users. JSC, JPL, and KSC, combined, maintain at least 106 specifications which must be addressed. Some of these may be Standard Operating Procedures (SOPs) and easily changeable. Moreover, most specifications and standards must be revised and go through many levels of approval before they can be implemented. Even prior to revision, new materials must be tested and selected as suitable replacements if a "how-to" type of specification is used as the alternate. If a performance driven or "performance-based" specification is used as the replacement document, the expected results must be clearly defined. Each of these approaches requires a significant amount of work, yet the "performance-based" specification becomes virtually timeless.

Any approach to implementing replacement technology in NASA specifications must also consider NASA Standards Policy (NMI 8070.6) requirements that encourage participation in development and use of "voluntary" or consensus standards when practical, and common, non-project unique NASA standards when this is not practical. Specifically, this policy requires: the adoption of, and gives preference to, non-government or "voluntary" standards where they meet NASA needs; support of NASA's participation in the development of standards by other government and non-government organizations; and developing and maintaining NASA Standards where need cannot be met by other sources. The NASA Standardization Procedures Manual (NHB 8070.3) describes the control procedures for engineering specifications and standards implemented at each center, as illustrated by the following approach utilized by MSFC. The MSFC Engineering Documentation Standard (MSFC-STD-555) describes reasonably straightforward requirements for the expeditious release of MSFC engineering specifications, standards and drawings. General specification, standards, and drawings require the approval signature of the designer or the preparer (designated as the Office of Primary Responsibility (OPR), a designated Materials and Processes (M&P) and Stress engineer, with Safety, Producibility and Inspectability as required depending on the type of document. Project specific specification, standards, and drawings require the same approval signatures as before, but additionally must be approved for release by Engineering Change Request (ECR) through the Project Configuration Control Board (CCB) with resulting Directive (CCBD). NASA-wide or NASA Handbook (NHB) type standards have a much more broad and complex review, release and concurrence process. All MSFC baseline specifications and standards are identified by OPR in the Approved Baseline List (MSFC-MNL-2348) of over 1000 documents of various types, of which approximately 40% are materials and processes type standards that would most likely specify the use of targeted materials. NASA specifications and standards, including those maintained as Goddard Space Flight Center (GSFC), KSC, MSFC, NHB standards are found on commercially available Military & Federal specification/standards services, such as searchable microfilm or CD-ROM systems.

Specification	Title	ODS	Usage
MSFC-SPEC-164	Cleanliness of Components For Use in Oxygen, Fuel & Pneumatic Systems	CFC-113 TCA	Cleaning/Verification (MSFC, ET, SSME, SRB)
MSFC-SPEC-250	Protective Finishes For Space Vehicle Structures & Associated Flight Equipment, General	CFC-113	Cleaning/Surface Prep. (MSFC, ET, SSME, ATP/ATD, SRB)
MSFC-PROC-166	Hydraulic System Detailed Parts, Components, Assemblies, and Hydraulic Fluids for Space Vehicle Cleaning, Testing, and Handling	TCA CFC-113	Cleaning
MSFC-SPEC-233	Nitrogen, Instrument Grade	CFC-113	Cleanliness Verification
MSFC-STD-366	Penetrant Inspection Method, Standard	TCA	Cleaning (Shuttle)
MSFC-SPEC-1870	Guidelines For Evaluation of Corrosion Inhibiting Preservatives	CFC-113	Cleaning
MSFC-SPEC-1919	Thermal Ablative Compound, Application and Cure of	TCA	Cleaning (MSFC, SRB, RSRM)
MSFC-PROC-1831	Analysis of Nonvolatile Residue Content Based on ASTM F331-72	CFC-113	Cleanliness Verification
MSFC-PROC-1832	Sampling and Analysis of Nonvolatile Residue Content on Critical Surfaces	CFC-113	Test Media/Cleaning Test Equipment
MSFC-PROC-404	Gases, Drying and Preservation, Cleanliness Level and Inspection Methods	CFC-113	Cleanliness Verification
MSFC-PROC-639	Procedure For Potting Connection Using Heat Shrinkable Boots/Tubing and RTV Silicone Compounds	TCA	Cleaning
MSFC-SPEC-592	Specification For The Selection and Use of Organic Adhesives in Hybrid Microcircuits	CFC-113	Cleaning
MSFC-10A00527	Sealing of Fasteners subject to Sea Water Exposure on the Solid Rocket Booster (SRB)	TCA	Cleaning SRB
MSFC-10A00528	Protective Finishes for Aluminum and Steel Alloys Subject to Sea Water Exposure on the SRB	TCA	Cleaning SRB
MSFC-SPEC-2083	Polyurethane Foam Insulation	CFC-11	Blowing Agent (ET/Orbiter)
MSFC-SPEC-2084	Mix, Application and Cure of Polyurethane Foam	CFC-11	Blowing Agent (ET/Orbiter)

Table 3: MSFC Specifications to be Revised for Environmental Compliance

From the beginning, the implementation of replacement technology in NASA specifications and standards adopted a Continuous Improvement (CI) teaming approach coordinated by NOET RT^2. NASA specifications and standards were tailored using CI through Product Development Teams (PDTs) involving both NASA and the specification customers/users, i.e. contractors, other NASA centers and other engineering disciplines. This approach had been utilized with much success by MSFC's Materials and Processes (M&P) Laboratory to effectively tailor project/program materials and processes requirements, deliverable Data Requirements (DRs), and consolidate multiple company specifications into common NASA specifications. The M&P laboratory experience with using this cooperative CI/PDT approach resulted in cost savings and launch flow/processing enhancements. Base on this positive experience, PDTs were also used to implement environmental compliance by replacing and updating NASA specifications that utilized ODSs with alternate materials, processes and technologies. These PDTs adopted the following groundrules to facilitate the effectiveness of their activities:

- Solicit direct input from the users of the specification.
- Empower team members with the responsibility for product specification.
- Empower team members to speak and make decisions for the organizations they represent.
- Operate the team and make team decisions based on a consensus.
- Encourage sharing of data.
- Eliminate "how to's" and lessons learned as specification requirements.
- If "how to" and lessons learned are considered essential, provide this information in the specification as guidance and not as added requirements.
- Base specification requirements on essential performance criteria.
- Start specification with zero-base requirements, where each new requirement must "buy their way in" based on value added.
- Challenge all requirements.
- Eliminate unnecessary requirements that do not "add value".

This CI/PDT approach proved to be an advantage to implementation of environmental initiatives in the NASA specification revision process. It provided an efficient and cost effective mechanism for: expediting evaluation of supporting data; streamlining and consolidating data reporting requirements to only essential and required information that would be evaluated by the approving authority; allowing for real-time assessment of potential impacts and costs associated with specification changes prior to their inclusion in program requirements; creating a cooperative teaming arrangement conducive to sharing data, common problems and experiences; and eliminating redundant and duplicative replacement technology development activities. However, the task of implementing replacement NASA specifications for ODS still requires a significant effort. "How-to" specifications require new replacement materials to be tested and selected, while "performance-based" specifications must be clearly defined the expected results. Ultimately, if suitable to the intended application of the resulting specification, "performance-based" specifications can becomes virtually timeless, eliminating the need for subsequent revision.

The most widely used ODS at MSFC, where this usage was specified in standards was CFC-113. As was the case generally for NASA in general, CFC-113 usage applications at MSFC were primarily for cleaning solvents and cleanliness verification media, with some usage for coolants, analytical methods and reference standards. The specification that required the most significant use of CFC-113 by MSFC, as well as by the MSFC Shuttle propulsion elements contractors was MSFC-SPEC-164A, "Specification For Cleanliness Of Components For Use in Oxygen, Fuel and Pneumatic Systems." MSFC-SPEC-164A applied to MSFC fabrication and testing activities and required the use of CFC-113 (and/or TCA) as a precision cleaning solvent for immersion and vapor degreasing, as well as a cleanliness verification test media for Nonvolatile Residue (NVR) and particulate analysis. Recent historical usage amounts of CFC-113 by MSFC are shown in Table 4. The figures for MSFC alone are the usage amounts for the fabrication, precision cleaning and analysis facilities in MSFC's M&P Laboratory where, due to facility constraints, very little if any of annual usage rate of about 65,000 pounds is recycled and recovered. As was stated earlier, MSFC-SPEC-164A is also applicable as contract requirement to MSFC Shuttle propulsion elements, including the External Tank (ET), Space Shuttle Main Engine (SSME), Alternate Turbopump Development (ATD) and Production (ATP), and Solid Rocket Booster (SRB). The total amounts used by MSFC and their Shuttle propulsion element prime contractors combined has been on the order of 200,000 pounds annually, with the recycle and recovery rates indicated in Table 4 being primarily due to Shuttle contractor efforts. Therefore, replacement of CFC-113 by substances without an ozone depleting potential would have a significant benefit to the environment. The steps necessary for replacement of CFC-113 in MSFC's precision cleaning and field cleaning operations requires identification of acceptable replacement materials for cleaning operations, NVR and particulate analysis, followed by revision of MSFC-SPEC-164.

Calendar Year	MSFC	Total (MSFC & Shuttle Contractors)
1991	65,052	221,582
1992	59,556	158,273
1993	64,300	175,000 (est.)

Note: 45% recycled/15% recovered

Table 4: MSFC CFC-113 Usage (pounds)

As the MSFC organization with prime responsibility for the materials selection and cleaning processes for on-site operations, as well as the Shuttle propulsion elements, the M&P Laboratory initiated a study of the center's Ozone-Depleting Chemical (ODC) replacement activities. Initially, in order to address the in-house activities in the fabrication and precision cleaning areas of the M & P Laboratory, a CI Chemical Replacement Team of Laboratory representatives was chartered to investigated ways to accommodate the elimination of ODCs. Operating as a PDT by consensus under the guidance of a facilitator, the specific recommendations of this team were as follows:

1.) Initial substitution of trichloroethylene (TCE) for CFC-113 in the final cleanliness verification process of MSFC-SPEC-164, with long range goal to eliminate halogenated solvent and pursue aqueous or semiaqueous cleaners. A significant data base existed from Saturn to Shuttle to implement TCE as alternate, with an overlap planned during the implementation approach period that would allow for revalidation of TCE data. TCE has very short atmospheric lifetime, is not a ODS, and costs significantly less than CFC-113 with no foreseeable punitive taxation/restrictions. TCE was removed from the list of suspect carcinogens and is not suspected as a human carcinogen according to ACGIH (reference 2). In addition, TCE is not currently listed as a carcinogen or potential carcinogen by NTP, IARC and OSHA according to the Materials Safety Data Sheet (reference 3). TCE is hazardous air pollutant, water pollutant and has toxicity problems requiring use of available control technology. In addition, the current use of CFC-113 at MSFC was more than was required for cleanliness verification and significant quantities were being used as a final rinse, with only the last 500 ml. being collected for verification, wasting significant quantities (up to 13 liters) per procedure. Therefore, with care and improvement in shop usage practices, the usage of TCE could conceivably be less than was required with CFC-113. The accelerated replacement of CFC-113 with TCE requires:

a.) Discontinued used of solvents as an unnecessary final rinse and redundant cleaning step, with final verification limited to the quantities specified in MSFC-SPEC-164. During an initial validation period, a duplicate verification will be conducted using both TCE and CFC-113.

b.) Installation of an exhaust system with scrubbers in the precision cleaning facility. The system should minimize personnel exposure to TCE in the laboratory environment to below the 25 ppm Personnel Exposure Limit (PEL) utilized by MSFC.

c.) Installation of a catch basin and pump to minimize exposure of TCE to the laboratory environment, minimize emissions in the laboratory and to aid in the collection of samples for cleanliness verification.

d.) Upgrade of facility pumps to accommodate conversion from CFC-113 to TCE may be required to accommodate materials compatibility issues.

e.) Personnel respirators with remote air service as personnel protective devices for routine operations, and in case of solvent spills. TCE is a potentially hazardous material when exposure exceeds 25 ppm and decomposes to produce toxic fumes if exposed to flames.

f.) Installation of TCE distillation/recovery system for reuse of the solvent.

g.) Installation of an isopropyl alcohol (IPA) cleaning station since materials compatibility issues could necessitate a second cleaning system. IPA precision cleaning systems are commercially available with distillation and fire suppression capabilities, and should be investigated for cleaning small specialty items.

2.) Replacement of solvent cleaning/verification with aqueous or semiaqueous cleaners as a long term goal to eliminate the use of chlorinated hydrocarbon solvents. Considerable effort will be required to select and qualify these replacement materials.

3.) Other recommendations under consideration include: replace existing degreasers with Low Emission Vapor Degreasers (LEVD); eliminate vapor degreasers and convert to aqueous spray precleaning stations; and select and qualify (long term) aqueous or semiaqueous cleaners.

Even though the initial recommendations identified trichloroethylene (TCE) and isopropyl alcohol as potentially acceptable alternatives to CFC-113 for MSFC operations, neither material is universally applicable and must be considered as complementary. Cost estimates for implementation of TCE and IPA slightly favored TCE. This was due in part due to the flammability, higher boiling point and need to assure complete removal in oxygen components of IPA. Other considerations included: the incompatibility of residual IPA in oxygen systems; IPA was not as mature a replacement alternative as TCE; and data indicated IPA had a low recovery efficiency for certain fluid system contaminants. Due to these factors, MSFC selected TCE as the intermediate cleaner/verification solvent, with a longer term goal to qualify aqueous and semiaqueous materials. Yet the prime contractor for the ET is proposing to use IPA (in addition to TCE) for selected precision cleaning/cleanliness verification applications, including cleanliness verification media for hydrogen and oxygen lines, vessels and components. This is being proposed utilizing proper control methods and will be substantiated by qualification/validation data consistent with the requirements of the new replacement specification for MSFC-SPEC-164A.

Additionally, it was recognized that instrumental analytical verification methods, e.g. Optically Stimulated Electron Emission (OSEE), Fourier Transform Infrared (FTIR) analysis , etc.

could ultimately replace the chemicals used for NVR and/or particulate analysis. In order to accommodate these potential changes in the future, MSFC-SPEC-164 would have to become a more adaptable standard, versus it's more traditional role as a "how to" specification. By using the approach of developing a "performance-based" standard, the requirements could be easily tailored to accommodate alternate approaches or changes essential for future programs, without creating significant procedural constraints or producing unnecessary cost impacts for the users. The "performance-based" specification approach was ideally suited to the user needs.. Ultimately, this new specification would be a verification standard, defining the general data requirements and design considerations that would be required for approval of the cleaning and cleanliness verification process by the procuring activity. As such, the cleanliness verification performance requirements could be derived from the significant and successful data base developed over the last 25 years, from Saturn and Shuttle through the current advance propulsion technology test bed experience at MSFC .

In order to initiate this "performance-based" specification approach and replace the ODSs in this fluid system cleanliness specification, all principal users or customers of MSFC-SPEC-164, including the Shuttle prime contractors for whom MSFC-SPEC-164 was a Contract End Item (CEI) specification requirement, were invited contribute to the revision effort as members of a CI team during the initial Technical Interchange Meetings (TIMs). Participants that formed the PDT included representatives from all Shuttle propulsion element prime contractors organizations, and MSFC organization representatives from M&P Laboratory, fabrication services, facilities, propulsion test operations, component assembly and refurbishment, analytical chemistry, materials selection and control, contamination control, propellant compatibility testing and quality assurance. This approach allowed the participants to take ownership in the product and follow the CI/PDT groundrules discussed earlier. Ultimately, this enthusiastic team participated in numerous reviews, as the MSFC-SPEC-164 rewrite progressed. Copious input and comments were assessed through many iterations of the specification, with the team's consensus recommendations being incorporated into the final team product.

The resulting product, an environmentally compliant NASA cleanliness specification for components used in fluid systems, does not discard the established materials utilized successfully for so long to perform these processes, but rather uses these materials and processes, as well as their associated data bases to establish a baseline that all subsequent replacements must meet or exceed. In this replacement specification, the "performance-based" approach defines general data requirements and design considerations for producing data necessary to support approval of alternate cleaning and cleanliness verification processes by procuring activity. The performance criteria are particulate and NVR cleanliness verification levels based on successful performance experience in the field, during testing and in flight. The new specification strengthens particulate criteria by deemphasizes particle counting and bases requirements on maximum absolute particle sizes with a prohibition against silting. This aspect has an added benefit of simplifying analytical procedures. In addition, this revision establishes tape lift testing as an alternative for cleanliness verification when component flushing is impractical. New packaging material requirements take advantage of the substantial data generated by another center (KSC) to define appropriate material selection requirements. This replacement MSFC-SPEC-164 establishes new in-service and field cleaning criteria for ground test systems are based on accumulated history of successful propulsion test bed operations at these levels of cleanliness. New considerations allow for utilizing cryogenic cold shock to aid the cleaning process for the fluid system components prior to conducting cleanliness verification. Verification and inspection frequency and sample size are clearly defined for all testing required by the specification. Drying effluent gas verification analysis assures no residual accumulation of organic solvents or moisture that would be detrimental to system performance, e.g. IPA in oxygen system components. Less stringent purge gas requirements for tanks and vessels eliminate the need for "missile grade" air or gaseous nitrogen, based on the successful and cost effective performance history of ET. Requirements for approval of alternate verification procedures define specific criteria for sample selection, verification test quantities and minimally acceptable statistical significance for data. The CI/PDT approach to teaming of specification customers and users has produced a viable specification that will benefit NASA-wide standardization activities for cleaning processes. This example will serve as a pathfinder and a model for the significant efforts that are required to bring the remaining NASA specifications and standards that reference targeted materials into compliance with environmental initiatives.

Already other MSFC specifications identified in Table 3 are being revised for replacement of ODSs using this same approach. For example, in MSFC-SPEC-1919, " Application and Cure of Thermal Ablative Compound," TCA is used as a solvent to clean and prepare various surfaces on the SRB and RSRM for application and bonding of the ablative compound. The revision will implement the downselected aqueous or organic hand wipe cleaners, e.g. Jettacin, Prime, Reveille, and/or PF Degreaser, and provide for consistent processing across Shuttle interfaces, launch flow enhancement at KSC and data sharing among the Shuttle element prime contractors. MSFC-SPEC-2083, "Polyurethane Foam Insulation (PDL-4034-2.5)," consolidates ET, Shuttle Orbiter and KSC requirements for into a common material procurement specification that provides common acceptance criteria and consistent material procurement requirements. The revision will implement HCFC-141B as the alternate blowing agent to replace CFC-11 without degrading the properties of this critical Thermal Protection System (TPS) material. MSFC-SPEC-2084, "Mix, Application and Cure of Polyurethane Foam (PDL-4034)," is the process specification that corresponds to the pervious TPS material specification, and consolidates ET, Oribter and KSC processing requirements for enhanced launch processing and commonalty. The revised specification implements the HCFC-141B alternate blowing agent as a replacement for CFC-113 to assure process consistency.

Finally, in all these activities, the teams utilized the NASA Environmental Information Network System (NEIS) as a tool and data source for ODS replacement in MSFC specifications. NEIS is a system of environmental data bases which are a part of the MPEEN system residing on a VAX cluster maintained by MSFC, which is available through the Materials and Processes Technical Information System (MAPTIS). NEIS is a tool currently being developed to support the NOET functions and is designed to: provide a central environmental technology resource drawing on all NASA centers' capabilities; support NASA programs to deliver hardware compliant with performance specifications and environmental regulations; track and access environmental regulations, usage, and new technology developments; and provide a channel of communication throughout the aerospace community. All data is dynamic, continuously updated and is intended to be flexible in order to meet the environmental community needs as they become know. NEIS is designed to aid in environmental compliance efforts, such an the implementation of replacement technology in NASA specifications and standards. The point of contact for more information is Marcia Clark-Ingram, NASA/MSFC/EH44, at 205-544-6229.

CONCLUSIONS

The discussion presented herein indicates that NOET and RT^2 are implementing a planned approach for accommodating environmental compliance through alternate replacement technology in NASA specifications and standards. Numerous NASA specifications and standards call specifically for the use of targeted materials. Because these specifications and standards generally have wide applicability, the impact of changing them to implement replacement technology has potentially serious and broad implications for the users. However, Continuous Improvement (CI) and teaming of customers, users and the procuring activity is a productive approach to gaining consensus, when common/consolidated specifications that minimize impacts to projects and programs are required. Tailoring specifications and standards to meet environmental initiatives while precluding unnecessary project costs and data requirements is essential for success in the current environment. NASA is encouraging and pursuing implementation of common NASA-wide solutions to environmental issues. Through the NOET, NASA is actively sharing data and coordinating data and results to producing specifications and standards that are compliant with current environmental needs and requirements. NASA policy is to use of "voluntary standards" or existing consensus industry standards and actively participate in their development. When voluntary standards are unavailable or do not meet agency needs, replacement specifications and standards for environmentally hazardous materials and processes must rapidly establish and implement solutions, maintain currency and support program requirements as well a future needs without compromising or degrading performance. "Performance-based" specifications that clearly defined the expected results and are adaptable to new developments become virtually timeless, providing a distinct advantage in the task of implementing alternate technology to replace ODSs in NASA specifications and standards.

REFERENCES

1.) Schwinghamer, R. J., Congo, R. T., and Goldberg, B. E., "Environmental Initiatives at NASA: Taking the Lead in Alternative and Replacement Technologies," Federal Facilities Environmental Journal, Winter 1993-94, pages 437 through 455.

2.) American Conference of Governmental Industrial Hygienists (ACGIH), "1992-1993 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices," pages 40 through 45.

3.) PPG Industries, Inc., "Trichloroethylene," Materials Safety Data Sheet (MSDS), Form 6372 Rev 3-88, 07/12/93, pages 1 through 3.