ODC Elimination and Conformance
to Military Specifications and Standards

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When the Montreal Protocol was first signed by a number of parties in Sept of 1987, there seemed to be little awareness in the public sector that with the stroke of a pen, a multibillion dollar effort had been initiated. There was also little awareness that the technical challenges that lay ahead would be minor when compared to legal ramifications and problems that were about to unfold. The desire to eliminate ozone depleting chemicals from the environment soon became a challenge, as military specifications were changed; new government and industrial policies were initiated at local, rational and international levels; and lastly, more reliable and definitive data was obtained from satellites and airborne systems monitoring the earth's atmosphere.

This paper attempts to identify some of the steps taken by both the government and industry in their endeavors to eliminate ozone depleting chemicals. The areas of fire suppressants and refrigeration chemicals is not addressed as, from a DoD OEM point of view, their replacements are tentatively identified and there is less escape of these materials to the atmosphere than with the solvents and therefore are less of a problem.

There is little doubt that at the time of publication of this paper, that the OEM community will have a clearer path to fully implement new solvent technologies. But still ahead of us will be the issue of compliance to existing contracts and the label law as outlined in the Clean Air Act. The latter requirement, at least as of now, requires much greater definition and direction from all affected branches of the federal government.

The Protocol

It can be safely stated that most of the adult population in the U.S., as well as in other industrialized nations, are now aware of the thinning of the ozone layer over the poles. There are however, some die-hard individuals in government, communications networks, and religious organizations that do not believe the satellite and other supporting data. They simply regard this situation as a ploy on the part of some government agencies to gain more funding. These attitudes tend to defocus the public eye on the critical issue of solving the problem of ozone depletion. Nonetheless, the evidence continues to mount and more members of the scientific community regard the thinning of the ozone layer as a real threat to life on earth. They have also stated that ozone depleting chemicals contribute to global warming and have attributed 15 to 20% of the warming to the ozone depleting chemicals. However, more recent theories place far less importance on these chemicals as global warmers.

The international community has responded to this global threat in an overwhelming majority via the signing of the Montreal Protocol in Sept 1987 and again with the London Amendments signed in June 1990. The parties to these documents will have met again by the time of this conference, with an intended goal of modifying the amendments to even shorter periods for ODC elimination. Regardless of what goal we strive to meet, the problems will be the same. Phase-out of the originally
targeted chlorofluorocarbon (CFC) solvents and then the expanded category of all ozone depleting chemicals (ODCs) has required that specific, well thought out steps be taken before total ODC elimination can occur. As these steps have been taken conflicts have arisen between the international protocol and individual, previously negotiated contracts, purchase orders, military specifications and standards. These conflicts cannot be taken lightly as the issues in question can be traced back to the fundamentals of contract and constitutional law.

'Ad Hoc'

It was recognized early on that the DoD-OEM community had through the years developed optimum cleaning processes that were relatively inexpensive and reliable. Furthermore, the solvents utilized were non-flammable, essentially non-toxic and chemically pure, as well as stable. It was obvious that elimination of such solvents also meant that sacrifices had to be made in some of the aforementioned solvent attributes as well. It should be noted that cleanliness and product reliability were not to be offered up as a part of the sacrifice.

Thus in March, 1988, a group of individuals from the EPA, DoD, industry and material and equipment suppliers met to ascertain "how clean is clean." Under the auspices of the IPC, this group grew in number and scope such that today 'ad hoc' exists now in three separate phases:

- Phase I - Cleanliness Standards
- Phase II - Alternate Solvent Technology
- Phase III - Alternate Fluxing and Cleaning Technology

The cleanliness standard was eventually published by the IPC as TR 580 in October 1989, in which one can review the various levels of testing undertaken in Phase I. Unfortunately, for the DoD OEM community, Phase I testing essentially reflected the needs of the commercial electronics manufacturers, as the equally important DoD issue of product reliability was not to be a part of the test. Cost was one of the guiding factors as was availability of facilities for this decision. It was also recognized that the printed wire boards and number of devices selected for Phase I did not adequately reflect the thermal input experienced by high population density and thick multilayer circuit boards that are used for Military and NASA hardware. This becomes an important issue for later discussion as each OEM must realize that no amount of ad hoc or any other independent testing can fully reflect the thermal stresses that a specific product line will undergo.

Phase II of ad hoc was rapidly inundated with new solvent candidates (Figure 1), but, of these, only nine materials eventually met the cleanliness criteria of Phase I and finally only four met all EPA and DoD requirements, i.e., without request for waiver. Impartial test monitoring and verification teams were formed and requested to assure that each candidate solvent was properly tested. A review of the
materials that can be used, will also provide additional concerns, as several of the candidates, specifically the HCFC and diluted CFC solvents, can only be considered for short term utilization as they have ozone depletion potentials (ODPs) above the EPA guidelines (VIS - ODP \leq 0.1). One will also note that of those solvents that remain for long term usage, none can be considered to be a "drop-in," i.e., a solvent that can be introduced to the manufacturing floor with only minimum adjustments to be made to existing degreasing and cleaning equipment. Hence, one sees that one of those sacrifices to be made is capital equipment costs.
Figure 1
Listing of Alternate Solvents Proposed for Phase 2 Evaluation

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Solvent</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genesolv B2</td>
<td>Miraclem 100</td>
<td>M-Pyrol</td>
</tr>
<tr>
<td>Alpha 565</td>
<td>Isotron 141B</td>
<td>Propaklone</td>
</tr>
<tr>
<td>ByPas</td>
<td>Bioact BC-7*</td>
<td>Genesolv 2004</td>
</tr>
<tr>
<td>Axarel 32*</td>
<td>Unitech CV-250</td>
<td>Freon SMT</td>
</tr>
<tr>
<td>Genesolv 2010</td>
<td>KyzenIonox LC*</td>
<td>Kester 5121</td>
</tr>
<tr>
<td>Aqueous CT1 and CT2</td>
<td>Freon SMT</td>
<td>Kester 5769</td>
</tr>
<tr>
<td>Chlorothenne SM</td>
<td>Hi tron L 4000</td>
<td>Prelete</td>
</tr>
<tr>
<td>Axarel 38*</td>
<td>KCD 9434</td>
<td>Marclean</td>
</tr>
</tbody>
</table>

* Solvents that passed phase 2 testing and additional EPA/DoD criteria

Figure 2
JEDEC Survey of ODCs in the Microelectronics OEM

<table>
<thead>
<tr>
<th>Sites Reporting Chlorocarbons</th>
<th>Sites Reporting CFCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylchloroform</td>
<td>60%</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>12%</td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>12%</td>
</tr>
<tr>
<td>Perchloroethylene</td>
<td>8%</td>
</tr>
<tr>
<td>Chloroform</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3
JEDEC Survey on Nominal Lengths of Contracts

| Typical Period of Performance: | 1 yr 63%; 2 yrs 37% |
| Longest Period of Performance: | 1 yr 13%; 2 yrs 34%; 3-4 yrs 40%; Bal 13% |
| Ratio of Effort (Original: Follow-on): | 100:1 - 46%; 50:1 - 8%; 10:1 - 23%; Bal 23% |
| Purchase Order:                | 73% yes 27% no       |
| Release vs. Contract:          |                       |
Unfortunately, even these alternate solvent systems are not fully applicable to specific manufacturing lines. This dilemma has been addressed in part by ad hoc Phase III, where alternate soldering and defluxing technologies are now being addressed. As stated earlier, as ad hoc grew in number, it also grew in scope. Today Phase III is subdivided into at least three subgroups, these are listed below:

Ad Hoc Phase III

(1) CFC Alternative Technologies
(2) Controlled Atmosphere Soldering
(3) Water Soluble Flux Technology

DoD Activity Commences

In the same timeframe that ad hoc Phase I had been formalized, the DoD published its first (and perhaps only) Directive on this issue, vis - Number 6050.9 dated Feb 13, 1989. Under the signature of the Deputy Secretary of Defense, W. H. Taft IV, the DoD was to commence an all-encompassing program to assess the impact of CFC elimination, as well as to commence efforts to modify military specifications and standards, and lastly collect data, on CFC replacements to name just a few tasks. As these various DoD tasks unfolded the respective efforts and results remained unknown to the public as little information on these activities followed. This is not a condemnation of the military, it is instead, an example of our human nature to fail to properly communicate.

The Electronics Industry Association, Joint Electron Devices Engineering Council (EIA/JEDEC) has also commenced efforts to modify military specifications at the microelectronics level. In some areas an excellent rapport was established with the Preparing Activity (PA) for specific Mil Specs. In other areas attempts to coordinate with the DoD to modify the specifications met with some confusion, as the PA referred intended changes to their respective custodians and/or agents for the specifications, thus causing more delays and confusion on how to eliminate CFC solvents from the specifications.

As a part of the JEDEC community's attempt to identify the impact of CFC elimination, it had generated several industrial surveys to assess what solvents were in use. Figure 2 shows that an unexpected distribution of solvent usage between CFC solvents and other ODC solvents existed. And that CFC solvents represented only half of the ODC solvents then in use. From this data it becomes apparent why a CFC ban had to yield to a more encompassing ODC ban. A straw pole taken in JEDEC in mid-1991 also indicated that approximately 10% of the membership was either using or intending to introduce hydrochlorofluorocarbon solvents (HCFCs), as these solvents appeared to be the interim "drop-in" that the DoD-OEM community needed to implement in order to address the mutual concerns of cost and schedule, while conforming to the requirements of the Montreal Protocol.
QPL/QML

In its review of the CFC problem, the JEDEC organization also realized that a major problem area had not yet been addressed. The DoD-OEM community makes a large portion of its component or standard parts purchases through manufacturers that are on a Qualified Products List (QPL). The hybrid device suppliers have a similar listing known as the QML, Qualified Manufacturer's List. There are 179 QPLs in existence. Each list can have anywhere from several to hundreds of companies listed. All of them gain QPL (or QML) recognition via a formal, documented process with DESC, the Defense Electronic Supply Center. Once QPL or QML is granted, a given company cannot change its manufacturing processes without the consent of DESC. The problem arises that when any of these hundreds to thousands of QPL and QML houses are using CFCs or ODCs - any intended change must first be DESC approved. A JEDEC task group, originated to address CFC/ODC issues sought to make this device supply community aware of the potential rush for recertification via a press release issued from EIA on Jan 10, 1991. The release was picked up by various electronic magazines, but the hoped-for results did not materialize. Perhaps one of the reasons for QPL/QML inactivity was that there already was a rumor in the supply industry. By the end of 1991 the rumor was fact - the EPA had taken action against HCFCs as solvents. The sought after 'drop-in' was no longer available and the funds expended to bring these solvents into manufacturing processes had been wasted. The OEMs could not afford expending additional funds until the DoD and EPA had formalized an acceptable alternative solvent plan.

However, the problem didn't end here for the device supplier community. A very large percentage of the devices purchased for military and NASA systems are non-standard parts. These are usually "built-to-print" on a special purchase order basis between supplier and buyer. Usually devices built-to-print cannot undergo process change without the individual procuring group first reviewing and approving the change. So again the issue of prior approval inhibits the supplier community.

DoD/CFC Advisory Committee

Concurrent with ad hoc, IPC, and EIA-JEDEC activities for CFC/ODC solvent elimination at the first two levels of manufacturing, a committee of DoD, EPA and the defense industries (OEMs) was created to advise congress of how best to eliminate CFCs/ODCs from the defense industries. This select group of five individuals from each sector released a report dated July 26, 1991 in which several important recommendations were made. The group centered several of its recommendations on opening communication lines between the services and industry. It also made estimates as to the potential costs involved for the DoD and the OEMs to eliminate the use of ODC solvents. Their figures show that capital equipment replacement alone for all ODC applications in the OEM community will exceed $1 billion, this again is a cost that the suppliers must absorb because of the nature of fixed price/fixed fee contracts and the lack of a clear, definitive directive from the government to eliminate ODC usage. Nevertheless, the DoD/CFC Advisory Committee provided an excellent service for the public in that they generated one of the few, publicly released assessments of the costs and effort required to replace ODCs in the OEM community.
It is most interesting, that in the late March time-frame of 1992, the New York Times released an article written by Keith Schneider, in which the Deputy Secretary of Defense, D. Atwood was reported to have made the same interpretation of the President's press release that the OEMs had made. There were additional statements made available to the Trade Organizations for CFC Elimination that indicated that Mr. Atwood was to pen a directive to military personnel at all levels which contained essentially the same points presented in the proposed change to the FAR at the Williamsburg conference, i.e., the same points of discussion that the Office of the Deputy Assistant Secretary for Procurement (DoD) had turned down. According to the New York Times article the policy statement had been drawn up in the Office of the Assistant Secretary of Defense for Environment and had already been approved by the Comptroller of the Defense Department, Mr. Sean O'Keefe. Unfortunately, the Atwood memo, which in draft form was clear, concise and what the OEM community needed to commence process changes, was not released, at least not as of the time that this paper was written. But, the anticipated directive, released in draft form and reviewed openly with the public, had added more confusion to the issue.

Mil Specs and Testing

Several organizations, both government and industrial, had taken action to eliminate the directives to use CFC and ODC technologies. JEDEC took the action via a task group which addressed Mil Stds 202, 750 and 883. These documents were respectively developed for electrical components, semiconductor devices and microcircuit devices, all of which are considered to be first level electronic devices. The specific test methods that directed the use of CFC solvents were re-written and the suggested wording was submitted to the respective preparing activities for coordination. The early action taken by these groups allowed usage of the HCFC solvents in some of the test methods. The decision at a later date by the EPA to disallow these solvents for electronic device cleaning added to the confusion in the industry as several OEMs had already commenced product reliability studies with these solvents.

Second level packaging specifications were addressed via a different approach by a group of industrial advisors and the respective preparing activity. Cleaning and defluxing requirements had been detailed in Mil Std 2000. Additionally, specific aqueous fluxing and subsequent cleaning technologies were not originally permitted. These directives were ultimately changed when Mil Std 2000A was issued on 14 Feb 1991. This document was re-written to be, in essence, a philosophy of manufacturing document, i.e., a Total Quality Management (TQM) concept was promoted which now allowed the OEM to introduce any effective cleaning technology, providing supporting quality and reliability data was available. A supportive memo was also issued by the Navy under the signature of W. J. Willough, Jr., the director of Product Integrity. This memo encouraged the SPO and contractors to implement the new mil spec and allow the OEM to "move up" through the spec revisions without having to re-negotiate the contract. Unfortunately, this department could only encourage such a move. It was not a directive (directed change), nor could it provide the necessary short-term relief that the re-writing of Mil Spec 2000A had intended, i.e., for existing contracts.
It is seen once again that even though the DoD, the EPA and the OEM community has attempted to eliminate ODC technology, the lack of a central figure or focal point has prevented these various sectors from acting in a uniform, coordinated capacity. With the passage of time, along with the gradual clarifications from the various agencies, one can clearly see that no one federal sector was empowered nor did any one sector step up to coordinating the complexities of total ODC elimination.

Again, one must be especially appreciative of the efforts of the DoD/CFC Advisory Committee for providing an assessment of financial impact to eliminate ODCs.

Williamsburg Conference

The Williamsburg Conference was held in Williamsburg, VA on September 11-13, 1991. It was at this meeting that members of the OEM community made their first proposals on how to address the issue of conflicting requirements that existed between military contracts and the Montreal Protocol. A group of OEMs attempted to create a mechanism by which they could readily phase-in the use of non-ODCs. The mechanism was a proposed Federal Acquisition Regulation (FAR) which was to have the following points:

- The proposed FAR would be applicable to all open DoD/NASA contracts.
- The proposed FAR would allow the OEM to eliminate CFC based solvents.
- The proposed FAR would require the OEM to provide notice of change and data.
- Additional consideration was to be an OEM/SPO option.
- There was to be no change in schedule.

However, the proposal was short-lived, as by late 1991 attempts to bring this proposed FAR forward to the DoD for consideration, modification and inclusion into the existing FARs was rejected by the office of the Deputy Assistant Secretary for Procurement in the DoD. The proposal had been made by the members of a joint committee from EIA, AIA, AEA, SCA and NSIA. It was reported that the DoD did not envision a change in the FAR to be the appropriate mechanism by which the individual OEMs could commence changes in their respective processes. Continued discussions within this committee revealed a potential alternative approach to making permitted (or acceptable) process changes. In December of 1991, EIA/JEDEC issued a survey ballot to its membership requesting information about the average period of performance for contract, as well as other information. As shown in Figure 3, on the average, contracts between the DoD and the OEMs are not actually drawn up for several years, but for shorter periods of time. A particular production lot, phase, or deliverable is contracted for under a contract or purchase order. Once the period of performance ends, a new agreement is drawn up. This appears to be the means by which the OEM can commence changes to a cleaning process. Unfortunately some agreements have been made to last beyond year-end 1995, by which time the production of all ODCs is to end. Nevertheless, this mechanism seems to be the most viable for the OEMs and, at the time of this writing, continues to be researched for eventual inclusion in future negotiations between the DoD and the OEMs.
Accelerated ODC Phase Out

NASA and NOAA had continued to monitor the ozone layer and measure the degree of thinning caused by the ODC species gradually diffusing to the stratosphere. On February 20, 1992, Dr. J. G. Anderson of NASA released a preliminary (AP) report of the work that some forty scientists had been engaged in. Their data indicated that the ozone layer was thinning even more rapidly than was earlier believed. In apparent response, President Bush had a statement released to the press on Feb 11, 1992 in which he proposed that the production of ODCs cease by year end 1995. This was an interesting proposal, as it was not a Presidential Order and it addressed only for the manufacture of ODCs, not their continued use. This again creates some confusion in the OEM community and perhaps led to even more statements from the DoD which just added to industries' dilemma. In March, Secretary of the Air Force, D. Rice and General M. A. McPeak jointly released a draft letter via Air Force channels which stated that as of July 1, 1992, Air Force procurement personnel were to cease purchases of ODC materials and any equipment that had been manufactured with ODCs. This memo came down to Systems Program Offices (SPO) and their respective OEMs via different routes. Not only did the document arrive via different routes, it also came in different levels of intensity. Air Force laboratories and some OEMs started to respond, but in larger manufacturing facilities the different requests caused the supplier to seriously question how it was to respond. Conflicting responses from an OEM would not be acceptable. Since the press had already released erroneous data on ODC usage, and legal precedents were being set, one could not afford to appear to have an unclear response. The Rice and McPeak memo had created an impossible situation, clarity was missing, the time line was too short and the legal implications were beyond number. So again it was seen that a clear and precise direction was lacking, yet, the onus had been placed on the OEMs to eliminate ODCs. Or was it? The need to phase out the use of ODCs was not clearly stated in the Bush press release, yet the Air Force had apparently believed that a full phase-out was in order. The only potential mechanism to address this problem was that stated earlier, to renegotiate the contracts (and directives) that kept the OEMs committed to ODC utilization.

The Label Law

During all this time another section of the Clean Air Act had gone unaddressed by the OEM community. Legal staffers and lobbyists were attempting to obtain clearer information on the Label Law. This law, which goes into effect May 15, 1993 will require that any part manufactured with the use of a CFC or a chlorocarbon solvent will have to bear a label which warns the public to that effect. The preliminary wording provided to the public by the EPA again leaves room for confusion. For example, the use and labeling of product manufactured with an HCFC was not explicit in the document (nor was it implicit). Another one of the problems with the proposed label law was that the wording of the label was too lengthy to be printed on most small area product. The instructions were that, then the label was to be placed on the next higher level of assembly. The question then arises - "If the higher assembly manufacturer does not use an ODC but his suppliers do, then who is to bear the cost of labeling the higher assembly?" There is the additional question of, "why should the higher level assembly
manufacturer have to bear the negative advertising of a warning label when he's been environmentally conscientious?" Additionally, one has to consider the logistical nightmare of fabricating a product that doesn't require labels (or does) and then stocking it for three or four years. How can one possibly trace each and every component through a time period when the law went into and out of effect? At this time, it appears that the implementation of the label law has the potential to create even more problems and confusion. It is hoped that by the end of the Second International Conference for CFC Elimination, that the government will have provided some additional information as to how to implement this law in the military microelectronics industries. For, once again, the government has imposed a regulation, long after the contracts have been negotiated and in a declining defense industry, equitable cost distribution is a must.

Lastly, at the May '92 meeting of JEDEC JC13 in Seattle, Washington, the committee membership formalized a proposal which was to be presented to the EPA and the ad hoc committee. The text of the proposal recommended that the DoD/OEM community should be exempt from the label law for the following reasons:

1) There is a potential to add significant cost to DoD contracts where the final products are never seen by the public, hence the reason for the hardware labeling would have been defeated.

2) There is no value add to the system.

3) For such contracts, the label law (if imposed) would be a third party intrusion into a previously negotiated contract.

Concluding Remarks

The EPA and DoD have, for various reasons, chosen to accelerate ODC phase-out. The OEM community essentially agrees with the proposal. But it needs a centralized authority to make policy decisions that do not create additional legal problems, are to be done in a mutually acceptable and logical time frame and, whose costs will be open for reconsideration. Conflicts in interpretation that have been created by the ad hoc approval of HCFCs and their subsequent disapproval by the EPA, the conflicts between the President's press release and the Rice-McPeak memo, and the problems created by the label law should never have occurred. It is hoped that by mid '93 that a clearer picture is presented to the OEM community and the DoD for the final and complete phase-out of all ozone depleting chemicals.