SEPARATOR QUALIFICATION

for

AEROSPACE NICKEL-CADMIUM CELLS

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ABSTRACT

In late 1981 customers of General Electric Battery Business Department (GE/BBD) were notified that supplies of Pellon 2505ML separator would be exhausted in about 2 years. Efforts were made by Pellon Corporation to duplicate this material but were unsuccessful.

A joint Government program to qualify a new separator for nickel cadmium (NiCd) cells was proposed. The joint program would eliminate duplication of effort between Agencies and Contractors. Cell buys are being made by NASA/GSFC and Naval Weapons Support Center, Crane (NWSC). Cells will be acceptance tested and several cells will be operated in a charge/discharge characterization matrix. Cell packs will be life tested at NWSC in low earth orbit (LEO) and geosynchronous (GEO) orbit under real time and accelerated conditions.

It is anticipated that preliminary qualification data will be available in about 1 year with more complete data in about 3 years. A new Pellon Corporation separator will be evaluated by simulated testing in advance of actual space usage.

BACKGROUND

The separator material of choice for aerospace hermetically sealed NiCd cells has been Pellon Corporation product number 2505ML. This non-woven nylon fabric is used in virtually all aerospace NiCd cells today and is the only qualified material in most applications.

Manufacture of the 2505ML separator, which was part of a series of similar materials produced by Pellon Corporation, was discontinued in 1976 and the last available material at GE/BBD will be committed in 1984. All

future cell orders would require a new or replacement separator. In December, 1981 GE/BBD notified all users of the separator material of the coming problem.

At the instigation of GE/BBD and other users Pellon Corporation made several attempts to re-produce the 2505ML material. These attempts were made on equipment similar to the original production line which had been dismantled and utilized starting nylon fibers slightly different than previous material. The separator from several product runs was evaluated. Product characteristics were found to be variable.

At this point alternatives were examined. Since the manufacturing process utilized zinc chloride in a critical step and the process effluent could no longer be dumped without expensive treatment there was a serious cost impact. Further, a new non-polluting process, similar to one in use for about 10 years in Germany, was being installed to produce separator material claimed to be superior. Early evaluations of the new separator were positive. It was decided to wait for the new material produced by Pellon Corporation in their Lowell, Mass. facilities.

APPROACH

Informal discussions were held between NASA/GSFC, Naval Research Laboratory (NRL), Air Force Space Division (AF/SD), and Aerospace Corporation personnel active in NiCd usage. The benefits of a coordinated program in terms of cost and data base size were clear. The following program outline for a joint characterization/qualification test were formulated:

- NASA/GSFC purchase NASA standard cells
- AF/Navy purchase military program typical cells
- NWSC to conduct testing
- Generate a coordinated test/data base
- Coordinate with Contractors to assure test validity and acceptability
- Avoid duplicate qualification and life tests

AF/NAVY JOINT PROGRAM

Since the AF/Navy needs and cell requirements are close it was decided to have a common cell buy and center the program management function at NWSC. Technical support, component testing, and data analysis will be performed by Aerospace Corporation.

A single buy of 150 cells with the following general characteristics will be made:

- o Cell Types
  - 26.5AH - 42B030AB10
  - 34 AH - 42B034AB02
  - 35 AH - 42B035AB02
  - 50 AH - 42B050AB24

- o Electrode Types
  - All silver treated negatives except 26.5AH which is teflon treated
  - All positives are "standard" process

- o Separator Types
  - Half Pellon 2505ML
  - Half Pellon Corporation new nylon material

Cells will be procured to a single procurement specification that is performance oriented. The unique features of this document are requirements for a listing of manufacturing documentation sufficient to define the methods, processes and procedures at a given point in time and mandatory customer inspection points at key manufacturing steps. The first requirement is intended to help clarify and identify any changes which may occur with time in the production of an aerospace cell. The second requirement is intended to provide close coordination and cooperation throughout the cell manufacturing cycle between customer and vendor.

After the cells receive an acceptance test at the vendor, GE/BBD, they will be acceptance tested at NWSC for comparison and pack matching. A sample quantity of cells from each subcategory will be vibrated to simulate launch environment then be placed in characterization testing. These characterization tests at various currents and temperatures will provide assurance there are no gross derivations between the "old" and "new" separator cells and the existing voltage-temperature charge curves are valid for the "new" separator cells.

Additionally, samples of each cell type will be set aside unactivated (dry) and activated (wet) to act as controls for possible use in future destructive physical analysis. Samples of separator material and electrodes will be provided to Aerospace Corporation for evaluation.

Following cell pack matching and assembly the packs will be placed on test according to the test matrix shown in Table I. In both LEO and GEO orbits two test levels were selected. The higher temperature and greater depth of discharge (LEO only) was chosen to simulate a worst case condition and offer an attempt at accelerating any degradation effects. The second

set of test conditions was an attempt to simulate the actual use environments being experienced, except for acceleration of the GEO operation, for any possible long term or subtle differences well in advance of actual flight usage.

It should be pointed out the use of 10 cell packs is an attempt to get somewhat more significant statistical data. A constant source of irritation and consternation facing the test designer is that compromise between funding and the desire for more cells and test conditions. The partial use of 10 cells packs is an attempt to balance these needs.

Details of the testing conditions are shown below:

- LEO Orbit - Real Time
  - 33.6 minute eclipse
  - 67.2 minute sunlight

- GEO Orbit - Accelerated
  - 42 eclipses per season
  - 72 minutes maximum eclipse
  - 56 days per season
  - Recondition between seasons

The NASA/GSFC test matrix complements the AF/Navy test. Table II presents this test matrix which will proceed in parallel with the AF/Navy test and be conducted at NWSC. It can be seen that positive electrodes manufactured to earlier processes will also be compared to the latest GE/BBD electrode processes.

SCHEDULE

The joint program has been funded and is proceeding. A cell procurement specification has been reviewed and is in the final approval stages. A schedule of major activities is presented below:

o	Component Evaluation (start)	Nov 83
o	Cell Purchase Order	Jan 84
o	Detailed Test Plan	Sept 84
o	Cell Delivery	Nov 84
o	Cell Evaluation, NWSC	Nov 84 - Jan 85
o	Life Test Start	Jan 85
o	First Report	June 85

CONCLUSION

These separator qualification tests will provide a common and direct comparison of Pellon 2505ML and a replacement separator in advance of actual flight usage. When actual flight usage is imminent the confidence generated by an accumulated cell test data base will be appreciated. By performing this testing at a single location, NWSC, the quantity of directly comparable data can provide a more statistically valid data base at lower cost to each program.

To maximize test value a series of widely distributed, to typical NWSC distribution, is planned. There will be an acceptance test report including vibration and characterization data, annual NWSC life test reports, special reports on component evaluation, and trends analysis to the actual users.

Table I

AF/Navy Joint Program Test Matrix

				2505 ML SEPARATOR			NEW SEPARATOR		
ORBIT	DoD % ACTUAL	CHARGE CONTROL	TEST TEMP °C	50 AH	34/35 AH	26.5 AH	50 AH	34/35 AH	26.5 AH
LEO	25	V-T TAPER	5		5	5		5	5
LEO	40	V-T TAPER	20		10	10		10	10
GEO ACCEL	75	V-T TAPER	5	5	5		5	5	
GEO ACCEL	75	V-T TAPER	20	10	10		10	10	

Table II

NASA/GSFC Test Matrix

ORBIT	DOD RATED (%)	TEMP TEST (°C)	NASA STANDARD CELLS	OLD POS PLATE NEW SEPARATOR	NEW POS PLATE 2505 ML SEPARATOR	NEW POS PLATE NEW SEPARATOR
LEO	40	20	5	5	5	5
GEO (real time)	80	20		5		5
LEO	40	0				5

NOTE: ALL CELLS ARE 50 AH-NASA STANDARD MCD

MATRIX COURTESY D. BAER, NASA/GSFC

SESSION III

DISCUSSION

Q. Hendee, Telesat Canada: Quite interested in your program. I think it's a very valuable thing to be pursued. Several questions however. It might have been that I couldn't hear you. Incidently, next time don't use blue background. I can hardly see them back here.

A. Milden, Aerospace Corp.: It was for those who wanted to go to sleep.

Q. Hendee, Telesat Canada: Where you were saying the negatives were teflon and silver, is that one type of negative electrode that has both teflon and silver? Or is it two separate types of electrodes.

A. Milden, Aerospace Corp.: The 26½ ampere hour cell has teflonated negatives. All the others have silver.

COMMENT

Hendee, Telesat Canada: This is sort of a general comment which was made by some of the more subtle comments in the audience. I'd love to know what your standard positive is these days.

Milden, Aerospace Corp.: No comment. I don't think Guy is here.

Q. Hendee, Telesat Canada: Guy isn't here to defend himself. Okay, your cell spec that you're coming up with is this going to be generally available to other than the contributers to this program? Is the general industry going to be able to get copies of it?

A. Milden, Aerospace Corp.: I really don't think you'd want a copy of it, Ed. There's nothing unique in it. It's just a spec that defines the 4 cells we're trying to buy - nothing more. There's no secret proprietary or anything extra.

Q. Hendee, Telesat Canada: No, I know. We'd better not be after proprietary information, but - I'm getting to another one. You said the test information is only going to be available to the users. I'm getting - I'm terribly interested in this program. I think we all ought to be.

A. Milden, Aerospace Corp.: I'm sorry if there's any confusion on that, Ed. The reason we're having them do the testing is so that the information would be available to everybody. The comment that I made there is that on each of the individual programs that are actually paying for it, the program support people will be doing

A. Milden, Aerospace Corp. (Con't): analysis for that individual program, but that's over and above "the normal Crane reporting". We may want to get a computer dump of more accurate data or more detailed data than is normally available from Crane. But that's available to anybody at extra cost.

Q. Hendee, Telesat Canada: Okay, obviously I've got a great interest in this. Take that as a left-handed compliment. A couple of more things- your real time geosynchronous is basically what I'm interested in. Are you going to be doing periodical chemical analysis?

A. Baer, NASA/Goddard: As usual we didn't have much money. So we couldn't get really enough cells to do that much analysis ourselves So there probably won't be too much chemical analysis. There are a couple of extra cells and we probably will, at some point in time, pull a couple of them out and do some analysis. The other point I'd like to clarify is that in the NASA program they're all 50 ampere hour cells. They are all teflonated negatives and they're all going to be built to a NASA standard MCD, which is a little different than GE's standard MCD.

Q. Hendee, Telesat Canada: Now in your real-time geosynchronous life test, two things: Why did you pick 75% DOD and - which ties in - What kind of a lifetime are you expecting from these?

A. Milden, Aerospace Corp.: Well, the reason that was chosen is because there's a data base on it and it would be comparable to the existing data base. Dave and I have discussed that. Mike, I asked him the same question. You want to take the second part of it, Dave?

A. Baer, NASA/Goddard: As far as the real-time geo goes, I had thought about doing 60% - that's rated incidently. But, at 60% it's going to take a heck of a long time when you're running real time to know if they're any good or not. We do have somewhat of a data base at 80%. There have been tests run in the past and right now I'm thinking about doing 80% just to kind of accelerate a little bit. With a little bit of arm-twisting somebody might be able to change my mind if they know of a good reason to run 60 here. But it just seems like 80 is a nice compromise between getting some results in a reasonable amount of time and having something to compare to.

COMMENT

Milden, Aerospace Corp.: By the way, Ed. The actual life testing won't start for awhile. If anyone has any comments on the levels we've chosen or anything of that sort, I'd be very happy to listen. Because basically we're trying to have as universal a test as possible to avoid individual qualifications to your programs. So, if we can fit it in somewhere, we'd be more than happy to.

Hendee, Telesat Canada: There's one other comment. If you want some help or something maybe talk to me later.

Q. Roth, NASA HQ: This may be off base or maybe I just don't know much about these things but I wondered if it's as significant a problem as you say it is and the fact that you won't have this separator material and so on after next year. Do you have any contingency plans in case things don't work out the way you think they should?

A. Milden, Aerospace Corp.: The answer to that is we sort of have a contingency plan in that we've basically been waiting for the US manufactured material and Pellon-US has had some problems in starting up and they believe they're ready now - Lee is going to address those questions. And, in terms of contingency we always have the Freudenberg, that is Pellon's parent company, material which has been used successfully for a number of years in European satellite programs and in commercial cells in this country. I guess to a great extent we're saying that, pardon the expression, we're going to be a success oriented program. We don't foresee any differences because once the material has been looked at and gone through screening tests, it's not likely that there would be any major deviations. And, yes, it's a very important thing to examine - the Ni-Cd cell is a subtle thing and if you're looking at the cost you're talking about roughly $1-1½ million to do the test and we launch how many billions of dollars worth of satellites a year? It's a drop in the bucket.

Q. Hafen, Lockheed: A number of years ago we had the 2503 separator and I was wondering about the availability of this and what your opinion is of the test results.

A. Milden, Aerospace Corp.: Well, the 2503 is manufactured using the same process as the 2505. It's just a different thickness and it will no longer be available either, because it uses the zinc-chloride step. Lee can comment on its equivalent and what will be available. Basically the industry is pretty much, except for 1 or 2 very limited applications, standardized on 2505 and I think I know what you're talking about. There is sufficient material available in 2503 to last a long time. I don't know how many years but we've checked that issue and the material is available and set aside.

Q. Rogers, Hughes Aircraft: When you use the zinc-chloride process you're certainly attacking the surface of the fibers.

A. Christensen, Pellon Corporation: No excuse me you're certainly attacking the fiber when you use zinc chloride process. Hot gas welding I should think would leave the surface in a very different condition.

Q. Rogers, Hughes Aircraft: How would you expect that this might affect the property and materials? It certainly wouldn't be the same or would it?

A. Christensen, Pellon Corporation: About the only way I can explain that if you, yes look at it microscopically you can recognize a difference in the two structures microscopically. From the standpoint of physical test and physical performance in the cells we don't really recognize any different in this respect. You're still attempting to set up a structure that holds electrolyte and still using the same fibers that cause the same degree of separation the pore size pore diameters of the structure are similar so that the filtration properties are the same, there would be no difference in temperature reactions, from this standpoint in all the testing we can do there doesn't seem to be any significant difference.

Q. Rogers, Hughes Aircraft: Okay. You emphasize the word physical twice. What about chemical differences?

A. Christensen, Pellon Corporation: Again the only difference I can find chemically speaking if I did not wash the new process then I would have the fiber finish on the fabric and that would be present in most of the commercial products we do. In terms of the product we are producing for this particular test we again wash the fabric so the fiber finishes are washed off and I find no chemical differences at this point or none that we can see.

Q. Unidentified, Hughes Aircraft: My question is in line with Howard's basically it looks like the cell matrix test is testing initial performance with the new material but I think at 5 or 10 degrees in two years when you are projecting perhaps to fly some of these cells you won't really have any results of the actual chemistry of that new material which we found in our own work.

A. Christensen, Pellon Corporation: Let me again address that you are using the same nylons - we are using the same blend of fibers, it's just a different bonding technique you're still using the same blend of fibers so to that extent you shouldn't expect any major difference.

Q. Gross, Boeing: When you say you are using the same blend of fibers do I take that to mean that we have a distribution of molecular weights? If so, do you know what that distribution is? I presume you're saying the distribution is the same.

A. Christensen, Pellon Corporation: I think that's what I'm saying but I'm afraid you've got me on that - I have a technical assistant here, Chester Petkiewicz from our R & D group. Chester can you answer that?

A. Petkiewicz, Pellon Corporation: What we are talking in terms of the zinc-chloride bonding process was a chemical attack on the nylon fiber - you actually had a hydrolysis of the nylon which was occurring and in order to have a consistent product you really needed to have a very consistent hydrolysis of the surface of the nylon fiber. It was at this time during the drying process that when you reached a certain level or a certain concentration of zinc-chloride the actual bonding of the fibers took place. This was a very critical process and we from a technical standpoint or from a manufacturer's standpoint really wanted to get out of this a long time ago because it was a very expensive process for us and the economics just weren't feasible to stay in the business. As Lee has indicated we tryed to stay in the business about the time that we tried to reproduce a product. One of the fiber suppliers told us they wanted to change a fiber, well which really threw us into a bit of a turmoil. But just going back to the zinc-chloride in order to do this the bonding took place because of the nylon fiber which meant that you are certainly going to have some low molecular weight components in that nylon fiber. You are actually physically, chemically, degrading a portion of that nylon in order to get the bonding to occur. Some of the low molecular weight nylon components could be washed out during the washing process - in order to get rid of the zinc-chloride we obviously had to wash the material after it had been bonded and dryed. In addition to washing out the zinc-chloride you could wash out some low molecular weight components of the nylon but at the same time you would have a change of the distribution of the molecular weight of the nylon. With the new process we feel it is a much more controllable process because all you are doing is thermally bonding in an indirect system. You're not physically degrading the nylon at all. There's no indication that the molecular weight distribution of the mylon fibers is changing at all contrary to what you might have in the zinc-chloride process. Some of the fiber finishes which are on the fibers are automatically driven off during the high temperature process that is used. We feel that you are going to have a much cleaner structure, a much more reproducible material, and a much more consistent product. We also feel that the pore size distribution will be better, more uniform, more consistent, from one production run to the next. Our equipment is in line. We spent a great deal of money putting up this new equipment. It is in line, the first production runs have been made. We have some minor changes that we are making to it at the moment but we feel very comfortable with this process - we feel very comfortable that the nylon you are going to be getting is going to be a cleaner more consistent product. We do have experience from around the world that this product has been used in nickel-cadmium cells for a good many years and the people in Europe and other parts of the world also had the same misgivings when they were asked to change from a zinc-chloride bonded product to this new product.

A. Petkiewicz, Pellon Corporation (Con't): The result was that they were quite surprised that the performance was consistently better. They found they had fewer problems in their cells, they had a more consistent product and we feel we will have the same thing here in the U.S. with our new process.

COMMENT

Christensen, Pellon Corporation: Just very quickly we plan to do the Hughes Malibu test when we have the separator materials available and try to finalize it by determining the loss of material. That's part of my characterization.