

LITHIUM CELL TECHNOLOGY AND SAFETY REPORT OF THE TRI-SERVICE LITHIUM SAFETY COMMITTEE

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What I would like to talk to you about today is the Tri-Service Lithium Safety Committee. This is a fairly small phase of a many-faceted problem that face all of us here.

This particular committee was initiated in September 1977 when representatives of the Army, the Navy, and the Air Force recognized that the lithium batteries are becoming the major military power source and that procedures should be established so that lithium batteries may be safely and responsibly employed.

(Figure 1-29)

This committee suggested that a tri-service group be established for the purpose of exchanging information on lithium batteries.

(Figure 1-30)

There is a fourfold purpose. The first was to exchange information on lithium batteries. Another area was to examine common areas of concern to the three services. The third was to provide guidance to the users. And the last was to set up common procedures where applicable, for the safe handling, deployment and disposal of lithium batteries.

(Figure 1-31)

Formally, this committee was organized in December 1977 as Lithium Battery Safety Group under the Joint Deputies for Laboratories Committee, Subpanel on Batteries and Fuel Cell Technologies.

(Figure 1-32)

Under a joint memorandum of agreement on batteries and fuel cell technologies, the Army is designated as the joint service focal point for lithium batteries and was appointed as the head of the safety group.

By July 1978, a charter for the group was officially accepted and extended to include NASA, the Department of Transportation, and other government agencies.

During the last 2 years, several key areas have been discussed at great length. These are shown on the figure, and I would like to expand upon each of these categories briefly for you and to tell you what conclusions we have been able to reach in a short period of time.

The first area is on transportation. When the committee was first initiated, we were talking about the first revision to the Department of Transportation Exemption No. 7052. Today we are looking at the seventh revision to Exemption 7052.

This safety group has been able to keep its members updated on each change, has been able to alert members when necessary, who need to be granted a party status to that exemption, as well as to our contractors.

And we have provided an opportunity for the members of the various services to meet with the Department of Transportation representatives to discuss the rationale and interpretation of those exemptions.

The second area of transportation concerns the FAA. One of our members, Paul Neumann, has been able to keep the services fully aware of the safety problems which have occurred in emergency locator transmitters.

The FAA has also been responsible for fostering and publishing an airworthiness directive and a technical specification order concerning lithium sulfur dioxide batteries for use in aircraft. Through this committee, the members have been fully aware of proceedings through the FAA.

The next area I would like to briefly touch on is disposal. Various reports, rumors, and opinions exist on the recommended methods for disposal of lithium batteries. This safety group has attempted to clarify within itself the issue of disposal. Success has only been marginal.

A major stumbling block of this committee is assessing the degree of hazard as defined by the EPA in their "Guidelines for Hazardous Waste Disposal" published in December 1978.

Adding to this problem is the multitude of chemistries, designs, manufacturers and users of lithium batteries. For example, there are at least 12 different chemistries of lithium cells in batteries.

One of these chemistries and designs was examined by Vasar, Inc., in Springfield, and they concluded that lithium sulfur dioxide cells of a balanced design did not contain significant concentrations of cyanide. In their report, this was so stated. An analysis of this report by the New Jersey Department of Environmental Protection concluded that sanitary landfills could be used for the disposal of balanced cells in batteries.

But, as I mentioned, there are at least a dozen different chemistries, and not all of the lithium sulfur dioxide chemistries have a balanced design.

As a committee, an Interim Guideline for Lithium Sulfur Dioxide Batteries was agreed upon to be followed until either firm clarification of the EPA Guidelines is established, or until specific testing against the EPA Guidelines establishes the degree of hazard. This is being looked at under an Army contract with LaPor, Inc., in Chevy Chase, Maryland.

(Figure 1-33)

The group's Interim Guidelines state that no more than 200 pounds of batteries shall be disposed of in a sanitary landfill per day.

Second, all disposal actions will be cleared with each state environmental protection agency. As I mentioned, the Vasar Report was looked at and evaluated by the State of New Jersey. Additional opinions may exist in various states throughout the country, and we felt it imperative that each state give their own opinion. What is good in New Jersey may not be good in California, or vice versa.

Next, cells, batteries will not be compacted or crushed or placed where they may be crushed.

And lastly, the landfill operators would be advised that cells contain lithium and acetonitrile, which are both possibly reactive and ignitable.

(Figure 1-34)

The next area I would like to talk about is storage. How shall we store lithium batteries, what shall we tell the users?

This question was asked at the first few meetings and discussed many times. Two aspects of storage became apparent: Should we protect the battery from the surroundings, or the surroundings from the battery? In part, as you know, the Department of Transportation Exemption 7052 describes packaging and materials and specific methods on sealing the batteries in plastic, cardboard, etc.

To further answer this question, though, several members of the safety group through their own agencies have begun studies and inquiries to assess this problem. The Army has determined that three depots have storage areas which will afford an acceptable level of safety. These are the Sharpe, Red River, and New Cumberland Army Depots. Characteristics of these areas are shown.

All the areas are to be well ventilated. Temperatures are to be less than 55°C. In effect, we are saying there that refrigerated storage is not necessary, but high temperatures must be avoided. The facilities may be either sprinkler protected or in noncombustible structures. Batteries should be segregated from other commodities, other flammables.

We have defined a 2000-square foot per pile stack limitation on batteries. We specified a minimum of two-foot clearance between the walls and any of the batteries. And lastly, since it is a flammable material, smoking is prohibited in the warehouse area.

Further, we have recommended that batteries should be disposed of as soon as possible after use and not returned to storage.

In the area of individual testing and test results, we found that this is the greatest area for data exchange. Programs from each Service have been updated at almost every meeting. It has happened that topics focused on lithium sulfur dioxide batteries and lithium thionyl chloride batteries in the three areas of experimental cells, service casting, and building reports.

This opportunity to share information in the area of lithium batteries, in particular safety, has resulted in several programs aimed at resolving common problems. One of these problems that will benefit the three Services, NASA, the FAA, and possibly industry, is the program I mentioned with LaPor.

In the area of battery design, thorough and complete discussions have existed. Proper and safe battery designs and acceptable procedures for using the batteries have been extremely important. Though, as you may have guessed, we all don't agree on any one design or any one chemistry, many commonalities have existed. These concerns have been incorporated into a NAVSEA Instruction No. 9310.1 issued in March 1979.

(Figure 1-35)

In addition to this, similar information can be obtained from the different Services or is being coordinated at this time.

Key areas of design that we are looking for are that all cells shall have a case-to-cover seal continuously welded. This, in conjunction with the next point that the seal between the electrodes and the cover shall be glass or ceramic metal tight, should give us an hermetically sealed cell. For each particular cell we are recommending that a safety venting device be installed and incorporated into the design.

The next point is that all metal parts of the cell or battery should be secured to prevent possible movement or shorting. In the area of battery design, we are recommending that each group of cells be connected in series with a fuse in series with a string of cells.

The next point is that whenever possible, completed battery assemblies should be procured from battery manufacturers. This is opposed to having cells sent out to an independent assembler who then constructs a battery in any configuration that he deems necessary.

In keeping with that, the last point is that assemblies should be by experienced – should not be by inexperienced personnel.

The last two points really go together. That we would prefer, whenever possible, to have the battery manufacturers who have the expertise, to actually construct the batteries.

In other areas covered by the NAVSEA Instructions, I mention them briefly here so that you are aware of them:

(Figure 1-36)

They pertain somewhat more to the Navy than the three Services. However, there are points that can be adhered to by the various users.

Qualification Procedures and Documentation – That is a major portion of the document, but it specifically talks about how the Navy will go to procure batteries. The same way with acquisition.

Under “Use,” they have a section which defines the proper means of selecting a battery, testing that should be done with the battery or cells to qualify that the battery is being used properly. Packaging, marketing, transportation, storage, and disposal are similar to the other comments that I have mentioned today.

I would like to conclude by stating that the important point of this group is that the various services and government agencies are developing a unified approach to deal with the design and use of lithium batteries. Each agency will still have its unique requirements, and exceptions will abound no matter what the committee can come up with.

Nonetheless, the frequent exchange of information of controversial or state-of-the-art issues provides a more meaningful data base from which future programs will be planned.

DISCUSSION

OTZINGER: It looks like you are starting out in the right direction here. One of the things I noticed that was under “Design,” one of the problems they are having with lithium or one of the corrections to a problem with lithium, was not having positive limit in the design.

Now, you know the welded header is a step in the right direction. The seal takes care of the seal problem, and also terminals are ceramic or glass. I am surprised, was it an oversight or did you purposely not include positive limiting as a design feature?

REISS: It is not an oversight. The reason it was not considered in the specific guidelines is that many different applications may exist for the lithium batteries. There are some places, particularly in the Navy, where they are talking about sonobuoy applications where their safety criteria are considerably less than NASA or the Army might have.

Therefore, as an overall guideline, we would not recommend that all cells go to the ballast or lithium limited design if we are talking about sulfur dioxide. It is a topic that has been discussed frequently, and, when applicable, this is a general guidance. But, I excluded it from the NAVSEA Instructions. It is not covered in the NAVSEA Instructions, but it is being considered by the various services.

OTZINGER: My understanding is that you have pretty well solved your disposal problem by just simply discharging the cell all the way down.

REISS: In the lithium sulfur dioxide system, it eliminates the generation of cyanide, which is the key toxic point.

OTZINGER: My only other comment was, are these instructions going to be put out for people to comment on and to feed back to you any suggestions?

REISS: No. The NAVSEA Instructions is a public document. It is finalized. It can be updated, I would assume, as necessary. But it is not out for general comment with a known date for comment period.

BARNARD: You gave instructions for storage of batteries in bulk. Now, what happens when you have a lot of items with batteries inside them. What about storage of those, any particular problem?

REISS: I cannot comment specifically on sonobuoys. It has been my understanding that batteries are not normally stored in equipment, particularly in the Army. I have to speak from that background. There might be somebody here from the Navy.

BARNARD: Yes, they would be stored in sonobuoys.

REISS: I would assume the same general characteristics would exist. You would need well ventilated areas segregated from other combustibles, flammable materials.

BARNARD: One of the requirements for a sonobuoy is that it goes up to a temperature of 70°C. It cannot be stored in that temperature?

REISS: That would be unique then for the sonobuoys. What I have tried to do is give general guidelines that have come out from the committee. There are exceptions to every phase of this.

If we talk about the sonobuoys in particular, I just mention that they may not have a balanced chemistry, balanced cell design. That makes them unique. And because of that uniqueness, other considerations may have to be given to them.

For the Navy, you might try to get in contact with Tony Sliwa at Crystal City. He might be able to give you the more specific information on the Navy's viewpoint on the sonobuoys.

JOHNSON: My question relates to the NAVSEA instruction, particularly the safety venting instruction. Is the NAVSEA instruction oriented toward all lithium cells, or is it specifically for the sulfur dioxide system only?

REISS: No, it is a general statement for all lithium batteries, various chemistry designs.

JOHNSON: I see. Do you plan to have specific instructions for specific systems later on? In particular, the carbon monofluoride system? Will there be special instructions for the safety in that system?

REISS: As a committee, at this point we don't have any items on the agenda to answer that question directly. We will be addressing the chemistries in time, but at this point we don't have a specific item to look at just that from the safety viewpoint.

BADCOCK: Two comments: It is unusual to see water reactor things like thionyl chloride with lithium stored in a sprinkler protected room. You might want to comment on that. Why don't you call that a hermetic seal rather than just a continuous weld?

REISS: To answer your first question, the committee for the various Services have seen pieces of data which indicate that lithium batteries, lithium cells, are not an extreme hazard when exposed to water. In fact, we have, in the various Services, done experiments where we have extinguished lithium battery fires with water. Water does reduce the hazard.

What we are doing with the water, in effect, is lowering the temperature and reducing the cardboard or other packing material from burning. It lowers the whole hazard associated with the batteries. And you can put out lithium fires with water.

BADCOCK: But there are better fire extinguishing agents which probably should be used.

REISS: The better agent we have discussed in something called Lithex, which is a powder, a graphite-type powder. It does put out lithium. However, it is not readily available in all of the warehouse areas throughout the Services, at least.

We have found that water does prevent significant damage to the surroundings, and therefore, if there is a fire, we are willing to say a certain quantity of batteries is lost. We are not going to use them again electrically. If they burn, fine. The hazard is controlled to a small area, and we accept that risk.

SEITZ: You would not require a safety vent, for example, on a lithium iodide button cell, would you?

REISS: No, probably no.

TAYLOR: Just one question with regard to the design. I am wondering, should you, in fact, have some statement about heat dissipation? For example, if you get a battery, should your instructions include the fact that one should not pot it in solid potting material? That was missing from the NAVSEA specifications.

REISS: The NAVSEA Instructions actually have some wording in there about potting a battery. The specific wording I don't remember, but it states that potting may be used provided the vents are not obstructed.

As far as heat dissipation is concerned, it is not covered in the specific NAVSEA instructions. However, it has been discussed by the various Services and incorporated into some of the different designs. Some of the discussions we have had with battery manufacturers in particular for the specific applications.

It has not been ignored. But it is a general guideline. It is not complete as we may like to see.

TRI-SERVICE LITHIUM SAFETY COMMITTEE

INITIATED: SEPTEMBER, 1977

FORMALIZED: DECEMBER, 1977

Figure 1-29

LITHIUM BATTERIES SAFETY GROUP

JOINT DEPUTIES FOR LABORATORIES COMMITTEE
SUB-PANEL ON BATTERIES AND FUEL CELL TECHNOLOGY

CHARTER ACCEPTED - JULY, 1978

Figure 1-31

PURPOSE OF LITHIUM SAFETY GROUP

EXCHANGE INFORMATION

EXAMINE COMMON AREAS OF CONCERN

PROVIDE GUIDANCE FOR USERS

SET-UP COMMON PROCEDURES

HANDLING, DEPLOYMENT, DISPOSAL

Figure 1-30

KEY TOPICS

- TRANSPORTATION
 - DOT EXEMPTION 7052
 - FAA
- DISPOSAL
- STORAGE
- INDIVIDUAL TESTING/TEST RESULTS
- BATTERY DESIGN - USAGE

Figure 1-32

INTERIM DISPOSAL RECOMMENDATIONS FOR LITHIUM SULFUR DIOXIDE BATTERIES

1. NO MORE THAN 200 POUNDS PER DAY SHALL BE DISPOSED OF IN ANY SANITARY LANDFILL.
2. ALL DISPOSAL ACTIONS WILL BE CLEARED WITH EACH STATE ENVIRONMENTAL PROTECTION AGENCY
3. CELLS/BATTERIES WILL NOT BE COMPACTED OR CRUSHED OR PLACED WHERE THEY MAY BE.
4. LANDFILL OPERATORS WILL BE ADVISED THAT CELLS CONTAIN LITHIUM AND ACETONITRILE, BOTH POSSIBLY REACTIVE AND IGNITABLE.

Figure 1-33

SUMMARY OF NAVSEA INSTRUCTIONS 9310.1

DESIGN

ALL CELLS SHALL HAVE CELL CASE TO COVER SEAL CONTINUOUSLY WELDED.

THE SEAL BETWEEN ELECTRODE AND COVER SHALL BA A GLASS OR CERAMIC TO METAL TYPE.

EACH CELL SHALL HAVE A SAFETY VENTING DEVICE.

ALL METAL PARTS SHALL BE SECURED TO PREVENT MOVEMENT AND POSSIBLE SHORTING.

EACH GROUP OF CELLS CONNECTED IN SERIES SHALL CONTAIN A FUSE.

WHENEVER POSSIBLE COMPLETED BATTERY ASSEMBLIES SHOULD BE PROCURED FROM A BATTERY MANUFACTURER.

ASSEMBLY BY INEXPERIENCED PERSONNEL SHOULD BE AVOIDED.

Figure 1-35

STORAGE FACILITIES

- WELL VENTILATED
- TEMPERATURES LESS THAN 130°F (55°C)
- SPRINKLER-PROTECTED OR NONCOMBUSTIBLE STRUCTURE
- SEGREGATED FROM OTHER COMMODITIES
- LIMITED TO 2000 SQUARE FEET PER PILE/STACK
- A MINIMUM OF 2 FEET CLEARANCE BETWEEN ANY WALL AND BATTERIES
- SMOKING PROHIBITED

Figure 1-34

OTHER AREAS COVERED IN NAVSEA INSTRUCTIONS 9310.1

- QUALIFICATION PROCEDURES, DOCUMENTATION
- ACQUISITION
- USE
- PACKAGING, MARKING
- TRANSPORTATION
- STORAGE
- DISPOSAL

Figure 1-36