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PROCEEDINGS OF THE CONFERENCE ON THE STANDARDIZATION OF SAFETY AND PERFORMANCE TESTS FOR ENERGETIC MATERIALS

VOLUME II

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is a compilation of the workshop discussions held at the Conference on the Standardization of Safety and Performance Tests for Energetic Materials which was held at ARRADCOM, Dover, NJ on 21-23 June 1977.

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PREFACE

This is Volume 2 of the Proceedings of the Conference on the Standardization of Safety and Performance Tests for Energetic Materials which was held at the US Army Armament Research and Development Command, Dover, NJ on 21 through 23 June 1977. This meeting was sponsored jointly by the Energetic Materials Division, Large Caliber Weapon Systems Laboratory, ARRADCOM, and the Joint Technical Coordinating Group for Munitions Development, Working Party for Explosives. The general chairman was Dr. Raymond F. Walker, Chief, Energetic Materials Division, Large Caliber Weapon Systems Laboratory, ARRADCOM, and the program committee included Dr. H.J. Matsuguma, Dr. F. Owens and Mr. Louis Avrami. The purpose of the conference was to provide a rational basis for and a coordinated approach to the international standardization of tests for explosives, propellants and pyrotechnics.

This volume, the findings and recommendations of five discussion groups, represents a distillation of the best thoughts and ideas of the energetic materials community with regard to the requirements and prospects in the following topic areas:

1. Improved hazards and storability tests

2. Improved performance tests for propellants

3. Improved performance tests for explosives

4. Improved performance tests for pyrotechnics

5. Standardization and methodology

Conference attendees attended the study group of their choice and study group chairmen were requested to provide the general assembly a summary of their group's findings, conclusions and recommendations on the afternoon of the final day.

We wish to extend our thanks to the study group chairmen and to all of the participants in the various groups who worked so diligently to make this meeting a success. It will become clear from the material presented herein that there is general agreement in the Energetic Materials Community with regard to the need for improved, more well-defined tests on the safety and performance of energetic materials as well as for increased standardization on a national and international level. Hopefully, the material contained herein will provide the basis for ongoing international initiatives to achieve such a goal.

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TABLES

IMPROVED HAZARDS AND STORABILITY TESTS

DR. T. B. JOYNER, NWC

The group started out with a general discussion. We knew at the outset that we had a problem and deciding exactly what we were going to do with the problem became the more difficult thing with which to deal. We had a rather far-ranging discussion to try to arrive at some general philosophy of what we were going to attack. There was a good deal of discussion of the kind of a dichotomy that we have in testing. Many of our tests are used to characterize explosives and are extremely useful for determining the properties of explosives, whereas, many of our tests are also used to assess the hazards of explosives and explosive devices. We have both aspects of the problem to consider. The tests that are useful for characterizing explosives do not always tell us what we need to know about the hazards that the explosives would experience during their lifetime, manufacture, transportation, use, storage, and ultimate disposal. We thought that we had to wrestle with what kind of tests would help people all along the line (I don't know that we wrestled too successfully) but at least we agreed that we have a problem. It is generally agreed that it is extremely difficult to anticipate all of the environments that an explosive is going to see during its lifetime. Since it is difficult to anticipate those environments, it is difficult to devise the type of tests that would be useful.

We recognize, and it was frequently brought out, that there are hazards with large scale devices that small scale tests don't evaluate and sometimes the scale-up process in between is missed by both small and large scale item tests. There is a little bit of a gap in that particular area. We attempted to discuss various tests in more detail to decide whether or not they were adequate for our purposes -- whether we needed more and whether we could agree on what tests and what machines we should be using. Could we agree on mutually acceptable standards and, if we couldn't, what should we do about it? If we could agree, then we should get this down in documents. Having discussed all of this we, of course, got involved in the expected problems and the impact test was a perfectly good example.

Since all of us have probably used it at one time or another, all of us have strong feelings as to what is right or wrong about it. Without attempting to summarize the entire discussion, I think it is fairly safe to say that the impact test is very difficult to standardize (which is not news to anybody). However, it does have its place in allowing us to compare explosives, and it is useful in scaling up and in process engineering because it does tell engineers something about the material. However, if impact is a problem, then so is just about everything else. It was suggested that we ought to spend a little time trying to standardize philosophies rather than details of impact machines. One point made was that it might be a lot easier to understand impact than a lot of other things. To make use of the data, if we adopted a philosophy of having certain standard materials on which to run these tests, we could then agree to have each laboratory reference a standard material in reporting test results to permit others to assess the results for their particular applications. What this relates to is the need to be able to correlate results between one group and another. For example, when China Lake does something, ARRADCOM would be able to figure out what on earth we did. Thus, if the data turns out to be not relevant, throw it out, and, if it is relevant, make use of it.

It was pointed out, and I guess we all agree, that single point data may have its place but it can be a pitfall and one does better if he has the entire curve of data for an impact test or anything else. It was also suggested that we attempt to define a standard stimulus. Since it is very difficult to know what the explosive is seeing on an impact test, could we define some sort of scientific standard stimulus? I think this would be very difficult to do but at least it is something we might think about. It was suggested that maybe we are starting one step too far down the line and that the first thing we ought to do is get together and obtain a concurrence of ideas on what we think we ought to know about explosives, i.e., what characteristics are of interest and what questions we should be asking. Then we came to the general question of who should test. Should there be a single testing laboratory to avoid the problem of standardizing machines, should it be DOD, DOE, or perhaps a disinterested private lab? We came to no conclusions on that.

I think right now I have almost finished my summary, using the impact test as an example. We went on and talked about a lot of other tests, but I don't see any point in running through them. We all know what some of them are, the friction test, the thermal test. It is a general feeling that we are in pretty good shape on thermal tests. We at least more or less understand them and they do get down to fundamental properties. We have a nice ability to scale up through a series of tests until we get clear out into the field and somebody wants to bring up a boxcar full of stuff that they can more or less relate to -- something that is understandable in the scientific test. We agree that we have done a lot of shock tests that were pretty well standardized, calibrated and useful. There are other tests which we all know exist but it is not clear how we want to fit them into our spectrum of testing. We know we are going to be faced with increasingly stringent toxicity and carcinogenicity standards, we might just as well start worrying about them now. We have no alternative--the law is going to make us.

We addressed briefly, but not in as much detail as it needs, the questions of storability, service life, the assessment of the condition of munitions that have been stored, whether or not requested extensions of service life are justified and how do we tell, and what tests would help the guy who is asked to make the decision. Although we did not go into it, we felt that the whole question of storage opens up the general area of quantity--distance relationships, compatibility, and the question of fire risks versus detonation risks. Someone also brought up the question of the damage mechanisms that needed to be considered in this type of situation, i.e., blast, fragments, fire, etc. Finally, there was a comment on the fact that it would be much nicer if our documentation was more centralized and more accessible.

This was a capsule summary and I think probably the best thing for me to do is shut up and let the individual members of the panel elaborate on the points I may have skipped or misrepresented.

DISCUSSION

Q. Dr. R.F. Walker, ARRADCOM - Was there discussion of a need for improved vulnerability tests, say for fragments?

A. Yes. We should have projectile impact tests, and one of the things we decided was that it was essential to characterize the projectile impact. The phenomena can include shock initiation, cookoff, a hot projectile hitting something, extrusion such as you see in a Susan or bullet impact test to tear something apart. Yes, we did feel that there are many tests and that they test many things. It is an area of very real concern, particularly to aviators who fly around with bombs under their wings and get shot at by airplanes. Yes, we definitely feel that is important.

HAZARDS AND STORABILITY

SUMMARY

STANDARDIZE PHILOSOPHIES

Standard "NBS" materials
Single point data vs. total curve
Standard stimulus
Need for "translation"
Concurrence on characteristics of interest
"WHO SHOULD TEST?"

TESTS FOR properties, applications, lifetime hazards (Include disposal and destruction)

IMPACT

Very difficult to standardize
Can give comparison and range

FRICTION

(Similar to impact in problems and needs)

THERMAL

TGA - EGA
DTA) → Henkin - Like test → ODTX → Small scale cookoff → Large scale cookoff
DSC)
Chemical reactivity
Long range kinetics

SHOCK

Small scale) → Gap tests
Large scale)

Wedge tests
Flyer plate
Gas gun

Gap tests

Minimum priming charge

DDT

Critical diameter
(Performance related)
Confined/unconfined

Susan Test

Projectile impact (many tests,testing many things)

Skid test

40' drop

Setback simulators

SHOTGUN TEST

TOXICITY - CARCINOGENICITY

ELECTROSTATIC TESTS

Need to know what we are trying to measure - mechanisms
Electrometer
Spark test
Arc

STORAGE COMPATIBILITY

Fire risk
Detonability risks
Propellants
Pyrotechnics
Quantity - distance

DOCUMENTATION/COMMUNICATION

Data bank

MANUFACTURING

Electrostatics

Problem in manufacture
Initiators

TESTS

Picatinny Arsenal
British (level of presentation)
RF hazards (AF survey by LASL) M. Joppa
New standard needed?
Franklin Institute studies

HAZARDS

Manufacture
Storage
Transportation
Use
Disposal

WHERE TESTS ARE APPLIED

Early as screening
To defend a factory
To transport

UNDERSTANDING

Theory
Properties
Immediate problem
Uses
Complexity of problem (which we have to live with)
Relation of small-scale tests to large-scale problems. (Thermal explosion)

SERVICE LIFE

How long?
How do we test?
Chemical problem
Mechanical problem
Low amplitude shocks
Do we test well enough?
Scale effects?

Surveillance
- Accelerated aging
- Field storage (M117 program)

<u>START SMALL BUT SCALE UP</u>

Characterization of <u>real</u> chemical system, Quality Assurance
Compatibility
<u>Real</u> stimuli
Anticipation of <u>Life-time</u> hazards including disposal
Types of damage
- Fragments
- Blast
- Heat
- Earth shock, etc.
- Toxicity
- Carcinogenicity

IMPROVED HAZARDS AND STORABILITY TESTS
DISCUSSION GROUP

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IMPROVED PERFORMANCE TESTS FOR PROPELLANTS

MR. C. LENCHITZ, ARRADCOM
AND
MR. C.B. DALE, NOS, INDIAN HEAD, MD

The meeting was attended by representatives from Germany, France, MICOM, BRL, two Naval Installations and ARRADCOM, Dover, NJ.

Although we started at an ambitious level and numerous propellant performance tests were listed and classified, we were not able to evaluate all of them. All of us agreed that we were confronted with a complex problem. Not only is there difficulty in interpreting test results, but the propellant community is faced with the diverse interests of rocket and gun personnel using heterogeneous and homogeneous propellants.

The first problem we confronted, and which took practically the entire session to discuss, was burning rate measurements. Although the strand burner is the perfectly controlled experiment (constant temperature, pressure, and volume), you will find large differences even here. Try matching your results with the CPIA tables. For this reason a JANNAF round robin on burning rates has been organized and is currently underway. This round robin includes not only strand burning rates, but also the more complex burning rates obtained from the closed vessel. It is noted that in this supposedly complex test, the NATO countries including Holland, England, FRG, France, and the USA obtained remarkably good agreement in a round robin closed vessel burning rate program several years ago. All agreed, however, that there is much room for improvement in closed vessel testing.

Particpants reviewed their closed vessel experimental techniques as well as the methods used for calculating burning rates. Attendees were encouraged to participate in calculating burning rates using data generated from ARRADCOM closed vessel firings. Representatives from France and Germany agreed to participate. It was apparent from these discussions that both closed bomb experiments and calculations are generally similar throughout the world.

The modeling of pressure and force in the closed vessel is still unsolved. There is evidence that none of the equations of state are universally valid beyond 0.2 LD. The calculation of covolumes is still uncertain and Codes currently in use (Blake) are only good approximations of what occurs at high temperatures and pressures.

We then discussed problems encountered by the Missile Command in assessing the homogeniety of slurries of heterogeneous propellants (ammonium perchlorate type). It was suggested that kinetic and thermochemical properties of these slurries be determined in platinum lined vessels. The experience at ARRADCOM, Dover, with these vessels was discussed.

The next item on the agenda was ignition. Here too, one finds little accord among laboratories. The arc image furnace which is the most commonly used method for measuring ignition, turned out to be very poor indeed as far as reproducibility is concerned. In fact, a round robin between CIT and the Navy showed a diversity of results. To date there is no generally acceptable method for measuring ignition.

As far as mechanical properties are concerned, all agreed that a high rate compression test is essential. The stress rate must approximate gun conditions. Impact tests were also considered. The general concensus is that if you cannot measure exactly the energy input, absolute values are meaningless. It was suggested that each installation use their own impact test and rank their propellants with a uniform well characterized sample or samples, i.e., an M-1, M-30, etc. A test for measuring shear modulus was also suggested.

Physical and thermodynamic properties of propellants were also discussed. The difficulty of determining thermal conductivity at high temperature was pointed out. To date the community still uses 5×10^{-4} cal cm $^{-1}$ sec $^{-1}$ deg $^{-1}$ for all propellants. Specific heat tests are fairly good. Improvements in DTA measurements have extended the range and quality of data. Calorimetry testing on nitramine propellants was also discussed. The community also showed an interest in thermal expansion tests.

In conclusion, I would like to point out that, whereas absolute values should be used where possible, i.e., calorimetry, burning rate, etc., rankings should be used rather than absolute values in the sensitivity tests. If you cannot account for heat loss, surface area impacted, impact time, etc., absolute values become meaningless. We all agree that this type of get-together is extremely important and we welcome, in particular, the participation of our guests from overseas.

DISCUSSION

Q. H.J. Matsuguma, ARRADCOM - Say again why you would drop shock sensitivity tests from propellant considerations.

A. Well, the card gap test for example--it's a test that is not needed--it's not applicable to propellants. It would interfere with our development of the nitramine propellants and I think Steve Mitchell has a lot of experience with that. Is Steve here? Steve would you want to answer that?

(Answer not transcribable)

Q. R.F. Walker, ARRADCOM - Don't you feel there should be separate tests for burning rates?

A. Well, we do run burning rates in both the closed vessel and in the strand burner. We conduct our tests over the range from -60°F to +140°F. In fact, in the closed vessel it is very difficult to conduct low temperature tests. At one time we tried to place the closed vessel assembly in a cold chamber. This was not possible because closures and fittings didn't mesh. Now we precondition our sample and fire it quickly in the closed vessel which is kept as close to zero as possible.

Q. D. Price, NSWC, WOL - I wanted to go back to the question of the dent test or some sort of shock test. I don't know how applicable it is in the case of gun propellants because you have detonable materials and you should know that. You should know the risks and hazards they are going to undergo and the conditions under which they are used. The test the French described sounds very like what is called the shotgun test by one of their industrial companies, I think it was Hercules, where a slug of propellant is fired at a steel plate at different velocities. They use it in conjunction with a quickness test to estimate the amount of damage that's been done. It is an excellent, qualitative dynamic strength test.

A. Thank you.

Q. H. Pasman, TNO, Netherlands - I think your idea to send some countries a set of data of measurement results, to calculate burning velocities from them is a very good idea. Would you mind making an extra set so we in Holland can participate?

A. I'll make sure you get one before you go home, if you want.

Q. Thank you, that would be fine. Second point, there might be problems involved because as a matter of fact to compare the results with this exercise you should, I think, take into account, the interior ballistic programs, in which the burning rate results are fed in to calculate the pressure-time history in the chamber of the gun.

A. We are trying to bridge that gap but before we get there we want to make sure that we are all talking the same language. If you look at USA results you will find, for example, different results from different laboratories. The next step is to interface what we see in the closed bomb with the actual gun firing. That is a problem we have to contend with -- we have been trying to do that for years. I would be glad to give you the data. I can give you the pressure-time and all the characteristics of the propellant before you go home. If there are any other foreign visitors who would like to participate in this round robin we will be happy to give you the data.

Q. R.M.H. Wyatt, PERME - There are two things. I would like to join in the discussion on the question of gap testing. I agree that it is difficult to consider doing most gap tests on gun propellants and we get a lot of interesting results on multi-perforated grains. We are more interested in the buildup from ignition. In the case of rocket propellants I think we have already mentioned the addition of nitramine and NH_4ClO_4 and Al and all that certainly increases the sensitivity and you start getting towards quite good high explosives. There again, excepting in the case where an explosive shock is liable to enter the rocket motor, we are usually concerned with what happens from a relatively small ignition source. In the case of materials which are wholly nitramine plus binder, I think probably when it is devised as a propellant it's usually got sufficient binder in it to make the transition from ignition to detonation much more difficult even though the material may be detonable if you put in a strong enough shock in the first place. The other point I was going to ask - you had a hot wire ignitability test. Can you comment on that? What size wire and what sort of system it is?

A. We used it as a backup for our arc image test results. If you use a different type of sample you have different absorptivities and you could run into a problem. In order to make sure that we were correct as far as the arc image results were concerned, we duplicated our results with a hot wire. But this was just a qualitative type of test. There is a Czechoslovakian report on hot wire ignition in which some very good work was done. They actually embedded the wire within the propellant, but there are always heat losses that you have to account for and the wire wiggles while you are heating it so you have a problem in determining how much energy was actually put into the sample.

Q. (Question not transcribable)

A. Yes, a controlled energy source, a capacitive discharge. They were also very difficult to reproduce from one laboratory to the next.

Q. E. Freedman, BRL - I am a little surprised to hear that the performance of the propellant depends on the curve that one uses to compute it. I think performance really ought to be measured either in a closed bomb or, somewhat better, in a gun. I think also you have to distinguish thermodynamic properties in two ways -- there are the thermodynamic properties for the propellant itself and the thermodynamic properties of the chamber gas. These are two different quantities. By and large, the thermodynamic properties of propellant ingredients are fairly well established now and there aren't too many questions about them. As far as the Hirschfelder code, I feel that it would be close to heresy to criticize something as good as that, but the fact is that it is based on essentially using average properties over a range of temperatures and, for the time in which it was developed, it represented incredible insight. In general, I feel that, to the extent that one wants the properties of the chamber gas, there are improved curves. Aside from Blake results, there is also the improved version of the NOTS code which Chan-Price has been using which gives quite satisfactory results. Until there is an improvement in the art of closed chamber testing I doubt that one really has to worry particularly about the code aspects.

A. How about the equations of state?

Q. My honest opinion is that the equation of state problem for gun pressures of which we are now talking and for the ones coming up for the next decade are exaggerated. The problem of making code chamber measurements under those conditions I think is much greater than the computational problems in getting an equation of state. The Virial equation with the coefficients calculated from Leonard-Jones parameters which Kerner recommended back in 1948 or 1950 is still a fine way to go to get results better than one can measure them.

A. You say that there are good thermochemical properties. You know nitrocellulose is a very heretogeneous compound and if you say you get a great deal of information from nitrocellulose, I cannot go along with that because you really don't know what happens to the nitrocellulose during the processing. Even if you did know, you don't know what you started with. There are limits as to what you can do as far as thermochemical properties are concerned.

Q. Yes, but the solution to that problem I think is very straightforward. Jessup showed a long time ago how to calculate from the heat of formation from nitrocellulose and no one has bothered to extend the work to nitrocellulose in other forms. The real question still remains. What kind of precision are you aiming for? Do you really expect that the small improvement in precision that you get from having the heat of formation for nitrocellulose is exactly the kind that's in the propellant? Is it going to tell you any more than you already know? Particularly in view of the fact that the real problem in ballistic calculations is not in the thermodynamics but in the performance codes.

Q. J. Haberstat, Naval Ordnance Station - I would like to comment about the card gap test. Right now I am associated with the standard missile medium range improvement program and we are worried about developing a new propellant for the standard missile. As soon as you start talking about differences in development cost between developing a Class A and a Class B propellant the difference is two to three times, just because of the legal distinction of the criteria of 70-cards for distinguishing between Class A and Class B. What would be more logical would be to do DDT tests on the propellant in quantities that you are working with. If you are worried about manufacturing hazards, I think it is better to do DDT tests on the propellant in a simulated mixer bowl to see if it can go off in that configuration and then, when you have the cured propellant, finding out what the critical diameter is to see if that propellant is detonable in the size rocket motor you are talking about. It is my personal opinion that the 70-card criteria is a little bit artificial and it might be more logical to look at what you are doing, what you are worried about -- you are worried about manufacturing hazards -- and then do the DDT tests on that configuration, or if you are worried about detonation in the rocket motor, do your DDT tests on the propellant in that configuration. Then classify your propellant according to the results you get from that test and set your quantity distance criteria and things like that.

A. Thank you. As you can see, there are really no problems associated with propellant performance testing.

PROPELLANT PERFORMANCE

SUMMARY

TOPICS DISCUSSED

Burning Rates

- Closed bomb (JANNAF Workshop)
- Strand (JANNAF Workshop)
- Slurry

Ignitability

- Convection
- Arc image
- CO_2 laser
- Hot wire

Mechanical properties

- High stress rate (compression & tension)
- Impact (air gun)

Thermodynamic properties

- Thermosensitivity (High T.)
- Thermoconductivity (High T.)
- Specific heat (High T.)
- Heat of reaction

Thermomechanical properties

- Thermoexpansivity

IMPROVED PERFORMANCE TESTS FOR PROPELLANTS

DISCUSSION GROUP

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IMPROVED PERFORMANCE TESTS FOR EXPLOSIVES

MR. J. HERSHKOWITZ, ARRADCOM

We were fortunate in getting a rather representative panel on explosive performance: Canada was represented; the United Kingdom was represented; there were two organizations from Germany; the CEA of France; the BRL; the DOE Laboratories; ARRADCOM; Hughes Aircraft; Explosive Technology; etc. We had a total of 16 people and excellent interaction. The group also represented different viewpoints, from warhead design to purchasing equipment to manufacturing. We did come to a conclusion. I would like to show you the conclusion first and then tell you the other points.

We feel that in the field of explosive performance one requires three types of tests. One requires a screening test (Table 1) that one can quickly make to compare explosives in a general sense. We suggest that the most efficient test for that purpose is a dent and detonation velocity test.

The second category of tests would give the kind of understanding that would enable the user of explosives to extrapolate to his needs. For this we suggest that there be more extensive measurement of detonation velocity as a function of diameter and all other parameters which influence it. We feel, in terms of metal acceleration, that one can use cylinder and sphere tests and also the flyer plate tests which give information, depending upon the thickness of the metal plate being accelerated for different parts of the isentrope curve from the Chapman-Jouget point. In the future, with the enhanced use of composite explosives, it will be increasingly necessary to measure the equation of state as a function of time, that is, its relation to the manner in which the energy is released, using hydrocodes, runup time and factors of this type. We feel that one gets a kind of information which is basic for Navy applications by studying underwater coupling. We finally believe that detonation products and calorimetry, when you are getting the detonation products, give you an understanding of what is happening in the explosion. It tells you whether you are getting the species that your computers say you are getting, it tells you to what extent you are getting reshocking and the effects of reshocking. Finally, even with these tests, we feel that you must turn to the question of application. You must verify what you are doing and, to some extent, it is not cost-effective to try to predict everything.

Table 1. Explosive performance tests

Screening

Dent & detonation velocity

Understanding

Detonation velocity (vs parameters, e.g. l/d)
Cylinder and sphere tests
Flyer plate tests
EOS as f(t)
Underwater coupling
Detonation products & calorimetry

Applications

Fragmentation
Cratering
Shaped charges
Air blast
Gap donor (small & large scale)
Performance under deformation
Performance vs aging

We suggest that one needs a test for fragment production, one needs shaped charge tests as a function, for example, of standoff and cone diameter, and one must make measurements on cratering and air blast as a function of the characteristics of the source. One should look at the question of gap donor properties, both small and large. In the small we are concerned with the properties that occur in the explosive train. How efficient is an explosive at transferring a signal, say, from a detonator to a lead? In the large we are concerned with the fact that certain explosives can be evaluated by seeing how well they can transmit energy across a gap. We feel that another place to look for applications is in the performance of an explosive when it is deformed. This occurs in a HEP round when an explosive squashes, so to speak, against a target and goes off in a delayed fashion. The exact manner in which the deformation occurs, the point at which one initiates the explosive, whether it will detonate and at what velocity are important. Also, for penetration of hard structures, it is rather important that the explosive be able to go through tremendous forces without initiating. So, from the viewpoint of applications, a test is required that indicates performance under deformation. And although not shown here, the point was made that we all are assuming that performance characteristics measured at a particular time continue on in time, so there should be some effort to ascertain whether or not performance characteristics are maintained with time, i.e., the aging effect. I would now like to briefly go through some of the other comments that were made.

We pointed out that procurement by specifications can qualify a process, that is how you make something, or you can use a requirement on performance and then use an evaluation method to measure it and to quality control it. If you do only one of these, then you are allowing the manufacturer to do the other as he sees fit. That is, if you tell him exactly how to make the detonator, how many milligrams of this to use and how to put it in and how to press it, you don't tell him what the final product must do and you must accept whatever he manufactures to your specifications. On the contrary, if what you do is simply ask that he deliver so many psi at such a distance away from a source, then, no matter how he manufactures it, you had better be sure that you want those psi at that distance and that that will do the job that you have in mind. We felt that there was some room for each of these approaches and that the best approach would be a combination of both. We very strongly feel that this region of understanding, which really is related to understanding how different parts of the expansion isentrope of explosive products do their work, is necessary to serve as a bridge for the designer and for everyone in the field.

We had a discussion dealing with the use of computer programs and there is a consensus that one can take a computer program and calibrate it by a set of measurements. For example, the HEMP computer program is calibrated by cylinder and sphere test measurements. When you have done this, you can take your computer program and use it for applications that involve different geometries and, under some circumstances, that allows you to scale results. When, in effect, you cannot scale, you may have to change your measurements and use a calibration that is more appropriate to your charge-to-mass ratio or more appropriate to your dimensions. The view was expressed that, in the future (these are two contrary views that I am going to give you) computer capability will exist so widely as to make the approach of using a calibrated computer program almost universally adopted. The contrary view asked that there be just a few simple tests with prescriptions for estimating weapon effectiveness from the tests. The viewpoint was, in both cases, that predictions by computer program require verification. The simple way to state this, I thought it an elegant way, was to say that computers represent numerical experiments that must be complemented by input data experiments and output prediction experiments.

We also discussed, as a separate subject, the possible further development of a set of plate dent tests for direct application to particular time ranges during explosive coupling (Table 2). The idea being that a plate dent test is obviously an integration over the period of time that the dent is formed. Therefore, we would be sampling the expansion isentrope. If we had a few of these, perhaps we could make deductions directly from these samples. I think that at this point I have covered all of the discussion points. I did them in a reverse order so that you could see the conclusions.

Now, if you compare this situation with the present series of tests which are in Table 3 (Table 5.2 of OD44811 which is the standard used for qualification of materials and which preceded the Tri-service document) you find that, depending on the application, particular tests are listed for performance evaluation. I would like to read this list of tests to give you an idea of the difference. They call for detonation velocity for infinite diameter, but not as a function of diameter. They call for fragment velocity, for Gurney constant, for fragment mass distribution, for pressure vs scaled distance, and impulse vs scaled distance, obviously for blast applications. Cylinder expansion is required, the Chapman-Jouget pressure, the shaped charge penetration, and the pentolite equivalent of the explosive and the mechanical bubble energy, which we would call the underwater coupling. In effect, we appear to have altered the situation by saying that there should be three categories, one of which is a screening category for use. We appear to have put a

Table 2. Time intervals for performance tests and for munitions

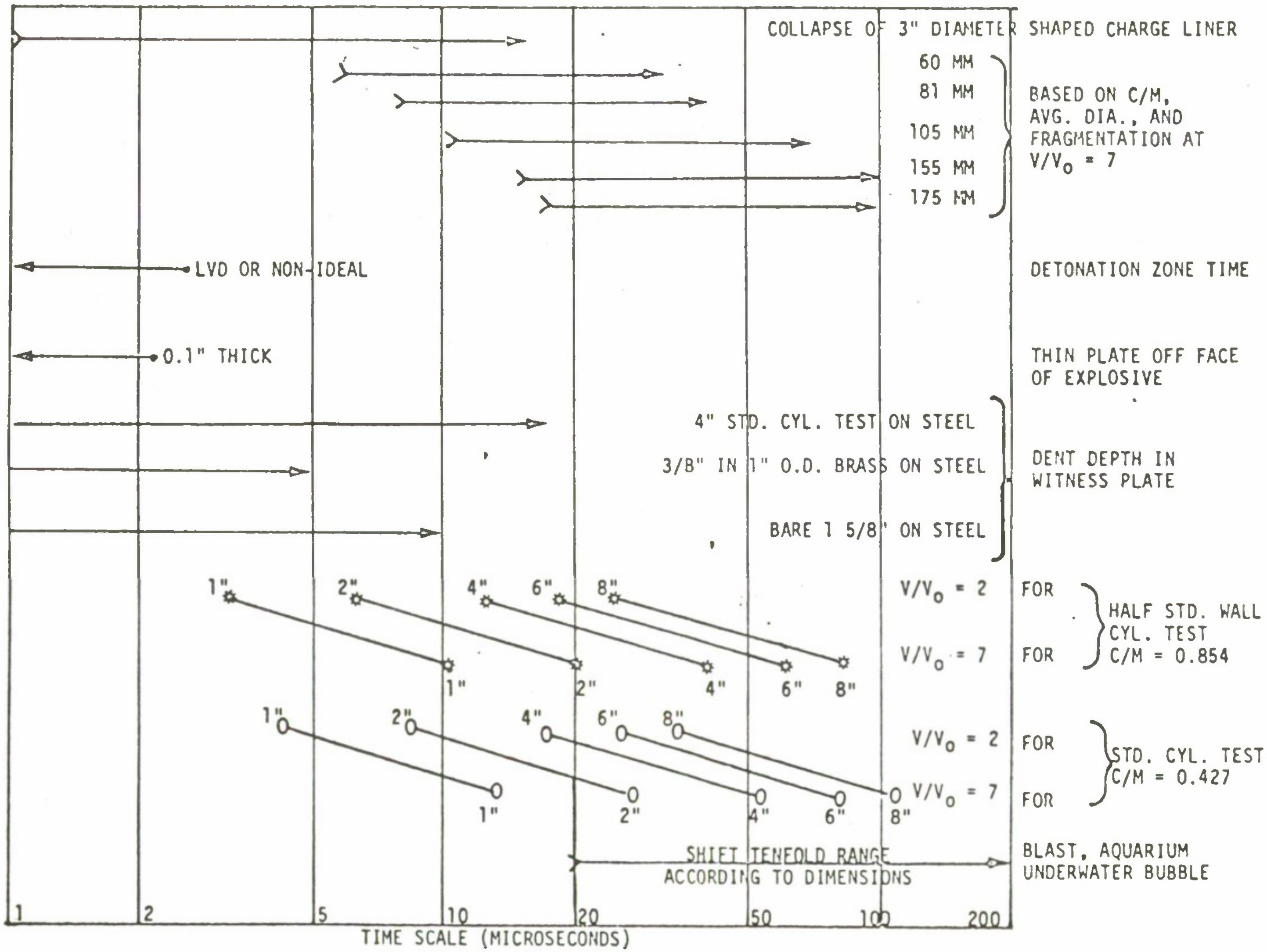

Table 3.* Performance evaluation of explosives

Application	Test method: Detonation velocity for ∞ diameter	Fragment velocity	Gurney constant	Fragment mass distribution	Pressure versus scaled distance	Impulse versus scaled distance	Cylinder expansion	Chapman Jouget pressure	Shaped charge penetration	W. D. (weight for same shock as 1-1b Pentolite)	M. B. E. (Mechanical Bubble Energy)
Bombs	+	+	+	+	+	+	+	+	-	-	-
Shaped charge	+	-	-	-	-	-	+	+	+	-	-
Small caliber shells (to 40mm)	+	+	+	+	+	+	+	+	-	-	-
Large caliber shells	+	+	+	+	+	+	+	+	-	-	-
Torpedoes	+	-	-	-	-	-	-	-	-	+	+
Depth charge	+	-	-	-	-	-	-	-	-	+	+
Mines	+	-	-	-	-	-	-	-	-	+	+
Blast	+	-	-	-	+	+	-	-	-	-	-
Focussed blast	+	-	-	-	+	+	-	+	-	-	-
Continuous Rod W/H	+	+	+	+	+	+	+	+	-	-	-
Fragmenting W/H	+	+	+	+	+	+	+	+	-	-	-
Bomblets	+	+	+	+	-	-	-	-	-	-	-
Polygon charge	+	+	+	+	+	+	+	+	-	-	-
Destruct system	+	-	-	-	-	-	+	+	-	-	-

+ desirable.
- not needed.

*Table 5.2 of OD44811

little more emphasis on understanding because we believe this is needed more and, when it comes to applications, we have listed a variety of applications rather than mixing these two categories. I believe I shall just stand for questions now.

DISCUSSION

Q. L. Shulman, ARRADCOM - In all of these tests you mentioned, would they be measured on an absolute unit and could they be reproduced or verified by other installations making the same types of tests? Would you have to do it on a comparative basis and compare to some standard?

A. Well, let me run down the tests very quickly. In connection with the dent test it is very easy to specify a geometry. It is very difficult to specify a standard witness plate, therefore you would have to use a large amount of steel as standards, or else you would have to have a reference and a correction procedure. Detonation velocity can be measured by a variety of methods and no matter which lab does it you will get the same results. The cylinder test is very well standardized, one does have to control the copper but if you do that it will work beautifully. The flyer plates are no problem. All of the major laboratories will get exactly the same results with proper specification of methods. What I mean by that is that we could write a test procedure that would make it quite definite. There would be no difficulty. As far as the equation of state as a function of time is concerned, there is no standard method now. The "Forest Fire" -- "Pop Plot" approach at Los Alamos is one approach, the threshold and ramp functions at Livermore are another approach. This is a method for the future. In the notes I have, which I am handing in, I actually label them that way. The bubble test -- the Navy has done an excellent job there. I think that could be specified and be done quite correctly. As far as detonation products and calorimetry are concerned there has been a great deal of work done by Ornellas at Livermore. There has been some work done by Urizar in Los Alamos. I think that needs a little more development but it is almost ready. In applications there are standard tests and I think from laboratory to laboratory there is agreement. So the answer is that one could write specifications for almost all, but not quite all, of these tests and there might be a certain amount of work to get the writing done and perhaps a round robin to get agreement. The difficult one would be the dent test and the equation of state as a function of time. Those are the ones that require considerable work. The rest of them I think would go very quickly. It is more a question of getting one laboratory to work with another and to agree to adopt what the other has done than it is a question of do we know how to do it. Any other questions?

Q. R.F. Walker, ARRADCOM - I know it really doesn't fit strictly within your thing but it's not being addressed. What are your feelings, personally or the group as a whole, about the need for a DDT test? It seems this is something that is important, both the vulnerability and the other question that is coming up all over the place.

A. I must have asked about 20 people exactly that question, so let me first tell you the response. I spoke to Dr. Wyatt just yesterday or the day before and he feels this is an important question to look at. I have spoken to others and one man said this is a problem of the future. I think that the equation of state as a function of time sort of drives you into that also. Speaking for myself, if you are going to tailor explosives then you are really going to understand deflagration to detonation. If explosives can be made to deflagrate as propellants without detonating, then you begin to wonder whether or not you can make them detonate on command the way you want them to. So that's another reason to go that way. If propellants are going to be explosives that are made to burn, I, for one, feel very uneasy taking a random walk on a plateau and not knowing whether or not there are any arroyos, as they call them in the West, where the cliff is. I can see a situation where a designer who is designing a very energetic material containing nitramines or TAG nitrate decides that he is going to make a change. He will change particle size of HMX from fine to coarse and lo and behold he's suddenly got an acceleration in burning rate which he had not been aware of and it might take off on him. I see the possibility that in an effort to get longer range they will decide to strengthen the breech of guns. Weapon designers will say "Sure you want me to run at 110,000 psi. All right, I don't like to do it but I am going to give you a stronger gun." Well, that's fine. At 80,000 psi you get a breech blow which is damaging enough, but at 110,000 psi, with an ignition system that doesn't ignite properly, this time you might get a detonation. So I feel that deflagration to detonation transition should be studied. That was an excellent method that was presented by the NOL people and I feel it is a subject that is important for explosives and propellants and I really don't think there is a problem in pyrotechnics, but maybe I just stuck my foot in it. It is a problem there, too, O.K., fine.

Q. H.J. Gryting, NWC - How do you propose to evaluate explosives which won't detonate in diameters of below say about 16 inches?

A. Well, I think there are a few things that can be done. It's a fair question and it deserves an answer. First, you gave me an out because you said 16 inches and I assume you mean unconfined. O.K., so that gives me a little out. I can bring the dimension down to something less than 16 inches by extremely heavy confinement. The second thing -- there are techniques such as Varicomp which enables me to obtain the data. Let's take an example. Let's suppose we're talking about ammonium nitrate with nothing in it and you need 80 inches or whatever diameter you wish. Suppose I take this particular explosive and I seed it with something else, say, 20% RDX. Suppose at that point I find that with 20% of RDX I can detonate it in 1/5 the diameter that you are worried about. Then suppose I make it 10% RDX. In principle, I can attempt then to predict what would happen if I removed all of the RDX.

EXPLOSIVE PERFORMANCE

SUMMARY

23 June 1977

<u>POINTS MADE</u>

1. Procurement by specifications can qualify a process and/or use evaluations for performance and quality control of the finished item.

2. The standardization of tests which provide understanding and basic data on performance constitute a bridge between these two approaches and are essential for design.

3. The link between the tests in the description of explosive product behavior as a function of expansion, the isentrope, or more generally, the equation of state allowing for some current and future applications, is the time dependence thereof due to finite rate phenomena.

4. A reorganized approach is making key measurements that calibrate a computer program which can then be used for design in various applications and configurations. The view was expressed that in the future computer capability will exist very widely making this approach more universally adopted. The contrary view asked for a few simple tests with prescriptions for estimating weapon effectiveness from the tests. The viewpoint was also presented that predictions by computer program require verification. In effect, one can state that computers represent numerical experiments that may be complemented by input data experiments and output prediction experiments.

5. The possible further development of a set of plate dent tests for direct application to particular time ranges during explosive coupling acts was discussed.

6. The importance of a specification including all requirements for standardization of method was agreed to and it was also noted that the specification should require furnishing all essential data obtained in the measurements, a statistical treatment thereof together with interpretation of the meaning.

7. Tests for performance were divided into three categories:

SCREENING

DETAILED UNDERSTANDING

APPLICATION

8. For screening the combined dent and detonation velocity test was recommended.

9. For detailed understanding

DET. VELOCITY (VS PARAMETERS, e.g., 1/d,)

CYLINDER & SPHERE TEST

FLYER PLATE TESTS

TESTS FOR TIME DEPENDENT EOS

UNDERWATER COUPLING

DETONATION PRODUCTS & CALORIMETRY

10. For applications the tests may vary, but the following are indicative.

FRAGMENTATION

SHAPED CHARGES

CRATERING

AIR BLAST

GAP DONOR (Small scale & large scale)

INITIATION & IGNITION UNDER DEFORMATION LOADING

11. In addition performance vs aging.

IMPROVED PERFORMANCE TESTS FOR EXPLOSIVES
DISCUSSION GROUP

	Affiliation
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IMPROVED PERFORMANCE TESTS FOR PYROTECHNICS

MR. T. BOXER, ARRADCOM

The first problem our panel addressed is the definition of pyrotechnics. There are many definitions for pyrotechnics even such an all encompassing one as, pyrotechnics comprises all energetics except explosives and propellants. We defined pyrotechnics in our panel as energetic reactions which produce heat, sound, smoke, and/or light (from the UV to the IR). Since this doesn't really answer the question that was posed in terms of performance, the panel defined pyrotechnics in terms of its military applications. In the outline we have listed nine applications, from illumination to thermal sources.

To cover all these applications with respect to performance and requirements would be impossible in the time allotted, so the group considered some of the more important applications. Standardization of flare static tests including facilities and instrumentation from the UV through the IR was considered as a significant need. Standardizing the physical facilities so as to minimize and characterize the smoke and reflection problems would be important. If this were done, we would at least have a standard to permit correlation from one test facility to another. During the Vietnam situation, the method of testing illumination flares for candlepower was loosely specified. This could result in poor flares being accepted and good flares being rejected, by arranging the physical conditions within the tunnel such as the distance from the hearth to the photocell, or increasing the air flow for smoke removal.

The panel also decided that definition of the test sample was very important. Sample size, loading pressure, case material (steel, aluminum and/or cardboard), orientation of the flares (face up, face down, or sideways) and test geometry are the factors which will effect the results. Another factor that has to be determined is the test environment, temperature humidity and barometric pressure. The parameters to be measured should be specified in terms of spectral distribution, shape of the bandpass, and time-intensity curves. All of these factors are necessary to achieve a correlation between one test facility and another. At the present it is very difficult, particularly with respect to candlepower, to compare one flare to another when they are tested in different tunnels under different conditions.

For flame and incendiary items one needs to determine temperature, heat flux, overpressure and types and number of reactive fragments. For tracers one important item is spin, and for delays and igniters we need to know ignition properties, heat transfer, temperature and pressure dependence, and reproducibility. These are performance requirements specific for these applications.

In summary, we concluded that there was a need for standardization of static tests and test results to permit correlation between test facilities. In the pyrotechnics area we also lack good dynamic tests. There is only one US facility which can perform dynamic tests on visible flares - Yuma Proving Ground. Much work had to be done to upgrade this facility to be completely operational. There is also a need for an interface test between the system elements such as the primers, the igniters, delays and the pyrotechnic element so we can assess safety and reliability. The panel felt that some of the tests used for explosives and propellants are really not applicable to pyrotechnics.

Finally, the panel recommended that test and test results should be standardized by an international committee. One committee was established five or six years ago in the TTCP and we had an ad hoc committee on measurements. The latter operated for about a year, had one meeting, and then, during reorganization of TTCP and changes in personnel, was dissolved. We also think that energetic materials tests should be broadened to include safety as related to pyrotechnics.

DISCUSSION

Q. K. Beedham, Ordnance Board, UK - I just wondered, in performance tests on flares, whether there was any possibility of having a standard flare by which you could compare results?

A. That was tried with the MK24. Special lots were made up about six years ago at Crane, Indiana, and they were sent to various facilities for comparison tests. The results were disappointing because the test tunnels were differently constructed and gave different resutls. We dropped that approach and considered using not an actual flare, but an aluminum torch to give us a specific controlled output for a comparison. Due to lack of funding it never was pursued beyond the initial stages.

Q. R.F. Walker, ARRADCOM - You mentioned that it was necessary to determine certain parameters. Presumably you should determine these as a function of height, in certain instances. Shouldn't we standardize on certain heights?

A. Yes, certainly with regard to IR decoy flares. We test them at various heights in ARRADCOM but we do not have a standard height, as far as I know, throughout the various countries. That is one of the parameters that should really be specified because performance is very much dependent on altitude.

PYROTECHNIC PERFORMANCE

SUMMARY

DEFINITION

Pyrotechnics involve energetic reactions which produce heat, sound, smoke, and/or light (UV → IR).

PYROTECHNIC APPLICATIONS

1. Illumination (visible and IR)
2. Signaling and marking
3. Decoys
4. Flame and incendiary
5. Screening
6. Tracers
7. Simulators
8. Delays and igniters
9. Thermal sources

STANDARDIZED STATIC TESTS FOR FLARES (UV → IR)

1. Facilities:

   Minimize and characterize smoke and reflection problems

2. Instrumentation (measurement):

   Calibration and correlation

3. Sample definition:

   Size, loading pressure, case material and orientation

4. Environmental conditions:

   Temperature, humidity, pressure and geometry of test

5. Parameters to be measured·

Spectral distribution, shape of bandpass and time-intensity curve

SPECIALIZED PYROTECHNIC PERFORMANCE REQUIREMENTS

1. Flame and incendiary:

   Temperature, heat flux, overpressure and reactive fragments

2. Tracers:

   Spin

3. Delays and igniters:

   Ignition properties, heat transfer, temperature and pressure dependence and reproducibility

CONCLUSIONS

1. Need standardized tests and test results·

   a. Simple

   b. Correlatable

   c. Good dynamic test

   d. Correlatable between static and dynamic tests

   e. Test of interfaces between system elements

2. Need specific safety tests for pyrotechnics in many applications

RECOMMENDATIONS

1. Form an international committee to address item 1 of the conclusions

2. Energetic materials tests should be broadened to include pyrotechnics safety tests.

IMPROVED PERFORMANCE TESTS FOR PYROTECHNICS

DISCUSSION GROUP

	Representing
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U. Brede	Dynamit Nobel Aktiengesellschaft, GE
W. Johansen	Dyno Industrier A/S, Gullaug Fabrikker, Norway

STANDARDIZATION AND METHODOLOGY AMONG NATIONS AND COMMODITIES

Dr. R. F. Walker, ARRADCOM

This group was concerned with the question of standardization and methodology and, to make it clear, by methodology we do not mean tests; we mean procedures, or the principles by which we go about arriving at the qualification or certification of materials for military use. We addressed three basic questions and these will be stated first and then the response will be presented.

The first question was "Do we recommend the establishment of an international/interservice methodology for the qualification of energetic materials for military use?" Second question was "What should be the basis of any agreement?" And the third question was "What is the institutional mechanism to achieve and to sustain the agreement?"

The short answer to the first question was, and I forget who expressed it: "Yes, we do recommend the establishment of an international methodology because we are in trouble if we don't."

With respect to the second question -- what should be the basis of any agreement? -- Ten points were put forward for discussion on this subject. I'll take most of the time going over what those ten points were.

First -- We thought it would be possible for us to arrive at an international agreement on the basic steps to be used in qualification and that these could be defined by a manual.

Second -- We thought that basic agreement could be achieved with respect to the kinds of tests that we should be undertaking -- that is, with respect to the questions which we are seeking to answer during qualification.

Third -- We felt the necessity for continuing judgements by committees of experts as to the meanings of those tests. Nobody wanted to confine us to tests alone. Judgement based on history and experience must also be brought to bear on the acceptability of new materials for service.

Fourth -- It was agreed that in conducting the methodology it is necessary to specify the application, at least the type of application in mind, before one could consider a material qualified for use. By type of application I mean we don't have to consider whether it is for a specific projectile, but we should at least know whether we are talking of fill which is for a projectile, a bomb, or a shaped charge; or for a gun propellant, a small arms propellant, or an illuminant, as the case may be.

Fifth -- We thought that since there is the potential for an agreement on a sufficient number of specific tests and computational tools it would be possible for us to commence to prepare an international manual, like our Joint Services Manual, to which each of the nations would subscribe.

Sixth -- It would be possible for the nations to agree on our ability to define and specify within the manual the national and service approval authorities which would certify that each step of the qualification procedure had been achieved. We think that probably those authorities already exist within our nations and it is only necessary to identify them and put them in writing.

Seventh -- We felt that it would be possible for us to get individual nations to act as proponents for the development of selected required tests. In other words. rather than having nine nations, or as many of you as are represented here, independently developing the same test, it should be possible for us to get one nation to act as a proponent nation for the development of a test with the technical assistance and guidance from the other nations and in this way we could achieve the development of many more tests more economically than if we each went about in a haphazardly competitive way.

Eighth -- We thought it would be possible, once new tests had been developed, or even with existing tests, for nations to furnish one another with the facilities so that each could have its own comprehensive test capabilities. The point being that there are serious difficulties in being able to transport materials around the world, even within countries. And, therefore, it is desirable that there should be more than one center of competence for performing the tests. The point further being that if a nation acts as a proponent to develop a new test, then it should communicate the complete know-how with respect to that test to the other nations, and help them set up their capability to do the same test.

Ninth -- We felt that we could move purposefully to the international transferability of certification. What we are saying here is that we think that it is possible, if we make up our minds to do it, for us to qualify an explosive in one NATO country and get the other NATO countries to accept the qualification data. You can argue about it, but we think it's possible.

Tenth --- We think, and this may be one of the crucial issues upon which the success of international standardization may turn, that we can get an agreement between ourselves about the potential savings to be achieved by the introduction of the above methodology, and that we could arrive at a plan to move aggressively to meeting the objectives that are represented by those savings. In other words, we think there is a lot of wastage in the way we go about doing things now with regard to the selection and choice of energetic materials for military use, and that if we got together on this matter of trying to identify those areas, such as we did in the United States with respect to the elimination of tetryl, we could well justify the introduction of standardization on the basis of the savings.

Those are the ten points upon which we based our discussion and that should be the basis of any agreements that we enter into. The bottom line is that we can make standardization pay for itself as the cost-effective way to do our business.

The third question dealt with the institutional mechanism to achieve standardization. We considered the very large number of institutions that are now involved in this sort of activity. We listed organizations (Table 4) ranging from semi-private industrial groups to the United Nations and NATO, and to the TTCP and Data Exchange Agreements. The listing shows that there are already bilateral even quadrilateral international agreements in existence which permit the achievement of some standardization. As shown in the table, we divided the organizations into whether they were regulatory or whether they were people who did hands-on development. We concluded that the most effective way to approach standardization is through NATO and other treaty countries. This would exclude very few nations represented here. A number of the people who are members of the NATO Sub-Panel on Energetic Materials are already also associated with the OECD Group, with the JTCG's, JANNAF, and so forth, so a mechanism already exists, at least informally, whereby the military people can interface with the civilian industry.

Table 4. Organizations currently involved with energetic materials test standardization

Coordinating	Development
United Nations (UN)	Tetrapartite Technical Cooperation Program (TTCP)
North Atlantic Treaty Organization Program (NATO)	Joint Army, Navy, and Air Force Group (JANAF (US))
Tetrapartite Technical Cooperation Program (TTCP)	International Study Group for the Standardization of the Methods of Testing Explosives (EXTEST)
Joint Technical Coordinating Group (JTCG (US))	International Organization for Standardization (ISO)
Joint Army, Navy, NASA, Air Force (JANNAF (US))	Institute of Makers of Explosives (IME)
Organization for Economic Cooperative Development (OECD)	American Society for Testing Materials (ASTM)
International Organization for Standardization (ISO (EXTEST))	Bureau of Mines (BM)
American Society for Testing Materials (ASTM (US))	Organization for Economic Cooperating Development (OECD)
Department of Defense Explosives Safety Board (DDESB (US))	North Atlantic Treaty Organization (NATO)
Department of Transportation (DOT)	Bureau of Explosives (BE)
Bureau of Explosives of the American Railways (BE (US))	**Regulatory**
Institute of Makers of Explosives (IME (US))	Mining Enforcement and Safety Administration (MESA)
Bureau of Alcohol, Tobacco and Firearms, Department of the Interior (BATF (US))	Bureau of Alcohol, Tobacco and Firearms, Department of the Interior (BATF (US))
Mining Enforcement and Safety Administration (MESA (US))	Department of Transportation (DOT)
	Department of Defense Explosives Safety Board (DDESB)
	Ordnance Board (UK)
	United Nations (UN)

Followup meetings will be required to decide the approach to be used and to establish the working groups to deal with particular facets of the problem. But the first step is to get agreement for us here to proceed and I proposed to approach first at the Joint Logistics Commanders' level and get their reaction to the idea. This basically will bring together the technical communities of the US Army, Navy and Air Force on this matter. I can then raise the issue at the NATO Subpanel of experts that deals with energetic materials. If there is approval in that body, we should have received sufficient encouragement to move systematically to try to achieve the standardization goals outlined in the foregoing.

DISCUSSION

Q. (Not identified) I just wanted to say that probably the only way that standardization is going to work is by somehow getting together some valid figures on savings that would be realized, and I'm not sure how these figures would come about or where they come from. If we could somehow convince the higher-ups that this would be cost-effective then we could get funding to work on this problem, but otherwise it's not going to go anywhere. It's something that is going to have to be funded before it will get off the ground.

A. It will have to be funded. Sure, we'll all pay, but I think, as General Lewis said the other day, a lot of it is going to come from within you. A lot of it is going to depend on your belief that it's a good thing and the right thing to do. About the only other word that I would mention by way of caution is there is a danger in this which I think, is reflected by my insistence that any manual be a loose-leaf manual. We do not want to block the advancement of the technology base by placing the heavy hand of a fixed methodology and tests on our approach. We must approach standardization by, on the one hand, agreeing to agree on all of those things upon which we can agree and at the same time we must leave room for disagreements to be aired and explored and used as a basis for continued advancements. The last 20 years we have been so busy disagreeing that we have taken no time out to agree. I think there is a lot we can agree on, and if we do agree, I personally do not have any question about the economic benefits.

Q. G. Lennertz, GE: I want to say to you and to your people "Thank you very much." You treated us very well and we find all over the place open doors and open offices and I hope that we can go on this meeting and have other meetings on standardization in this sense as you wrote it down and said to us. Thank you very much.

A. R. F. Walker: Thank you very much and on behalf of all of us we have been very pleased to have you. We set out with some trepidation in organizing this meeting and wondered if we were going to have anybody come and we have been more than gratified not only by the attendance of people from overseas, but from private industries and each of the service organizations as well. We were very pleased that you could come and incidentally I would like to add one point here. We started on this business for the benefit of industry, and I don't think we want to lose sight of that. We are trying to develop something here which will enable the whole of our technological community to do a better job in serving our needs and doing it more efficiently and more effectively.

Gentlemen, thank you, and a special thanks to the authors for getting their papers completed and presented in time.

STANDARDIZATION AND METHODOLOGY

SUMMARY

1. STEPS IN PROCEDURE

   INTERIM QUALIFICATION

Screening Selection Producibility	) Only material

   FINAL QUALIFICATION

   In weapon

2. KINDS OF TESTS

Small scale Sensitivity	(Shock (Friction (Thermal (Spark (etc.

   Stability/compatibility, etc.

   Large scale Sensitivity

   Performance

   - Brisance
   - Det. vel.
   - Penetration
   - Etc.

3. JUDGEMENTS

   Service basis
   Independent of proponents
   Application

4. FINAL QUALIFICATION/ACCEPTANCE SHOULD BE BASED ON APPLICATION

   Production base

5. <u>TESTS/COMPUTATIONAL TOOLS FOR BASIC TEST MANUAL</u>

   Cite acceptable tests for given test area
   Utilize existing "Joint" tests as point of departure
   Mutually acceptable tests
   Mandatory/information tests

6. <u>DEFINE APPROVAL AUTHORITIES</u> (see table 4)

   Military
   Civilian
   Interagency
   International

7. <u>PROPONENT(S) FOR DEVELOPMENT OF NEEDED TESTS(S)</u>

   One nation (agency) agree to develop test, using ideas, etc. of all, and then all others would accept final result.

8. <u>INTERNATIONAL TRANSFERABILITY OF TESTS DEVELOPED BY PROPONENTS</u>

9. <u>INTERNATIONAL TRANSFERABILITY OF CERTIFICATION RESULTS</u>

   Promote interchangeability, interoperability and standardization

10. <u>SPECIFIC SAVINGS</u>

<u>ACTIONS TO BE TAKEN BASED ON DISCUSSION</u>

1. Minutes of meeting (overall)

2. Append notes of discussions (after comment from attendees)

3. Issue final revised minutes w/any changes needed in discussion notes

4. US: Begin action to achieve desired national/international results: (<u>R.F. Walker</u>)

<u>ALL PARTICIPANTS</u>

Use existing channels to maintain contact and work toward goal.

Use development of "international" qualification manual as first objective of this group.

Define potential savings and payoffs.

Followup meeting to decide approach and establish working groups.

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