(4)

ARMED SERVICES EXPLOSIVES SAFETY BOARD
Washington

In reply refer to
ASESB-59-59/1

26 January 1959

MEMORANDUM FOR THE BOARD

SUBJECT: Resume' of the 188th Meeting of the ASESB, 19 January 1959

Present: Capt. W. T. Jenkins, USN, Chairman
Col. R. C. Constabile, USA, Member
Mr. F. M. Bishoff, Alt. Army Member
Capt. C. McKellar, USN, Member
Mr. H. M. Roylance, Alt. Navy Member
Mr. F. Z. Hough, BuOrd, D/N
Col. R. T. Fincke, USAF, Member
Mr. D. E. Endsley, AFSESB-EA
Lt. Col. P. S. Brengle, USAF, AFSWP Consultant
Lt. Col. O. M. Lamb, USA, AFSWP
Mr. G. F. Wigger, OCE
Col. A. W. Hamilton, USA, ASESB
Lt. Col. G. Couch, USAF, "
Mr. W. M. Wiesenberg, "
Dr. Ralph Ilsley, "
Mr. R. G. Perkins, "
Mr. F. N. McNamara, "
Mr. C. A. Breeding, "

1. Capt. Jenkins explained Mr. Marsh's absence, due to other important commitments; also, that Mr. Marsh retired from Hercules Powder Co. as of 31 December 1958, but will still work with the Board.

2. Dr. Ilsley made a presentation to the Board on "Effectiveness of Reinforced Concrete Dividing Walls for Protection Against Simultaneous Detonation and Explosion Communications." The need for recognition of hazards in light of present-day conditions was stressed, as well as the possible need for tests. A paper on this "Presentation" will be prepared for distribution to the Services for further study and review.

3. The Chairman briefed Board Members on recent conferences, which he attended as Board representative, pertaining to actions on rail facilities at the Holston Ordnance Works. The Army Secretary's final action letter was made available to Board Members for their information.

4. In accordance with the request in letter of transmittal, the Naval Medical Field Research Laboratory report on Military Helmet Design was brought to the attention of Board Members.

5. Lt. Col. Couch, USAF, briefed the Board Members on Mr. Herman's participation in the 1 - 5 December NATO conference on Explosives Safety. It appears that the standards being prepared by the conference, for NATO use will agree very much with U. S. standards except for possibly the following three points:

5837

a. Distances for fixed ammunition to be based on known missile density and therefore will vary with quantity.

b. Credit for barricades will be given to inhabited building distances only for quantities of explosives of not over 15,000 lbs.

c. Explosives are to be grouped in seven classes instead of twelve. U. S. Classes 7, 8 and 10 are to be grouped by NATO as one class. U. S. Class 5 is being placed in Class 4 and U. S. Class 12 is being placed in Class 2.

6. The Chairman informed the Members that the proposed Quantity-Distance Standards for Piers & Wharves are ready to be sent to the Service Secretaries, requesting concurrence, prior to submitting them to DOD for promulgating as a directive. The proposed standards are essentially the contents of Chapter IV of the Piers & Wharves Manual.

7. The Research Team on Underground Storage has completed its report. The work group will review the report of the Research Team at a meeting to be held on January 26th.

8. The Air Force, in reviewing the proposed procedure for hazard classification, has questioned the need for full scale tests of items such as IRBM and ICBM. The Air Force comments are being transmitted to the Army and Navy Members for study and comments.

9. Need for exchange of information on explosives incidents, between the Services, was discussed. A recent incident at the Naval Propellant Plant was discussed. A conference of safety engineers of explosives plants handling the same materials as the Naval Propellant Plant has been proposed, with that Plant acting as host. Action and implementation of these related subjects will continue.

10. The Army Member informed the Board Members of the scheduled dates of Nike Hercules safety tests and stated that a formal invitation will be sent to the ASESB by the Ordnance Corps, inviting observers to the tests.

W. T. Jenkins

W. T. JENKINS
Captain, USN
Chairman

3898

~~Secret~~ FRD

VERBATIM TRANSCRIPT, BOARD MEETING #188, 19 JANUARY 1959

Present: Capt. W. T. Jenkins, USN, Chairman
Col. R. C. Costabile, USA, Member
Mr. F. M. Bishoff, Alt. Army Member
Capt. C. McKellar, USN, Member
Mr. H. M. Roylance, Alt. Navy Member
Mr. F. Z. Hough, BuOrd, D/N
Col. R. T. Fincke, USAF, Member
Mr. D. E. Endsley, AFMSS-EA
Lt. Col. P. S. Brengle, USAF, AFSWP Consultant
Lt. Col. O. M. Lamb, USA, AFSWP
Mr. G. F. Wigger, OCE
Col. A. W. Hamilton, USA, ASESB
Lt. Col. G. Couch, USAF, "
Mr. W. M. Wiesenberg, "
Dr. Ralph Ilsley, "
Mr. R. G. Perkins, "
Mr. F. N. McNamara, "
Mr. C. A. Breeding, "

1. First item on the agenda "Presentation by Dr. Ilsley on Effectiveness of Reinforced Concrete Dividing Walls for Protection Against Simultaneous Detonation and Explosion Communication" written up separately. (See page 18 on 3916)

2. Capt. Jenkins explained Mr. Marsh's absence was due to prior commitments and that he retired from Hercules Powder Co. as of 31 December 1958, but will still work with the Board.

3. The Chairman briefed Board Members on recent conferences which he attended as Board representative pertaining to actions on rail facilities at the Holston Ordnance Works. The Army Secretary's final action letter was made available to Board Members for their information.

4. In accordance with the request in letter of transmittal, the Naval Medical Field Research Laboratory report on Military Helmet Design was brought to the attention of Board Members.

5. Briefing by LtCol Couch on Mr. Herman's participation in 1 - 5 December NATO conference on Explosives Safety:

Col. Couch: As you recall, Mr. Herman was to go the first part of December as a member of a group of experts to review a paper proposed by SHAPE. This group of experts consisted of representatives from the U. S., The Netherlands, United Kingdom, France, Germany and personnel from SHAPE itself. Due to the numerous changes that had to be made in this SHAPE document, another meeting was called and is in progress beginning this morning. In reviewing the SHAPE document, each phase was reviewed by the group of experts, that is hazard classification, compatibility groups, quantity-distance relationships, etc. In most areas, the group agreed, however, there were some points of disagreement. These were resolved by majority vote. No attempt was made to prepare a minority position. The proposed standards as they were concluded at the time of the last meeting, unless they should have some changes in this meeting, agree very much with U. S. standards except for three points. One is that the distances for fixed ammunition are to be based on the known missile density and therefore it will vary with quantity. As you know the U. S. is a flat 1200 ft. inhab. bldg. distance. Credit for barricades will be given inhabited building distance only for quantities up to 15,000 lbs., above 15,000 lbs. only unbarricaded distance is used. The classes of explosives are reduced from 12 to 7, classes 7, 8 and 10 are grouped as one class, items in class 5 were placed in class 4, items in 12 are placed in 2. These are the only major changes from the U. S. standards. SHAPE has been asked by the group to furnish them at this current meeting with some instructions as to what they propose the standards to be used for. In other words, under what circumstances they would be used. This may vary the findings of the group. As I stated before, they should complete their work at this meeting and be ready for the presentation which is to be given to the parent sub-group in February.

Mr. Bishoff: Where is the parent sub-group?

Col. Couch: The parent sub-group consists of three people from the United States, as far as U. S. representatives are concerned, they are Mr. Brzezinski of the Navy, Lt. Col. Lappin, Air Force and Mr. McInerny, Army.

Mr. Bishoff: Are we going to get a chance to review it before it's given to NATO?

Col. Couch: I think so, I can't give a positive statement.

Mr. Bishoff: I'd like to recommend that we do.

Col. Couch: I'm almost certain it will, but I can't say that it will because that isn't up to the group or isn't up to us to prepare a final paper and present it to the sub-group. This would be done by the people in NATO.

Mr. Bishoff: I'm a little confused on whose thinking the committee represents in its thinking and secondly, what effect it will have on American standards.

Col. Couch: As I say this is a group of experts, it won't effect the American standards in the U.S., certainly not. What effect it would have on U.S. operations in ~~the~~ Continental Europe, we might say is unknown. This is what the group asked SHAPE to provide them with at the beginning of the meeting, and is expected to be provided at this meeting. Most people that I talked with from U.S. seemed to think that it will have very little effect upon U.S. operations in Europe.

Capt. Jenkins: Mr. Bishoff, before you came to the Board, when the Staff found itself in this, I wanted to make sure there was absolutely no indication that we were in effect sticking our noses in somewhere where we were not wanted. We only came in at the express request of this sub-group, because they wanted technical assistance and help. I brought it up at previous Board meetings to indicate that we were only coming into it because we were requested and we were not getting into it for personal desires or anything like that. We had a formal invitation that a certain man's services were desired and it was approved by members of the Board

and also, we are bending over backwards, that there is no intent to change the U. S. standards, that if anything like that comes up, we have to get the services view on it, the same way with respect to other nations. This is to try and get something which will be uniform for the NATO powers. I think it's a very desirable objective, but whether anything will come out of it, I don't know. We'll find out more from Mr. Herman when he comes back this time.

Col. Fincke: As I understand it, Herman is over there right now at the pleasure of the three services, he's the U. S. representative and was asked for by the Army who chairs the U. S. Delegation.

Capt. Jenkins: DCS/Log is primarily handling it Mr. Bishoff.

Mr. Bishoff: The point I don't understand Capt. Jenkins, if the Board advises this group on explosives safety standards, how can they be different from safety standards as proposed by the Board or the U. S.

Capt. Jenkins: In anything that comes up, Mr. Herman says our standards are thus and such, he is attempting to work out something not with the agreement of the U. S., with the full realization that anything that does come up would have to be approved by the U. S. and the three services.

Col. Couch: Mr. Herman's position in going over was the U.S. position and as I said, where there were points of disagreement, they voted and the majority vote went into the paper, that was the position which goes into their paper which is only a presentation to the sub-group and the sub-group is the one that makes the final decisions as to whether this is an acceptable paper or not and they don't make any decision, Mr. Bishoff, without first coming back to the States and getting a tri-service position on their paper. This is a long drawn-out process but you get several opportunities to comment on this before a final decision is reached.

Mr. Roylance: To answer your question of how can it be anything other than the U. S. standards, these NATO meetings are just one great big compromise after the other and it's the only way they ever get anything done. What Mr. Herman is there for is to get the best compromise he can I think. This is strictly for application to NATO storage, it has nothing to do with what we do over here. If the other NATO countries want to accept it as their own standards, they're perfectly at liberty to do so. I think we're probably going to get something better out of this than we have in some other countries at the present time, that we're living with without saying anything about it really.

Col. Couch: These points that change from ours are really minor points. Mr. Herman reports that the group fell almost in line with going right down the road on U.S. standards, the only points that differ now are apparently those three points which I gave you.

Col. Fincke: Did they change the NATO paper very much?

Col. Couch: It changed considerably yes and most every change was in line with our standards.

Mr. Bishoff: If they fall in line with American standards they're not going to be acceptable to any country over there.

Mr. Roylance: This is what surprised them at the meeting, so many of them asked for increased distances over what was originally proposed and this was quite a shock to some people because they expected them to go the other way, to ask for less. How they're going to apply them nobody knows.

Capt. Jenkins: The last item on the agenda 'Status reports on current projects.' We have a memorandum prepared in the rough soon to go out for the Asst. Secretaries proposing the q-d standards for pier and wharf facilities be promulgated as a DOD directive. We're asking for concurrence of the Army, Navy and Air Force represen-

tatives, Chapter IV, with certain minor modifications in order to make Chapter IV stand on its own two feet as we discussed at the last meeting. When this goes to the various Secretaries, I assume that the first people it will come to will be Board Members.

Mr. Bishoff: This application material, will the Board get a look at that before the letter goes to the three Secretaries?

Col. Couch: This material consists only of definitions that were removed from Chapter II that are applicable to what's contained in Chapter IX. There is no text material changed at all. It's just rearranged.

Capt. Jenkins: Tables 4 and 5, an addition to the notes has been made giving examples for clarification of these tables. Is it not in order, Mr. Breeding, for the Board Members to see this letter to their Secretaries before we send it to them?

Mr. Breeding: If they'd like. As far as the text material is concerned, there have been no changes in the text material. Only those pertinent definitions have been incorporated into the proposed directive in order to make it stand on its own and the examples have been put in there because the questions have been raised by people in the field as to how to apply certain of those tables which were in Chapter IV. Those examples have been put in to clarify the application only.

Capt. Jenkins: Would you like to read it (the letter) during the meeting and if there are any questions about it after the meeting, then we'll send it to you for a closer look.

(Chairman's Note:- Copies of the memoranda were reviewed and initialed for concurrence by Capt. Jenkins.)

'Standards for Underground Storage' - the research team has completed its long effort on that and has approved the report. We have called a meeting for 0900 on Monday the 26th, a meeting of the work group to go over the research team report on underground storage. 'Revision of the Board Charter' - we recently received the Navy reply to Mr. Higgins' proposed letter to the Asst Secretary of Defense.

We have that pretty well lined up. The Air Force and Army concurred in the memorandum. The Navy concurred subject to a couple of extra comments which I think we can work in very easily. The next step won't need any Service coordination and we'll have that memo over to the Secretary very shortly. Col. Hamilton has something new on 'Procedure for Hazard Classification.'

Col. Hamilton: We have heard from all three services and the three services are in agreement with the procedure that has been written up including all the technical details except for one important point which has been raised by the Air Force. I believe it is one that all the rest of you will want to look at. It has to do with the testing of the ICBM and IRBM missile propellants specifically as to whether or not full scale shots are necessary. I'll send a copy of the paper that was transmitted to us from the Air Force, to the Army and Navy members so that they can have their own specialists look at it. I believe one of the principle objecters to the use of scale tests before was the Doctor that you had down from the Naval Research Lab and I hear informally that there has been some development that he feels that there may be a way of getting true results, in other words, results of what would happen to the propellant of the whole missile by a new type of scale test. That is something for the technicians to go into.

Capt. Jenkins: 'Liquid Propellant Criteria' - nothing on that. Capt. Atkins called on the phone just before this meeting commenced on something that has a specific bearing on the Indian Head incident recently but is applicable to and of interest to all of the services. Capt. Atkins has been going into this thing very thoroughly and he feels that possibly some trouble may be caused by supervision; that although we talk a lot about safety regulations, the safety regulations are not getting down to the little man at the end of the line, and he brought up

the advisability of having a conference both with civilian industry and the three services who are responsible people in the field of solid propellants with Indian Head possibly as the host and talk over ideas with a view to cutting down the relative frequency of these solid propellant incidents. After discussion with Capt. McKellar and Mr. Roylance, it seems to be a good idea. Mr. Roylance mentioned that the Solid Propellant Information Agency should be brought into this. Do you think it would be advisable for the staff to contact this agency, to contact you people further with a view toward setting up this get-together.

Mr. Breeding: Army used to have a committee on different types of items, one was on propellants but I think it has since died.

Col. Costabile: That was with Ordnance and some of the outside manufacturers.

Col. Hamilton: Of course there are training programs that can be used.

Capt. Jenkins: My immediate reaction is there would be considerable value in these people from various civilian organizations and the services to get together and trade ideas. Of course Capt. Atkins is extremely familiar with the Board's operations and that's why he called. We'll think a little more about it and get in touch with you. In that connection, Mr. Bishoff, we had conversations with you on the Indian Head incident. Mr. Perkins, while I was away, wrote up what appears to be a complete treatment of the case and I think this will give answer for you some of the questions you may have had. (Mr. Bishoff shown Report).

Mr. Bishoff: Will you get the Board report from Indian Head?

Capt. Jenkins: We will later.

Mr. Hough: I have a summary here you may have.

Capt. McKellar: We have been kicking around the idea of promulgating the results of these accidents as the Army has done, abstracts of them. Do you feel its worthwhile?

3947

Col. Costabile: It has proven worthwhile in our installations.

Mr. McNamara: I think it is Captain, because when we go out in the field they definitely like to receive the Army abstracts and I know if they wanted to receive the Army abstracts they certainly would like to receive the Navy ones too.

Mr. Roylance: The IG now promulgates them, what the distribution on the monthly letter is I don't know, whether the Army gets them, I don't know. I thought a year ago of doing something like this and I thought it would be a duplication of what they're doing.

Col. Hamilton: We don't get it over here.

Capt. McKellar: I think we should look into it and give it wider dissemination.

Capt. Jenkins: There are two very important things which have a bearing on these two items, Capt. Atkins conversation and Dr. Ilsley mentioned we make sure we get any reports of incidents that you might have where dividing walls come into the picture. When I was on the recent inspection trip, at Cape Canaveral especially, there was a Dr. K , an Air Force medical colonel, he'd heard about the Indian Head incident, I described to him what I saw, I didn't make any recommendations or express any theories, but it came up from him and one other person, the Ground Safety Engineer, the need for getting rapid information to the other services in the event of an incident. They would like to know what happened at Indian Head because of this solid propellant business. I think we're getting them all from the Army, I hope we're getting them from the Navy.

Capt. McKellar: I'd like to have a routine method of getting them to you.

Capt. Jenkins: It came to my mind, should we take it upon ourselves to see that every other activity in other services get it or is there some other organization on whose toes we don't want to step that does that?

Col. Fincke: I thought they were circulated among the services.

Capt. Jenkins: We'll explore this and talk with you more on it. Mr. Hough, would Cape Canaveral get that accident report?

Mr. Hough: Not in the usual course of events now.

Col. Fincke: It's up to the service to make distribution.

Capt. Jenkins: I think we get as many of them as possible, maybe its up to us to have an informal SOP, we see one and then call back the service and tell them to see that the AF, etc. gets distribution on it.

Col. Fincke: We have offices of explosives safety and this is where it ought to come from.

Dr. Ilsley: This problem came up some years ago and the Navy realized that they were not getting the information to their outfits on explosions the same way that the Army was. At that time the Board was investigating and studying all explosions from the JAG and the Board agreed to it that we would continue to make those analysis and we would put out abstracts of the explosions and distribute those. That continued on for a while and that was dropped, then the Board realized that the services didn't know about incidents the other services had. For sometime we brought before the Board a summary of all the incidents and gave it to the Board Members so that they would at least know what the explosions were so they could get to the services. That folded up. To my mind the only way it can be done is by the services themselves and the Board cooperating to get people who are interested put on the distribution list of the services.

Capt. McKellar: You have commercial contractors in this field that are interested too, we may have an explosion of interest to Thiokol, an Air Force contractor, not Navy at all.

Mr. Bishoff: I think you're quite right, I don't know what use Cape Canaveral is going to make of this report, as far as I know they don't handle casting powder, it's only they're very curious. This report is of interest to Government plants which manufacture propellants and to private plants that manufacture propellants.

Capt. Jenkins: Col. interest in it was how these men were killed and injured and was very interested in the fact there was no apparent high order detonation.

Mr. Bishoff: He'd get the wrong impression because it's roughly only 5% nitroglycerin in the casting powder but when it's joined with the solvent there is quite a bit more.

Capt. Jenkins: He knew about that. We discussed it.

Capt. McKellar: I feel we should learn something from the other man's mistakes.

Capt. Jenkins: We'll try to streamline some of it.

Capt. McKellar: Does this Board promulgate any safety criteria which is peculiar to solid propellants? Or do you think there is any need for special criteria?

Capt. Jenkins: We haven't.

Capt. McKellar: Is there any data from other explosives, they don't like to call them explosives out at Aerojet.

Mr. Roylance: Some of them are different and some of them are not, it all depends on what you're talking about.

Capt. Jenkins: We have a liquid propellant criteria project which is the primary Air Force ~~Navy~~ interest.

Capt. McKellar: I'm talking about solid propellants.

Mr. Roylance: All I know is that NOL was conducting a series of tests to determine whether you can on a small scale assess a hazard classification to the propellant itself. This so-called card gap test tells you one thing but it doesn't tell you

a lot of other things which might be of interest. The whole thing needs a real good going over I think.

Capt. McKellar: I'd suggest something like the liquid for solid.

Dr. Ilsley: The liquid propellant criteria was submitted to the Board to work out. The Board sent it out with specialists, in the meantime the Navy became very much interested in it and came out with their liquid propellant manual group. That was utilized by the services for a long time for advice. Then they realized the liquid propellants should be revised. It finally wound up that the liquid propellant group is a group with the Fuels and Lubricants Group of OSD and they have come out with a manual on liquid propellants. The main reason why that was decided to go up to OSD was because usually the Board has not been concerned with R&D until it becomes standardized as an item of use. Whereas this group is interested both in the standardized item and the development of it. The logical place for such a solid propellant group would be a group similar to the liquid propellant which is represented by specialists from all of the R&D people, etc. and they have not tackled that job as yet.

Capt. McKellar: How could we get it started?

Capt. Jenkins: Do you think it might be pertinent to bring this objective up to the man who headed the liquid propellant group in OSD?

Mr. Roylance: I don't think so because that was the Fuels & Lubricants Group.

Dr. Ilsley: It was put in that group only as a means of getting the job done.

Mr. Breeding: Actually I don't think that would accomplish what the Captain is talking about because all they did was take the individual compounds and elements and give the physical and chemical characteristics and the associated hazards with it. As far as any q-d, that's not even covered.

Capt. McKellar: We're starting to haul big grains around the country and store them everywhere and make them by big companies that have never made them before and I think we're going to have a lot of trouble.

Col. Hamilton: Anything the Board puts out has to be general in nature, in addition to that you're going to have to have specifics for each plant, in fact for each operation, actual job analysis.

Capt. McKellar: Do you class these as a fire hazard now?

Col. Hamilton: It depends on which propellant it is.

Col. Couch: That is really the main problem, to determine what are the characteristics of the propellant. Once you determine this most of your other problems are solved.

Mr. Roylance: The biggest amount of trouble is in the manufacturing. Once we get a finished product and know what the classification is, then we can follow the proper safety precautions.

Col. Hamilton: Separation or q-d never prevented an original blast yet. What we're trying to do here is prevent that original blast. So that gets down into actual operation analysis, your safety features on each machine, your static grounding, etc. And then the training of each man in safety features of each specific operation.

Mr. Breeding: In other words, what Col. Couch is talking about, at the present time you can already determine what the inherent hazard on your chemical material that goes into the make-up of a particular propellant. That is not difficult to determine even now. In order to determine the particular hazard and a particular step within the manufacture it is going to be quite difficult and you're going to have to define certain parameters in hazards because with each chemical reaction you're going to have a different hazard and different step within the operation

3011

so that by the time you take your individual item that goes into the completed end item, all the intermediate steps of manufacture are going to vary depending upon the type of operation and method of manufacture. That would be a lulu unless you more or less categorize and lump together your different manufacturing steps and that comes under Col. Hamilton's operational analysis again.

Col. Hamilton: We used to conduct some training programs out of ORDSO on methods of doing that. The actual method is going to vary with every plant because of very different operations in every plant. You'd have similarity between propellant plants. You have to get very specific with them.

....

Col. Costabile: This area of solid propellants has so many different types of that go into it that it's pretty hard to say that anyone step in the process what precautions to take unless you are familiar with the manufacturing process. Each one of the chemicals has different hazards inherent to it in its mixing or blending or whatever you do. I think this committee that deals with propellant R&D projects would not necessarily be interested in the safety aspects of it.

Col. Hamilton: One of the best ways of cross pollination of ideas on safety of individual processes is to actually get supervisors to visit other plants where there are related type operations going on to see just what safety features they're using. A lot of these ideas are thought up in individual plants and never they get outside the plants.

Capt. Jenkins: All of this conversation points up a need for a get-together down there at Indian Head.

Dr. Ilsley: R&D is mainly interested in development of the item they want to develop and not so much on safety. That is true in the liquid propellant group because they are the operators and their idea of the hazard is under the conditions which they believe that they can control and that is where your safety people

not only in R&D in coordinating with them but you need safety people in such a group as this to point out "what about the condition if you can't control it."

Capt. Jenkins: As you know we tried to develop an across-the-board criteria for liquid propellants and found out that after we had sent out this memorandum with this view in mind that each operation is pretty much on its own.

Col. Hamilton: One of the benefits that we get from our Survey Division surveys is that our engineers do impart to people in specific operations good ideas that they have seen elsewhere around the country.

Dr. Ilsley: The only place that you won't have any difficulty is as far as q-d is concerned and in the liquid propellant group, if it is mass detonating, they will not touch it because they know that the responsibility for q-d is in the Board. As far as those other than mass detonating, fire hazard, etc., they still consider it as the Board's responsibility although actually the best method of doing that is, since they are running tests all the time and they have to determine what the fire prevention methods and also fighting fires they have all the information, they should be the ones to furnish the information if the Board is going to do it, to work up the standards for fire hazard distances, etc., or should work it up themselves.

Capt. Jenkins: Does anyone have anything else to bring up before we adjourn?

Mr. Bishoff: Regarding the Nike-Hercules box tests. The purpose and the results of the tests are classified SECRET. As of the moment, tentative schedule for the tests at White Sands Missile Range is as follows: 1st live shot, Monday, 23 March, 2nd live shot, Monday, 20 April, 3rd and last live shot, 25 May. Just for the record, I'd like to let all of you know that I'm leaving with the Chairman a set of plans that will show how the boxes are constructed, where they are and another

which shows the instrumentation that we will have for the three tests. We hope about the third week of February to firm up these dates and at that time the Ordnance Corps will send a letter to the Board inviting observers to the tests. People who want to go will have to clear through the Safety Branch, OCO and thence to White Sands Missile Range. I think you should also know this, you will have to get there on Sunday in order to see the test set-up. Everything will be in on Sunday except the igniters and boosters and the initiation system for detonating the warhead so we feel that on Sunday it will be safe for you to look at the set-up. You should also realize that if for some reason we cannot run the test on Monday, there will be a full weeks delay, the tests will have to be postponed until the following Monday. The reason is we're using all of the cameras at White Sands, 15 to be exact. On the Monday of each test the whole Missile Range has to shut down because of lack of cameras so if we can't run it on Monday we can't get the cameras on Tuesday, not until the following Monday. There is also a slight possibility that you may not be able to see the results of the tests until late on Monday perhaps even on Tuesday, we're going to be very careful that the area is safe for you to enter. There will be ample instrumentation taken of all tests and lots of pictures and I think we will get a lot of sufficient information out of these tests.

Capt. Jenkins: I'd like to add that it's not to continue an argument, but to get some good information. I hope indications are not that the Board is [redacted] the one that demanded or required these tests.

Mr. Bishoff: All we know in the Army Ordnance Corps is that the Secretary of the Army, perhaps it was even one of the Assistant Secretaries of Defense, has directed us to run the tests and we're running them.

Dr. Ilsley: It might be well to think that since the Board was involved in this problem very strongly that a Board Member other than the Army should attend as well as someone from the Technical Division of the Board Staff.

Mr. Bishoff: As far as I know, there will be no limits on the number of observers.

Meeting adjourned at 1315.

[redacted] For Bd Minutes

Presentation On

THE EFFECTIVENESS OF REINFORCED CONCRETE DIVIDING WALLS FOR PROTECTION AGAINST SIMULTANEOUS DETONATION, EXPLOSION, AND COMMUNICATION

By

Dr. Ralph Ilsley

At

ASESB Meeting No. 188, Held on 19 January 1959

1. Why should we reconsider the standard or principle for the reinforced concrete dividing wall? We should reconsider the standard, or for that matter, we should reconsider periodically, many of the safety standards or principles because:

a. The conditions for which the standards or principles were originally recommended may have changed remarkably.

b. The standard or principle may have been a compromise resulting from deliberations during which the major influences were what was necessary from an operational standpoint, and the probability of an incident happening, not so much what should be done for relative safety.

c. What was considered reasonable at one time, based on available data and knowledge, might not be considered reasonable when more facts are known. Additional experience is always gained from accidental explosions and from tests which, although not necessarily performed for this particular problem, are nevertheless valuable for the information obtained on explosion effects.

d. As time goes on, the fundamental basis of the original principle may be "lost" or may be superseded by new applications and variations for which the original principle was neither contemplated nor planned.

2. For the past 18 years, there has been no doubt as to what the safety people wanted the standard 12-inch reinforced concrete wall to accomplish; namely, if a mass detonation occurred on one side of the wall, the explosives on the other side of the wall would be prevented from simultaneously (or sympathetically) detonating. If this were accomplished, for quantity-distance purposes the quantity could be considered as only the quantity in a single bay rather than the quantity in both bays. Although the purpose was clearly stated in the principle, and the results to be accomplished were considered necessary, such a standard, to be complete, requires a determination of the bases of advices to be included with the principle so that if an incident occurs, the desired results would predict, reasonably, the actual results.

[redacted] UNCLASSIFIED

3912

[redacted]

3. Let us explore the comparison between "desired results" and "actual results" from a historical standpoint, based on:

a. Actual standards in use during the past 18 years.

b. Tests and accidental explosions which either were used or could have been used in developing data for prediction of results.

c. Correlation analysis for determining parameters for such data or advices, and exhibits which may furnish a good basis for recommendations.

I believe it is important, at this point, to give you my definition of "correlation analysis" from the standpoint of development of safety standards or principles. It is as follows:

> "The analysis of all known pertinent data, its correlation to determine probable relationships, and its display in a suitable exhibit so that, with the background data and method of correlation known, all may have the opportunity to evaluate any principle or standard to express the hazard or protection before the occurrence in relation to what may be expected, actually, to result from the occurrence."

4. First, let us consider item 3a, "actual standards in use during the past 18 years."

The dividing wall standard for prevention of simultaneous detonation has been consistent over the years, especially in the following particulars:

a. A uniform thickness of 12 inches for the wall.

b. A definite percentage by volume, and the placing of reinforcing rods, especially staggered.

c. The separation distance of the explosives from the wall, namely, 3 feet.

d. Tying in the wall with the floor.

The dividing wall standard for prevention of simultaneous detonation has not been consistent in the maximum amount of explosives which could be on either side of the wall, and, as will be indicated later, the basis for determining the maximums could not have been based, essentially, on reliable factual data from tests or by correlation research. The variation in maximums is shown by the following:

a. In the December 1941 Ordnance Safety Manual, a starting point for possible maximums was given by an example involving 3000 and 1000 pounds of explosives, with 3000 pounds in one bay and 1000 pounds in the other bay. The 3000 pounds was recommended as the quantity to be used for quantity-distance application. Since no actual maximum was stated, it could have been up to 250,000 pounds provided you could get that quantity in between the dividing walls.

[redacted]

UNCLASSIFIED

[redacted]

b. In the June and October 1942 Supplements of the Ordnance Safety Manual, maximums between dividing walls were stated as 20,000 pounds. In June 1945, the maximum was stated as 15,000 pounds.

c. In June 1944, correspondence between various groups of the Safety and Security Division, Office Chief of Ordnance, stated the following:

> "There is one problem which arises with embarrassing frequency however, for which we have literally no data whatsoever and which we have solved up to the present time entirely by guesswork; namely, that of interior substantial dividing walls."

Furthermore, in advices during World War II from the Field Director of Ammunition Plants, it was stated that a maximum of 65,000 pounds was permissible; and from responsible Safety and Security personnel, "the result from such a mass detonation on one side of the wall would probably be only low order detonation on the other side of the wall."

d. Six years after the excellent Arco Dividing Wall Tests, the ASESB (Board Minutes, page 2653) recommended "no more than 5000 pounds" to prevent simultaneous detonation. The Board standard was as follows:

> "As a result of the Army Ordnance Safety and Security Test on the 50-foot long and 12-inch thick dividing wall, the Board advises that 12-inch thick reinforced concrete walls should not be considered effective for preventing a simultaneous detonation of the total quantity of HE located in an approximate 30-foot bay on both sides of the dividing wall if more than 5000 pounds of HE are in the 30-foot bay. If more than 5000 pounds of HE are in the bay, the amount of explosives for application of quantity-distance tables of 1 April 1950 should be the total in all bays."

Note that no mention is made of a requirement for a specified distance from the wall.

5. Next, item 3b, let us consider the review from the standpoint of tests.

The major sources of data of value in the problem were the tests performed for military application such as contact charges on reinforced concrete walls used as sea walls, pill boxes, gun emplacements, and road blocks. These tests were accomplished during the period 1941 - 1943 by the Anti-Tank Concrete Committee of the British, and later in 1944, tests were performed by the Army Corps of Engineers with contact charges on concrete. In addition, the British were interested in determining the effect of the explosion of enemy bombs against British type of construction, and they also performed other tests to see what the effect would be in varying the distance of the explosives from the wall. The most important of all were the extensive Dividing Wall Tests at Arco, Idaho, in 1944 and 1945, performed by the Department of the Army. All of the above-noted tests, with the exception of the Arco Dividing Wall Tests, were for the purpose of determining the relative damage to the wall, and were not directly associated with the problem of explosion communication.

[redacted]

6. Now, for item 3c, let us consider the correlation analysis of data and theory of damage to walls.

a. In 1941, the British published a paper giving tables and end results, but did not give the basis of the tests.

b. In 1945, the National Defense Research Council (NDRC), as a result of Freeman's work, published an outstanding exhibit indicating the relative damage to reinforced concrete walls by blast.

c. In 1949, several volumes titled "Bomb Damage Analysis", were published by LeHigh University under a contract from the Army Ordnance Department. Each report is a review of all sources of published information, with an analysis of same. Professor Shock, in one of the papers, evaluates the work of Freeman.

d. In 1955, another Army Ordnance contract resulted in two volumes published by the Armour Research Foundation. Here again was an analysis of the work of Freeman, and in addition they also presented their own determination of how to design a wall for a specific type of damage.

e. For the past 10 years, as one of several continuing projects, the Explosives Branch of the AEWES has evaluated and utilized Freeman's work, analyzed and correlated the extensive Arco tests, the earlier British tests, and all available accidental explosions, so that much of this work could be presented in a suitable exhibit to evaluate the possibility of simultaneous detonation and explosion communication. In the meantime, the basic work has been utilized for advices on current construction projects.

7. Since Freeman's work is to be the basis of reference for the Explosives Branch correlation with tests and accidental explosions involving dividing walls, we should have a general understanding of how the curves were derived, and their evaluation as determined by people other than the Board staff.

a. Freeman's work was entitled: "Damage to Reinforced Concrete Wall Panels by Detonation of Contact and Remote Charges", and was published as an NDRC paper. This paper gives the basis of how it was derived, and the sources of accidental explosions utilized in his paper. In conclusion, Freeman says:

> "The phenomenon of wall panel damage by contact and non-contact explosions appear to find a semi-quantitative explanation on the basis of impulse communicated to the wall by the detonation and the subsequent dissipation of the corresponding energy by work done against the resistance of the wall materials. Because of the large number of variables which may be involved, and our lack of quantitative knowledge of certain fundamental processes such as impulse delivered to the wall by contact and close-up shots, the computations should not be regarded as a definitive theory of these effects; nevertheless, the general trend and order of magnitude of the numerical results turn out to be correct when compared with experimental data."

[redacted]

UNCLASSIFIED

3919

[redacted]

Freeman's chart was published as Chart 6A6 in the NDRC report, and includes the formulas for each set of damage curves. Freeman utilized the 1941 and 1943 tests of the British, the 1944 tests of the Corps of Engineers on contact charges, and the British tests of varying the distance from the wall. The walls tested by the British were, in all cases, rectangular panels with face dimensions between 3 to 25 times the thickness. They were supported, for the most part, along all four edges. Charge weights in these experiments ranged from 2 ounces to approximately 1700 pounds. Concrete compressive strength varied from 2200 to 4000 pounds per square inch (psi). I believe the Army standard is 2500 psi.

b. In the Lehigh University report, C. A. Shook, as a result of scientific evaluation of Freeman's paper, says:

> "Although the author's assumptions may be questionable, the important point to consider is that he has arrived at a result which is in good accord with known incidents, and has exhibited these results in a form which can be used for predictive purposes."

Freeman's chart was utilized by the Office Chief of Engineers, Department of the Army, in a publication titled: "Fundamentals of Protective Design." Freeman's chart has also been utilized and quoted frequently, by various authors, in published reports and charts. Armour Research Foundation, as a result of their analysis of Freeman's work, found that his work was in good agreement with their own independent analysis.

8. Freeman's work is summarized in Weapons Data Chart 6A6 in the form of curves on coordinate paper, and with empirical formulas to determine the points for the different types of damage. These formulas were utilized to calculate points so that the curves could be extended beyond the ranges given, and especially so that they could be plotted on double-log paper. Although other charts have been prepared to show the empirical curves when various units were kept constant, the form of the charting, namely, by the parameters $t/W^{1/3}$ (t = thickness of reinforced concrete wall, W = weight of explosives in pounds) and $r/W^{1/3}$ (r = distance of explosives from wall), was derived in order to utilize more experience from tests and accidental explosions and to better illustrate the effects of these variations which may be more applicable to some of the problems of today where smaller quantities are stored within the reinforced concrete wall, as well as the problems associated with cooling bays of loading plants where larger quantities are stored. Freeman's chart and formulas were prepared and determined on the basis of ½% reinforcing steel by volume; however, he also gives a conversion factor for ¾% reinforcing steel. Since the standard 12-inch reinforced concrete dividing wall is ½% steel by volume, another curve has been added to the exhibit to represent the ½% value. This is the curve that we are more interested in, not only because it is the standard for the 12-inch reinforced concrete wall, but because all tests were on ½% reinforcing. Since the standard has been in existence for so many years, accidental explosions should be on the same basis. It should be pointed out that Freeman's chart is for: single air-backed walls, ½% reinforcing which can be modified for ¾% reinforcing, all probably on concentrated charges approaching a point source charge, on the basis of TNT explosives, damage by blast only and not by missiles.

[redacted]

UNCLASSIFIED

[redacted]

9. On the basis that Freeman's work is the best available, and probably would be applicable to explosions in between two walls if the walls are separated as in standard bays, let us consider a reasonable basis for evaluation of possible explosion communication hazard before considering the tests and accidental explosions. For the purpose of correlation of the hazards of simultaneous detonation and explosion communication, if one were to be relatively safe, one ought to consider the minimum as the "breaching curve". If a curve for "wall-destroyed" could be determined generally in relation to the "breaching curve", then the minimum should be approached as close as possible to such a "wall-destroyed" curve in order to avoid explosion communication. Whether one agrees or not with this thesis, let us consider it temporarily as the basis of correlation with tests and accidental explosions in order to determine the overall relative hazard.

10. With this general outline of the history of the standards and available tests and correlation analyses, now let us begin to consider the Board's correlation analysis, especially as to tests and accidental explosions. The subject of Exhibit No. 1 is: "The Evaluation of Damage to Reinforced Concrete Walls versus the Possibility of Simultaneous Detonation or Explosion Communication Through Such Walls." The abscissa is $r/W^{1/3}$ (r = distance in feet of explosives from the walls), and the ordinate is $t/W^{1/3}$ (t = thickness in feet of reinforced concrete wall). In both cases, W = weight of explosives in pounds. Freeman's curves are shown in the exhibit for slight damage, moderate damage, heavy damage, breaching ½% and breaching ¼% reinforcing by volume. The following symbols have been used in Exhibit No. 1 to show the results of the tests and accidental explosions:

a. A circle surrounding any explosives incident denotes the wall was destroyed.

b. A completely filled circle indicates target material detonated simultaneously.

c. A smaller filled-in circle, within a circle, denotes target material communicated and there was a mass detonation.

d. A cross within a circle indicates there was communication to the target material, with some high order detonation of the target material.

e. A horizontal line within a circle denotes communication to the target material only in the form of low orders.

f. A black dot in the center of a circle indicates there was no communication of the target material.

Now, let us get an idea of what Exhibit No. 1 shows in relation to the positions of the plotted points.

UNCLASSIFIED

[redacted]

[redacted]

a. First, on the exhibit there is a series of points in a straight line in the area of A to B. These points all happen to be for Arco tests of the standard 12-inch reinforced concrete wall, with the explosives 3 feet from the wall. Therefore, r and t are constants for these tests, and the only variable would be the weight of the explosives and they should follow along a straight line.

b. Now, let us see what the effect would be if we kept the reinforced concrete wall as a constant of 1 foot, and varied the distance from the wall. If the quantity was the same as Test 8-4, and the distances were 3, 6, 9, 12, 15 and 30 feet from the wall, the points would be as indicated on the exhibit, starting from position A (3 feet) to position A_1 (30 feet). This means that, if we had large quantities of explosives separated from the wall by these distances, it would not help too much in reducing the hazard of communication. In contrast, if small quantities of explosives were involved, it would have a much greater effect and would become an important measurement to consider. This comparison is important because what we are trying to determine here is a curve for a dividing line between simultaneous detonation and explosion communication, and between explosion communication and no explosion communication. Furthermore, we are surmising that these curves would be more or less parallel to the "breaching curve".

c. Next, let us see what the effect would be of keeping the distance from the wall a constant of 3 feet, and varying the thickness of the wall. This is where the positions of the 1-foot, 2-foot and 3-foot walls are shown on the exhibit, i.e., line A-B is for the 1-foot, line D is for the 2-foot, and line D_1 is for the 3-foot. Note in particular that when we are talking about damage to the wall, generally it is much easier to obtain lesser damage by increasing the thickness of the wall than it is by varying the distance of the explosives from the wall.

11. Since I have mentioned that a starting point for the basis of the analysis of the tests and accidental explosions would be from a "wall-destroyed" basis, let us take a look at the two explosions which will give us, possibly, a first approximation of where the wall-destroyed curve should be. The exhibit shows a dashed line for the estimated position for the "wall-destroyed" curve. The basis for this curve is, essentially, the Iowa and Picatinny explosions. (Photographs of the Iowa and Picatinny explosions were exhibited, and the damage to the walls was indicated in relation to the portion of the detonating explosives.)

a. The Iowa explosion involved the detonation of two melt kettles which were the outermost of three melt kettles in a room with no reinforced concrete wall between the melt kettles. The damaged walls were the reinforced concrete wall between the melt kettles and the mixing kettles of the adjacent room, and the reinforced concrete end walls of the melt kettle room. The total quantity of explosives involved was 1500 pounds in the two melt kettles, with the larger quantity probably in the east kettle. Damage to the 12-inch reinforced concrete wall between the melt kettles and mixing kettles was as follows:

[redacted]

UNCLASSIFIED

3922

[redacted]

(1) That portion of the wall opposite the east kettle was destroyed.

(2) That portion of the wall opposite the west kettle was not destroyed, but was damaged severely.

(3) That portion of the wall opposite the middle kettle, which was not in use, was not damaged.

The Iowa point is plotted as "wall-destroyed" for 750 pounds. If the amount were assumed as 1000 pounds, it would only move $r/W^{1/3}$ from .66 to .6.

b. The Picatinny explosion involved 4 mixing bays of equal size. Each bay had two 12-inch reinforced concrete dividing walls, and one 8-inch hollow-tile concrete-fill dividing wall. The explosion of 450 pounds in the mixer resulted in the following damage:

(1) Wall A2A, the nearer of the two 12-inch reinforced concrete walls, was destroyed.

(2) Wall A1A, the farther of the two 12-inch reinforced concrete walls, was pushed considerably out-of-line.

This explosion gives us two points which are plotted on the exhibit as Wall A2A and Wall A1A. (The exhibits shown during the meeting indicated the specifics of the wall damage by sketches and photographs.)

12. All tests plotted on Exhibit No. 1 are Arco, Idaho, tests, and each test will be described. The first tests to be described are those which involved simultaneous detonation of site and target piles. The site pile is the pile which is initiated, and the target pile is the pile for which it is desired to determine the relative hazard of communication from the site pile. Test 8 involved 30,000 pounds of bulk explosives concentrated in a pile, at 10 feet (Test 8-3) and at 3 feet (Test 8-4) from a standard 12-inch reinforced concrete wall. The target piles consisted of 500 pounds bulk explosives each, separated at various distances from the wall, but within the boundaries of lines drawn from the corners of the site pile through the ends of the wall. The target piles of Test 8-4 went high order at the following time intervals:

Pile No.	Perpendicular Distance, in feet, from Wall	Time in Milliseconds
1	0	0.18
2	10.4	31.6
3	16.0	13.1
4	25.4	33.2
5	30.8	38.0
7	45.7	—
10	60.4	—

UNCLASSIFIED

[redacted]

[redacted]

The measurement of time was from the center of site pile to the target pile. The probable path of communication was:

Piles Nos. 1 and 2	- from primary
Pile No. 3	- from primary or from No. 1
Pile No. 4	- from No. 2
Pile No. 5	- from No. 3
Pile No. 7	- from No. 5

The report does not indicate whether or not the individual target detonated simultaneously with the site pile. Although the point on the exhibit has been plotted as "simultaneous", it also has a question mark. The time interval would indicate that some of the target piles could have been simultaneous. Note particularly that this test involved bulk explosives; therefore, communication could have been caused only by the blast wave, including flame and missiles from the "boxes" and the concrete and reinforcing rods of the wall.

13. Test 1-2 represented 20,300 pounds of explosives in Dutch bombs, sited identically between 12-inch reinforced concrete walls. The explosives were separated 3 feet from each of the three walls. The bombs were placed in 5 rows at nearly the length of the wall, and were separated from each other by 2 feet, 2 inches. In addition, token bombs were sited in 4 directions, parallel and perpendicular to the walls. All three walls disappeared as a result of the detonation of the site pile. The report states that recordings indicated that both piles of explosives in the simulated bays detonated simultaneously. The craters under the site and target piles appeared to be identical. The following sketch and table shows the timing of detonations.

	Chronograph (Milliseconds)	Camera (Milliseconds)
4 to 3	3.52	4.59
4 to 2	8.23	7.50
4 to 1	9.38	—
5 to 4	0.064	—
5 to 3	3.4	4.59
5 to 2	8.4	7.50
5 to 1	9.46	—

Note that all measurements were less than 10 milliseconds.

[redacted]

UNCLASSIFIED

3924

[redacted]

The report states that blast pressure measurements indicated that the target pile went simultaneously with the site pile. A graph of blast pressure units versus distance was given for this Test 1-2, and also for Box Car Tests 2-16 (96,400 pounds) and 2-14 (26,400 pounds). The measurements on one line fall between those of 96,400 pounds and 26,400 pounds; therefore, the measurements would be closer to 40,000 pounds representing both site and target piles. In contrast, the measurements on another line were greater than 26,400 pounds up to a distance of 475 feet, and less than 26,400 pounds for distances greater than 475 feet. The latter line does not support, as well, the conclusion of simultaneous detonation.

14. The next test to consider for simultaneous detonation is Test A-2. This test was similar to Test A-3 and A-4 in that bulk explosives were involved as both site and target. There was 12,500 pounds bulk explosives, as a site, in between a 12-inch reinforced concrete standard wall and a simulated wood wall, sand-filled. On the other side of the standard wall was an identical target of 12,500 pounds bulk explosives. The piles were concentrated with no separation within each pile, but the piles were separated from the walls by 3 feet. Both walls disappeared when the site pile was detonated, and approximately 250 concrete missiles weighing from 1 to 75 pounds were recovered up to a maximum range of 765 feet. The report indicated that the target pile detonated simultaneously with the site pile. The basis for this conclusion was a correlation of the silt depth. There were no blast measurements made of this explosion. On the basis of the depth of silt deposited from the Arco Tests (Dividing Wall, Box Car, and others), it was concluded that the amount of silt deposited was a measure of the blast pressure.

15. The next, in the order of tests, to consider is Test A-3. In this test, the site pile consisted of 6086 pounds of amatol in 500-pound and 1000-pound bombs, with no seperation from each other except by lumber, but separated 3 feet from a standard 12-inch reinforced concrete dividing wall. This site pile also had a wood revetted wall to simulate a bay. The target pile on the other side, also separated 3 feet from the 12-inch reinforced concrete dividing wall, consisted of 2890 pounds of explosives in 250-pound and 1000-pound bombs. According to the report, the target pile apparently detonated simultaneously with the site pile. The basis for this conclusion was the position of the reinforcing missiles which were blown out on both sides in a straight line, parallel to the length of the wall.

16. Now, let us consider Test 1-3. In this test, although the target material supposedly did not simultaneously detonate, it did mass detonate; therefore, it should be considered as a siting for a probable future simultaneous detonation. Test 1-3 had 50,000 pounds in Dutch bombs, sited on their noses in between an Army "Sandwich" wall and a Navy "Yorktown Type" wall. On the opposite side of the Army wall also, were 50,000 pounds in Dutch bombs. In each case, these bombs were placed in six rows, parallel to the walls. On the opposite side of the Navy wall, 29 bombs were placed in a single row parallel to this wall. The construction of the Army and Navy type walls was as follows:

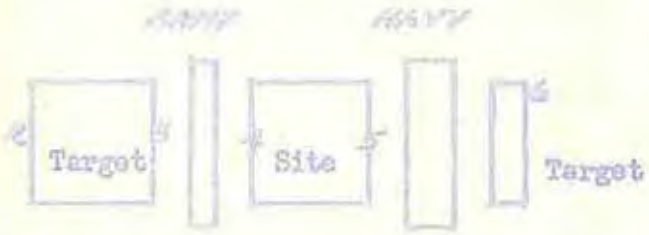
a. The Army "Sandwich" wall was a 12-inch reinforced concrete wall through which many steel rods projected 3 feet on each side. A 3/8-inch steel

[redacted]

plate was bolted on each side to the rods. The area between the 12-inch reinforced concrete wall and the steel plate was filled with tamped sand.

b. The Navy "Yorktown Type" wall was 6 feet, 8 inches thick, with a 16-inch outer wall of concrete blocks. The inner space was occupied by sand, but was compartmented every 2 feet, 8 inches, by 16-inch thick concrete blocks.

Blast pressure measurements indicated that the amount was in between the amounts obtained from the Box Car tests of 96,400 and 26,400 pounds; therefore, the target pile did not simultaneously detonate with the site pile of 50,000 pounds. The chronograph and camera records were as follows:



	Chronograph (Milliseconds)	Camera (Milliseconds)
No. 5 to No. 6	9.65	27.3
No. 5 to No. 3	9.42	5.84 or 7.76
No. 5 to No. 2	15.40	

No. 4 did not record.

Eight of the 29 bombs behind the Navy wall detonated high order; the others were found up to 3200 feet away in a flattened condition. The crater was the same depth under the site pile as under the target pile. Although the report indicated that the recordings did not indicate simultaneous detonation, note in particular that the recordings from No. 5 to No. 6 and No. 5 to No. 3 are similar to some of those of Test 1-2, which was said to have been simultaneous. Blast pressure measurements were made, and a chart of these, with those of Box Car Tests 2-16 (96,400 pounds) and 2-14 (26,400 pounds), shows that the measurements for Test 1-3 are midway between and therefore would be interpreted as not simultaneous detonation of site and target piles.

17. Another test of interest in the problem of possible simultaneous detonation is Test A-4. This test involved 3190 pounds of explosives in bombs in the site pile, and identical siting in the target pile, with a standard 12-inch reinforced concrete wall between. The report states:

[redacted]

"As regards the timing of the detonating wave * * * impulses were obtained which indicated 0.7 milliseconds between the explosion of the primed bombs and the explosion of the 500-pound bombs behind the 1-foot concrete wall, and about 2 milliseconds between the explosion of the primed bombs and the 6100 pounds of bombs behind the concrete block wall. Since the 100-pound bombs did not explode, and it is quite improbable that the 500-pound bomb on the opposite end to which the primacord was attached, exploded high order, it appears that the impulses indicated shorting of the wires by mechanical means such as crushing or cutting by missiles."

If the interpretation was not "by crushing or cutting by missiles", the time intervals would be much smaller than those for which simultaneous detonation was indicated.

18. The next tests to consider are those which involved communication of explosions through walls. For this purpose, we shall consider Test A-4 (12-inch reinforced concrete wall and Navy Yorktown Type wall) and Test 1-3 (Navy Yorktown Type wall).

a. Test A-4 had a site pile of 3150 pounds of explosives in 12 bombs, each bomb being separated from the others by 37-1/3 inches in a direction perpendicular to the wall, and 18 inches parallel to the wall. The target piles were:

(1) One pile identical to the site pile, with a 12-inch reinforced concrete wall between it and the site pile.

(2) The other pile consisted of six 100-pound bombs, with a Navy Yorktown Type wall between it and the site pile.

All piles were separated 3 feet from the walls. Detonation of the site pile resulted in the demolition of both walls. Two of the 12 bombs of the Army wall target detonated high order, and one of the 6 bombs of the Navy wall target detonated high order. 10 of the 12 bombs of the Army target were found from 150 to 275 feet away. None showed evidence of being penetrated by missiles although some were out-of round. The impulse measurements were discussed in relation to the possibility of simultaneous detonation of the bombs that went high order. It is important to consider the possibility of simultaneous detonation of one bomb, as in this test, because if the test had been repeated with a lesser distance between the target bombs themselves, the total target pile could have mass detonated, with a similar possibility of simultaneous detonation. Since two of the 12 bombs in the Army wall target detonated high order, and one of the 6 bombs in the Navy wall target detonated high order, from this only, it would indicate that the thick Navy Yorktown Type wall (concrete block and sand) accomplished no more than the standard 12-inch reinforced concrete wall. This statement needs modification if the results of the use of the same wall in Test 1-3 are considered.

[redacted]

[redacted]

b. Test 1-3 had a site pile of 50,000 pounds of Dutch bombs in several rows, parallel to the Navy wall, with the nearest row at a distance of 6 feet from the wall. Some of the bombs of this Navy target were detonated high order. The majority of the bombs were found at distances up to 3200 feet away, in flattened condition. On the exhibit, this wall test is plotted in Area B as if this wall (concrete block, sand-filled) were considered equivalent to a 2, 3, 4 and 5-foot standard reinforced concrete wall. It is evident that the greater the credit given to the Navy wall as equivalent to reinforced concrete walls, the lesser will be the amount of explosives that can be used as a minimum for prevention of explosion communication for the standard 12-inch reinforced concrete wall.

19. Although one of the Test 1-3 walls was discussed earlier for possible simultaneous detonation, it should be considered at this point from the standpoint of explosion communication. Similar to the Test 1-3 Army wall, points have been plotted for the Navy wall of Test 1-3 as if the Navy wall were equivalent to a 5, 4, 3 and 2-foot reinforced concrete wall. It is apparent again, that the greater the thickness credit is considered in relation to a reinforced concrete wall, the closer the explosion communication point approaches the tentative "wall-destroyed" curve.

20. The analysis of the Arco Tests in relation to what happened to the target pile, with a wall between, indicates that the explosives limit to avoid simultaneous detonation, for a standard 12-inch reinforced concrete wall, should be much less than 5000 pounds, and to avoid explosion communication, should be much less than 2000 pounds. As pointed out previously in this presentation:

a. The tentative "wall-destroyed" curve for a 12-inch reinforced concrete wall, with explosives 3 feet from the wall, would be at 365 pounds.

b. This curve should be the minimum for the basis of consideration of the explosion communication hazard, until more tests or data become available to warrant a revision.

21. Another important parameter, the effect of which was not determined by Freeman's analysis of damage to reinforced concrete walls, is that of non-concentrated charges. Whenever little is known about an assumed, complex condition, the number of variables are kept to a minimum. This is true, especially, in relation to the explosives detonated. In contrast, whenever it is desired to simulate actual conditions, the number of variables are not considered too important. Although the Arco Tests were performed essentially to simulate actual conditions, nevertheless the planning did anticipate consideration of the number of variables so that possibly some empirical relationships could be determined. The variation of siting of the bombs within dividing walls is indicated by the following table:

[redacted]

[redacted]

Test No.	Pounds per Cubic Foot Actual (1)	Pounds per Cubic Foot If Concentrated (2)	Percent (1) of (2)	Action of Target Pile
A-2	32.1	32.1	100	Simultaneous Detonation
A-4	15.9	50.7	31	Communication
A-3	10.6	44.0	24	Simultaneous Detonation
1-2	8.5	54.1	16	Simultaneous Detonation
1-1	3.4	50.8	7	Low Order Only

When the problem of concentrated charges versus non-concentrated charges is studied by various types of approaches, it appears that the degree of concentration is an important parameter in the relative hazard of explosion communication. This phase would take another meeting in which to both indicate and describe the possible conclusions one may derive.

22. A tentative conclusion, based on the Aroo Tests, would suggest that, to avoid simultaneous detonation, the explosives would have to be separated at approximately 10% or less of the possible full concentration of the siting.

23. In summary, it should be evident that:

a. The present Board standard of a 5000-pound limit for simultaneous detonation as now expressed, is not based on a reasonable risk.

b. The present Board standard does not meet present conditions when explosives are not highly concentrated, and are not 3 feet from a wall.

c. The present Board standard is limited to simultaneous detonation, whereas explosion communication may be the most important risk to consider.

d. The present Board standard should not "freeze" parameters of importance, thickness of wall, distance from wall, and degree of concentration.

e. The lack of conclusive data in the region of 200 to 3000 pounds indicates that tests to simulate important types of dividing wall usage would be advisable.

[redacted]

[redacted]

SUPPLEMENT

Arco, Idaho Test 1-1, 30 June 1945*

Summary

1. Test Layout.

Only one standard 12-inch reinforced concrete wall, which was 50 feet long. The site and target piles were identical, and consisted of 7980 pounds of 50/50 amatol in US 500-pound GP bombs, and 250 and 270 kg Dutch bombs. The bombs were 3 feet from the wall, and were in 3 parallel rows, each row separated by 5 feet, 3 inches. Each row of bombs was 42 feet long, with end of row 4 feet from end of wall.

2. Results of Detonation of Site Pile.

Concrete floor under site pile, which detonated high order, was badly cracked and slightly cratered under each bomb. Wall was completely demolished and pieces were scattered over an area of 100 yards or more. The floor of target charge was practically intact. It was evident that no bombs had detonated high order while sitting on the floor. One report stated that only one bomb detonated low order in target pile, and other 29 bombs were blown from the scene. Another report of observers stated that 25 of 29 bombs were located, and a more diligent search by others will disclose that two or possibly three bombs exploded low order.

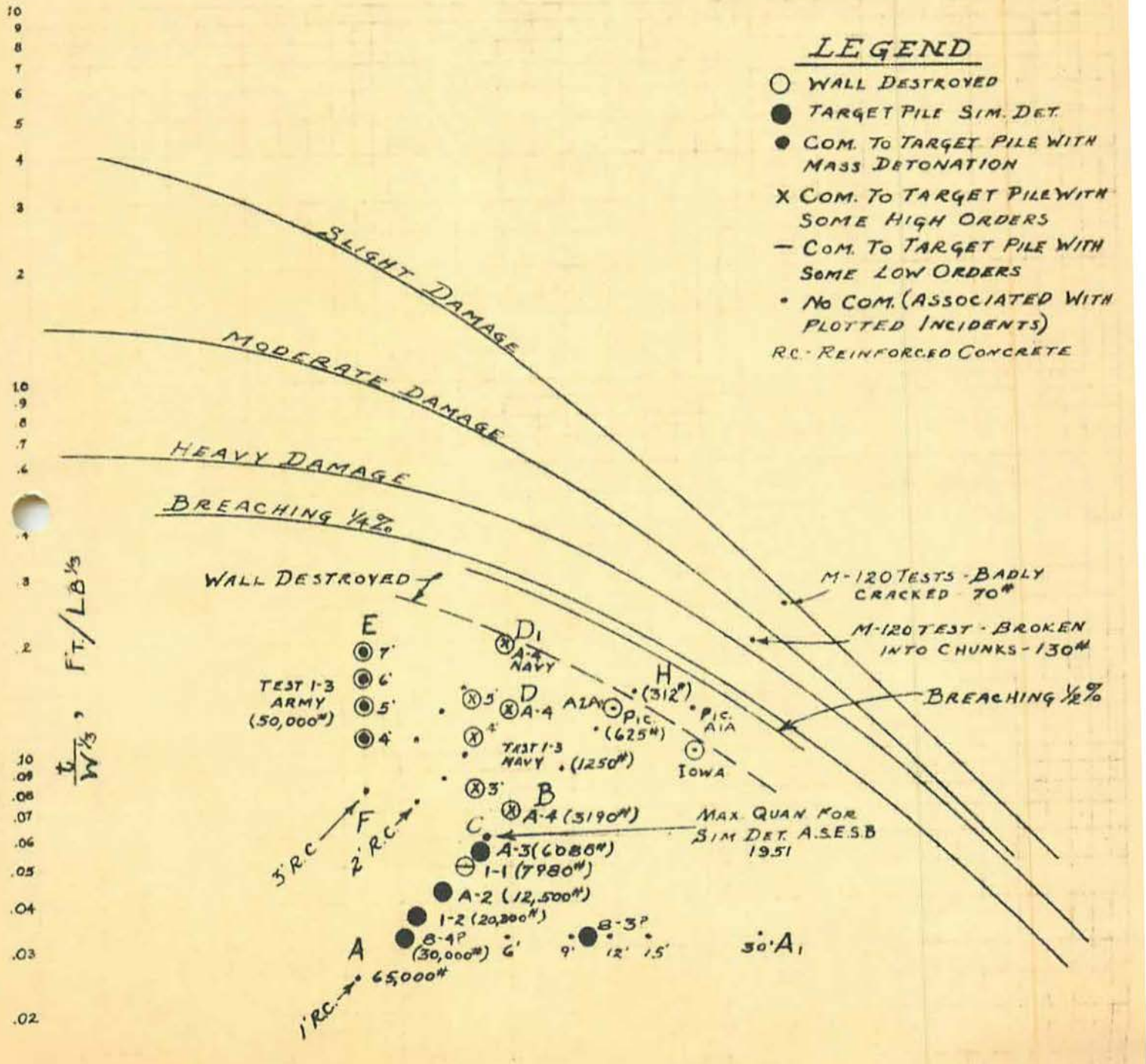
3. Comments.

In this test, neither site nor target piles had a wall in back of it. Test A-3, with a lesser quantity of 6086 pounds and with a simulated wall in back of site pile but no wall in back of target pile, was said to have detonated simultaneously.

* Details of this test are included as a Supplement since this test was not specifically covered in the discussion of the test and accidental explosion data.

[redacted]

EVALUATION OF DAMAGE TO REINFORCED CONCRETE WALLS VS THE POSSIBILITIES OF SIMULTANEOUS DETONATION OR EXPLOSION COMMUNICATION THRU SUCH WALLS



page 3932 ~~SECRET RESTRICTED DATA~~

filed in classified book

Dr. Ilsley: I'm glad you brought that question up. All of this material was put into this exhibit in order to raise the question concerning the 5000 pounds and as to what our sites are now. You have already indicated what one of our sites should be. We're talking about communication and we're talking about small quantities. This is a problem in all safety work - neither you, I, nor anyone else, at the time when there was far more than even 65,000 pounds in the cooling bay, realized the hazard in event of an incident if the limit was lowered to 5000 pounds. At the time it was thought that bringing it down from 65,000 pounds to 5000 pounds was accomplishing a tremendous feat in relation to safety; however, 5000 pounds will do the same thing that 65,000 pounds will do and that is simultaneous detonation. That means that a 5000-pound standard is no better than a 65,000-pound. What we are trying to do now is to get a better idea of what the actual hazard is. So, - what were the sites? The only sites they had were 65,000 pounds. What was the parameter? This went simultaneous, this didn't - a point in between. There were 3 tests - simultaneous, non-simultaneous and the standard.

Mr. Bishoff: That is a little hard to read from here -- where you have $r/W^{1/3}$ -- I don't know what that quantity represents. (End Belt 3)

Dr. Ilsley: This is where the 5000-pound standard comes on the chart. In this particular case it was 3 feet from the wall. You divide 3 feet by the cube root of 5000 pounds and it gives you this distance. You divide the 1-foot reinforced concrete wall by the cube root of 5000 pounds and you get this distance. The test they performed for 6000 pounds was Test A-3, and they got simultaneous with it. This one here, in which they had explosion communication, was 3190 pounds. So, the only parameters they had were: This went simultaneous, therefore it should be roughly less than 8000 pounds; this was 3200 pounds and it didn't go simultaneous. Therefore, it is somewhere between the 5000-pound in this group and this group.

Mr. Bishoff: But, you said "far less" than 5000. Were you talking in the area of 3200?

Dr. Ilsley: Whenever you get a high-order detonation on the other side of the dividing wall and it is represented by 9 milliseconds - a time that small - there is a good possibility that you are going to get simultaneous. Now, in that regard, we don't know what simultaneous detonation is. The only thing we know is that, with our blast pressure data, if the quantity on both sides goes up at the same time and the blast wave comes out at the same time, and destroys the certain one of the blast pressure measurements, and we measure it and it has the peak pressure of that full amount, we say that went simultaneous. On the other extreme, if this here goes up and the other does not go up simultaneous, I don't know how you measure it at the time being. If the blast pressure measurements indicate that this was only the amount at the site, we always say that it didn't go up simultaneous, but what we don't know is the effect - because if this was a short interval of time (and it doesn't take such a short interval of time to destroy the blast pressure), we are unable to measure the effect between the single charge and the double charge. It is this idea that we must look into - that it is either "the total of one" or "only of one", because although it isn't simultaneous detonation, we may have two units striking a building within intervals, and it will not be the combined damage of one, but it will represent considerably more damage than one unit. That will come into play mainly for those types of structures which are close to the explosion. In the case of inhabited building distance, it may not work the same way, but once those windows are knocked out and the building has a chance to take care of itself in a little better shape, the second blow may not damage it as much.

Mr. Bishoff: Doctor, you didn't answer my question specifically enough. What quantity are you thinking of when you say "far less than 5000"?

Captain Jenkins: I would like to see tests conducted to determine that. Dr. Ilsley has not set any specific quantity of 200 or 2000 pounds.

Mr. Bishoff: Is it between 5000 and 3200?

Dr. Ilsley: I have already said that I don't believe we have enough information to determine units, but for a 1-foot reinforced concrete wall, the starting point should be 300 pounds. That is where the present information would indicate that the 1-foot reinforced concrete wall would be destroyed. I don't believe it would actually be that low.

Mr. Bishoff: But we feel that 15 pounds will knock over or damage a 1-foot wall.

Captain Jenkins: But we are not thinking of damage, we are thinking of communication and simultaneous detonation.

Dr. Ilsley: When we are talking about walls, we have to realize that all of these parameters come into play. I haven't taken up some of these other cases, but you will recall that there was a test on the 70-pound and 130-pound photoflash bombs at Longhorn. On the basis of that information, right here is where those points would be and they correlate very closely with the type of damage that would be estimated by 3. On the other hand, there was one explosion out on the West Coast in which the wall was destroyed, and supposedly there was not more than a few pounds involved. I would seriously question that, however, I believe there was more material involved to produce the effects it did.

Mr. Bishoff: Are you taking into consideration the different rates of detonation of these explosions?

Dr. Ilsley: As I said before, this was based upon TNT. All of our Arco tests were based upon TNT or amatol loaded bombs. I don't know where we have had an explosion that would involve higher grade explosives. If it did, you would change this from $\frac{1}{4}$ to $\frac{1}{2}$ and take into consideration that it would make conditions worse for RDX or some of the higher brisance explosives.

Mr. Bishoff: At the rate of detonation of the photoflash powder in comparison to TNT, there are none that I can think of.

Dr. Ilsley: In the Iowa explosion it involved amatol, and Picatinny involved something else, so you won't have to take that into consideration.

Captain Jenkins: Are there any other questions to bring up?

Mr. Roylance: I have one question, although it doesn't relate particularly to this, but, when you were talking about this building up here in Test 8-3 and 8-4, you said that you considered that some of the communication was from the target piles themselves. Were they all constant weight, that is, was each target pile the same weight?

Dr. Ilsley: Yes. 500 pounds in bulk.

Mr. Roylance: If that were the case, then why wouldn't they all be gone then? Why wouldn't it just have kept on going until they were all destroyed?

Dr. Ilsley: I haven't analyzed these things in here in relation to the distances between those--if there was a different distance situation how would it go up. I think it is important that certainly these two couldn't have come from anything else. But, this could have gone - and this could have gone here. As a matter of fact, you know that these went way down to here, but that these stopped here and didn't continue on down through there. Again, it points out that not only is it important in relation to separating your material on one side of the wall if that happens to go up, but also on the other side because, by the separation on the other side, it would prevent a mass-detonation of the total and you may just get communication from one to the other.

Mr. Roylance: I would just like to add one observation and that is in relation to what Mr. Bishoff said about plutonium. That is, we may not be as bad off as it sounds because weights of explosives per weapon are coming down, down, and down

in that type, so that we wouldn't be too bad off actually with a 1-foot wall.

Captain Jenkins: If you hold it to those small quantities.

Mr. Roylance: Yes, depending on how many you want to put between walls.

Captain Jenkins: If you put 5000 pounds in --

Mr. Roylance: This would get unrealistic as far as numbers of weapons are concerned. In any number of weapons that we are dealing with, we can live pretty well with this, I think.

Dr. Ilsley: Yes. It is a possibility because you can separate your weapons within the bay in such a way that if you had a mass detonation of one --, well, you couldn't very well have a mass detonation on one side and not have the likli-hood of a like mass detonation on the other side. It would be all right if you could possibly separate them so you wouldn't have a mass-detonation of the total quantity in a bay. All of these were so exploded so that you would get 100% mass detonation.

Mr. McNamara: I believe the point that Mr. Bishoff brings up, though, is that if propagation occurs, the plutonium fallout increases.

Mr. Roylance: I realize that, but what I am saying is that we don't really have the problem of dealing with quantities of 5000 pounds with these weapons.

Captain Jenkins: Except that our standard provides a limit there and we can go up to it, Herb.

Mr. McNamara: We can get propagation with it.

Mr. Roylance: What I'm getting at is, when you start talking about that many weapons in one spot, to communicate through dividing walls, it gets pretty terrific in numbers.

Mr. Endsley: This may be true in static storage in an igloo, but when you get to the tactical item where you have other items aboard which may contribute to these

forces, then you are right back where you started and we still have the problem. We may have 500,000 pounds thrust on this item which is comparable to X number of pounds of TNT.

Captain Jenkins: Are there any other comments? (none) The objective of this presentation, of course, is to get us thinking about something which is extremely important now. What wasn't important in routine storage some years ago is exceptionally important now where we are dealing in small quantities. I noted a few summarization items here as Dr. Ilsley went along, in connection with these quantities:

1. The maximum quantities have varied considerably through the years. He mentioned in 1941 to 1950 they run from 3000 and 1000 up to 65,000 and now our present standards say a 5000 maximum.

2. Most previous tests were conducted on the basis of damage to the walls and not with respect to explosives communication. We shouldn't put too much faith, which has been our tendency, in the protection against communication with this present standard that we have.

3. What was good at one time may not be good now.

4. It is easier to reduce communication by increasing the thickness of the wall, rather than increasing the distance. There is great value in dispersion.

5. As Mr. Bishoff mentioned, a reasonable guarantee against simultaneous detonation with the quantities that we have to think about are far less than 5000; to prevent communication, possibly far less than 2000 pounds.

6. Another item, not more than a 10% concentration to prevent simultaneous detonation.

7. We were concerned about the amount of data available. There seems to be ample data available on this which, properly used and coordinated, should indicate

whether or not a revision of our standard - our previous concept of dividing walls - is necessary, especially in view of the small quantities in which we are dealing.

The only question I have now is, "Where do we go from here" on this? Initially I thought a paper or an accounting of this for people to think about would be in order, but should there be possibly something before that? The objective here was to get this to the Board members and to certain of our consultants, and have you start thinking about it, and to get some ideas from you as to what we should do further on it. Another thought on this is, do you think some further presentation of this to your technicians - the people who work for you and provide you with the answers - is in order? Not the complete briefing that Dr. Ilsley has given here this morning, but getting down to facts and fundamentals. How do you feel about it, Ray, as far as the Army is concerned?

Colonel Costabile: Well, we have spent an hour and a half here this morning discussing these safety distances (and certainly no offense to Dr. Ilsley) but, we fully realize that we have been operating and still are manufacturing ammunition in the greater of the occasions at 5000 and the total amount of explosives in the building separated by dividing walls as being the distance to separate the buildings by. We fully realize that it offers false security to anyone in these buildings because on the other side of the house we talk about 15 pounds being a dangerous area for the person working in the other room. It is not in the least bit consistent.

Captain Jenkins: No, that is not what we are talking about. The basis of all this is, is there a need for further testing. Would a test be in order - we can determine a lot/but to get absolute factual information? In some months past, we have talked about the tremendous quantities of ammunition available.

Colonel Costabile: But, Dr. Ilsley has presented here that we need tests, and 5000 pounds is false security under which we are operating. By the same token, the large amount of real estate that we buy today, with the economic and industrial problems of loading - we speed up our loading, it is mechanized and we need more capacity for kettles and we need more cooling capacity - we need so many of these things that it would be almost impossible to impress anybody that we should buy more real estate to safely manufacture our conventional types of ammunition. If you limit this discussion to hazards involving explosives manufacture of, for example, plutonium-bearing weapons, and we organize our thinking so we perhaps stay within a safe criteria, then I think we are doing something. However, if you have to go back to your Secretary and try to convince him that we need more real estate to safely do the job with all types of ammunition, he's "going out the front door".

Captain Jenkins: The intent is not more real estate, it is --

Mr. Endsley: It is going to eventually amount to that.

Colonel Costabile: How are you going to get around it? Because, all we're doing is we're staking out real estate and taking a greater risk and that is the way we are operating today.

Mr. Bishoff: I'd like to try to answer your question specifically. I think Dr. Ilsley has done an excellent job of preparing this study, and I'll admit frankly that I couldn't follow all of it from here because it is too far from these graphs and drawings. I would suggest that the Board prepare a paper on this study and let us distribute it for study before we come up with the recommendation that tests be run. I think it would make an excellent technical paper, and I, for one, would like to have the time to study it before deciding on "where we go from here".

Dr. Ilsley: I think that is an excellent suggestion, but frankly, I'm going out on this job and won't have time to prepare any technical papers. Theoretically, I was to retire this month when I became 62, but have agreed to stay on for two more months from the standpoint of assisting my replacement. My retirment plans have been known for 2 years and I have suggested to former chairmen that the last 2 years be spent in preparing technical papers on all the research that I have done; however, this was not possible.

Captain Jenkins: Without getting into some of the more intimate discussions that Dr. Ilsley and I have had about this, in the beginning my first thought was that this should be presented in a technical paper. Then, I began to consider that possibly a preliminary approach should come first in getting some of your technicians in on this. The latter is step 1 and the paper would be step 2. In fact, that is why we have the complete recording on this presentation; it is, in effect, the technical paper.

Dr. Ilsley: In connection with your technical people, I would like to point out that, when we say "technical people", we mean your structural engineers from the Corps of Engineers, Bureau of Yards and Docks, Chief of Naval Operations, etc., so to guide you on this, once you have an idea of this, then you are the technical people except in relation to problems wherein you would get technical advice from theoreticians in relation to blast pressures, etc. And, what we need more than anything else is some small scale tests in which they take a small amount of explosives, figure out the blast pressures and impulses, and then, in small increments of milliseconds of time, we set off other explosives and measure the peak pressures and impulses to find out what is the relationship between the two. That type of information is the way the "technical technicians" can help you.

First, for this type of information, and second, on some of the theoretical problems in which I don't know "where" the research work has been done on it.

Captain Jenkins: This is a very valuable step - Step No. 1: Bringing it to the minds of the Board members now. Step No. 2 will be commencement of a paper organizing all this information into a technical paper. In the meantime, not in any effort to "settle" anything in a day, month, or even a year, but, first - get together with your technicians in possibly, within the next two months, and give us information on that as you think about it further, in advance of the technical paper, with an end result in mind. Would further tests - small scale tests - be in order to get these absolute points of "where does simultaneous start" and "where does communication start", with the kind of walls we have today. There is certainly no intention to buy further real estate.

Dr. Ilsley: Another point is, by all means, if you have any accidental explosions, check with us to find out whether we have them or not. Furthermore, whenever an accidental explosion occurs, and this is fundamental, get the type of information that you need for such an analysis. Get the distance that the material was from the wall, the type of wall, the thickness of the wall, the type of reinforcing, and get pictures to show what the type of damage was. The statement "wall destroyed" or "wall heavily damaged" is not adequate. We need pictures to see what the actual damage was. In most cases, we have had to go back 3 or 4 times to get this additional information.

Mr. Hough: We have data on the recent Allegany Ballistics Laboratory explosion where 2-foot thick reinforced concrete walls were completely demolished by approximately 1500 pounds.

Dr. Ilsley: What we want is any information that fills in this area in through here. Be sure to check on all explosions that come in in the future to find out where they

come in into this chart. (End Belt 4)

Captain Jenkins: Should the Board, after preparing a paper, possibly make a certain recommendation on this that tests should be in order by one or more Services, or something like that? How to finance? I don't know.

Captain Kellar: We have such a time getting funds with hard competition between the Services, and there is competition within the Service to use what funds they do have assigned.

Captain Jenkins: That would come later, Captain. There is a lot of water to go over the dam before we say that we want certain tests to be conducted in a certain way to get a certain result. At this time, this presentation and discussion is merely to get this august body to thinking about it. The next step, at present, is uncertain. You people look over the value of a presentation of this, one of strictly technical material with a lot of this cut out, to your technicians. That will be the next step, in the next month or two. Bob, this has a bearing on many of the problems with which you are faced. Do you have any special comments?

Colonel Fincke: To me, we have to get it all down in black and white first. We have to have a paper for people to "get their teeth into" and analyze. I think it would be rather dangerous to call in a group of technicians and give them a briefing like this and let them go away with all of these doubts in their minds. Doubts as to the basis of it that 5000 pounds is a safe start.

Captain Jenkins: There is no doubt and there is plenty of basis.

Colonel Fincke: My point is that, whenever you go to a briefing, where you want people to do something about it, you have to give them something down in black and white and not just a lecture. First, get a technical paper worked up on this problem and then let some of our technicians analyze it and then decide on how we are going to approach it.

Captain Jenkins: We'll start ironing this out now, Dr. Ilsley. Your presentation is recorded here, and we'll work on it now.

Dr. Ilsley: The only thing I wanted to accomplish here was an up-to-date review of the problem. For a complete report, instead of an hour and a half, it would take 2 days.

Captain Jenkins: Well, I think you have done an extremely effective job of it, Doc, and as I told you the other day in the speed-run on this, you have done a world of a job on this.

Now, we haven't had a meeting in two months. As you will notice on the agenda, there is a lot of material to cover yet; however, it shouldn't take more than an hour and I would like to ask the Board members first for ~~a~~ action on it. Would you like to continue this this afternoon, or take maybe about an hour more here to finish?

Colonel Fincke: Let's take it up right now.

Captain Jenkins: All right. First, would you all like to take about a 10-minute breather? (End Belt 5)