REVISION OF TRI-SERVICE REGULATORY DESIGN MANUAL "STRUCTURES TO RESIST THE EFFECTS OF ACCIDENTAL EXPLOSIONS" (TM 5-1300, NAVFAC P-397, AFM 88-22)

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ABSTRACT

Initial guidance in the field of protective structures design was provided in 1969 with the publication of the Tri-Service Design Manual "Structures to Resist the Effects of Accidental Explosions" (TM 5-1300, NAFVAC P-397, AFM 88-22). The manual presents procedures for determining the blast effects resulting from an explosion and techniques for the design of reinforced concrete structures subjected to blast loads. A considerable amount of data, much of it not covered in the current manual, has been accumulated since its publication. This information has brought about the urgent requirement for revising the manual. This paper briefly describes the topics in the manual that will be revised, those that will be added, the format of the new manual, and the various committees set up to oversee the revision.

REVISION
OF
TRI-SERVICE REGULATORY DESIGN MANUAL

"STRUCTURES TO RESIST THE EFFECTS OF ACCIDENTAL EXPLOSIONS"

Introduction

The initial guidance in the highly specialized and complex field of protective design was provided in 1969 when the Tri-Service Manual, "Structures to Resist the Effects of Accidental Explosions" (ref. 1) was published. The manual presents procedures for determining the blast effects resulting from an accidental explosion and also techniques for the design of reinforced concrete structures which will provide protection for personnel, equipment and other explosive items.

A considerable amount of data (published as technical documents and others yet to be published) has been accumulated since the development of the Tri-Service Manual. Although some of this data updates the information contained in the manual, most of it deals with topics not covered initially.

Efforts by the Army, Navy, Air Force, and Private Industry in the area of blast effects and structural design created the urgent need for the revision of the manual to include recently published data and additional information. The publication of the Tri-Service Manual was considered a major step forward in the field of explosion-resistant protective design. The revision of the manual and the addition of newly developed technology will greatly improve this important document.

This paper describes qualitatively and in a concised form, the various topics in the manual that will be updated. Additional topics to be included will also be described briefly. The functions and activities of the various committees set up to oversee the revision of the manual will be presented.

Organization of Committees

Figures 1 and 2 show an organization chart of the various institutions and individuals involved in the revision and update of the Tri-Service Manual. The revision of the manual is sponsored by the Department of Defense Explosives Safety Board (DDESB). The U.S. Army Armament Research and Development Command (ARRADCOM) provides administrative and technical guidance to the Steering Committee. The ARRADCOM team has also the task of preparing the revised manual through a contractor, Ammann & Whitney, Consulting Engineers, New York, N.Y., and their subcontractor, Southwest Research Institute, San Antonio, Texas.

Steering Committee

The Steering Committee, comprised of experts from the Department of Defense Explosive Safety Board (DDESB), Army, Navy, Air Force and the Office of the Chief of Engineers (OCE) (fig. 2), meets twice a year to review the findings and recommendations of the two subcommittees; namely, Blast Technology and Design Application. The Steering Committee will periodically review the revision of the manual.

Blast Technology and Design Application Subcommittees

These subcommittees consist of personnel from the Army, Navy, Air Force, DDESB, COE and private industry (fig. 2). They meet every four months to identify new technological advances and to recommend appropriate revisions. They will also review the revised manual at the 50 percent stage of completion and the final draft.

Topics to be Revised

Two of the most frequently used design aids in the Tri-Service Manual are Figures 4-5 and 4-12. They show the variations of pressures, impulses, velocities and other parameters of shock waves with scaled distances based upon tests performed with TNT. Since their development and incorporation into the manual in 1969, additional theoretical and empirical information has become available, some of it published in the manual prepared by Southwest Research Institute (SWRI) for the Department of Energy (ref. 2). Some of the curves illustrated in the figures have been revised and refined by C. Kingery of the Ballistic Research Laboratories (BRL), and these new curves will be incorporated in the revised version of Figures 4-5 and 4-12 (figs. 3 and 4).

Other figures and charts to be revised include, but are not limited to, the following:

1. Figure 4-6 (fig. 5), Reflected Pressure Coefficient vs. Angle of Incidence - Will be replaced by new curves for pressure and impulse variation.

2. Figure 4-63, Exterior Leakage Pressure vs. Ground-Scaled Distance - The existing curves in the manual are out-dated and will be replaced. The bulk of the new data will be extracted from CEL Report TR R828 (ref. 4).

3. Figure 4-65, Maximum Mean Pressure in a Partially Vented Chamber - At present, the four existing curves, namely, NOL, Weibull, SWRI and TM 5-1300 (fig. 6), depict different conditions for mean pressure in a chamber. These curves will be analyzed and additional data from tests performed in Norway and the United Kingdom will be added to form a revised curve.

4. Figure 4-72, Leakage Pressure Coefficient vs. Pressure Differential - Recent test data will be examined for the revision of this figure (fig. 7), which is considered to be inadequate.

5. The human tolerance table will be updated, using recent data published by the Lovelace Foundation.

Besides the revision of other tables and figures in the manual, some topics have to be updated appropriately. One such example is the effect on explosive output due to shape of explosive and number of charges. This data which was previously referred to as "TNT Equivalency" will now be referred to as Equivalent Charge Weight with the effect produced by the variation of explosive material referred to as TNT equivalency.

Additional Topics to be Included

Since the development of the Tri-Service Manual, ARRADCOM and other organizations of the Army, Navy and Air Force have done a considerable number of studies on blast effects and the blast-resistant capacities of various structural elements. These studies will be reviewed and the topics pertinent to the subject of the manual will be incorporated. Some of these topics are listed in Figure 8.

Format of Revised Manual

To account for the addition of much needed information such as that outlined in the preceding sections, the revised manual will be divided into five volumes.

Volume I - Blast Loadings: This section will include the revisions of the first four chapters of the present manual and also additional topics such as the effect of charge shape on pressure output, and multiple explosion effects.

Volume II - Concrete Design and Fragment Impact: The bulk of the data in this volume will constitute the revised information from Chapters 5, 6 and 7 of the present manual. Additional information will include, but not be limited to, below ground concrete cubicles, single-revetted barricades and response of flat slabs to pressure-time loadings.

Volume III - Steel Structures: This volume will contain primarily new information. Design criteria for steel elements and structures will be provided, together with results of tests performed on pre-engineered and strengthened steel buildings.

Volume IV - Other Factors to be Considered in Explosive Facility Design: Chapter 10 of the current manual will be revised in this volume. Data will also be provided on safe separation distances between explosive items, blast-resistant capacities of glass windows and frames, and earth-covered magazines, etc.

Volume V - Computer Programs and Guide: Like Volume III, this section is new and will deal with the computer programs currently available to the Army, Navy and Air Force. The listing of the highly specialized programs (i.e., those programs written for blast design) will be provided in this volume.

It is hoped that the division of the revised and updated manual into five volumes will allow for a detailed and vivid presentation of the various topics in this highly complex field of blast design. References will be provided in each volume in the event that additional information in any particular topic is required.

Conclusions

The revision and update of the manual will be completed by the end of 1983. By then, it is anticipated that the five volumes that constitute the manual will contain the most recent data available in the area of protective design. Memos have been sent out to various Division Engineers and Commanders of the Army, Navy and Air Force asking them to identify any shortcomings of the present manual. Their responses have been taken into account in order that the final manual will satisfy the needs of the various users.

REFERENCES

1. "Structures to Resist the Effects of Accidental Explosions (with Addenda)", Department of the Army Technical Manual TM 5-1300, Washington, D.C., June 1969.

2. "A Manual for the Prediction of Blast and Fragment Loadings on Structures", DOE/TIC-11268, U.S. Department of Energy, Amarillo, Texas, November 1980.

3. GLADSTONE and DOLAN, "Effects of Nuclear Weapons", 3rd Edition, 1977.

4. KEENAN, W., and TANCRETO, J.E., "Blast Environment from Fully and Partially Vented Explosions in Cubicles", Technical Report R828, prepared by Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California, for Department of the Army, Picatinny Arsenal, Dover, New Jersey, November 1975.

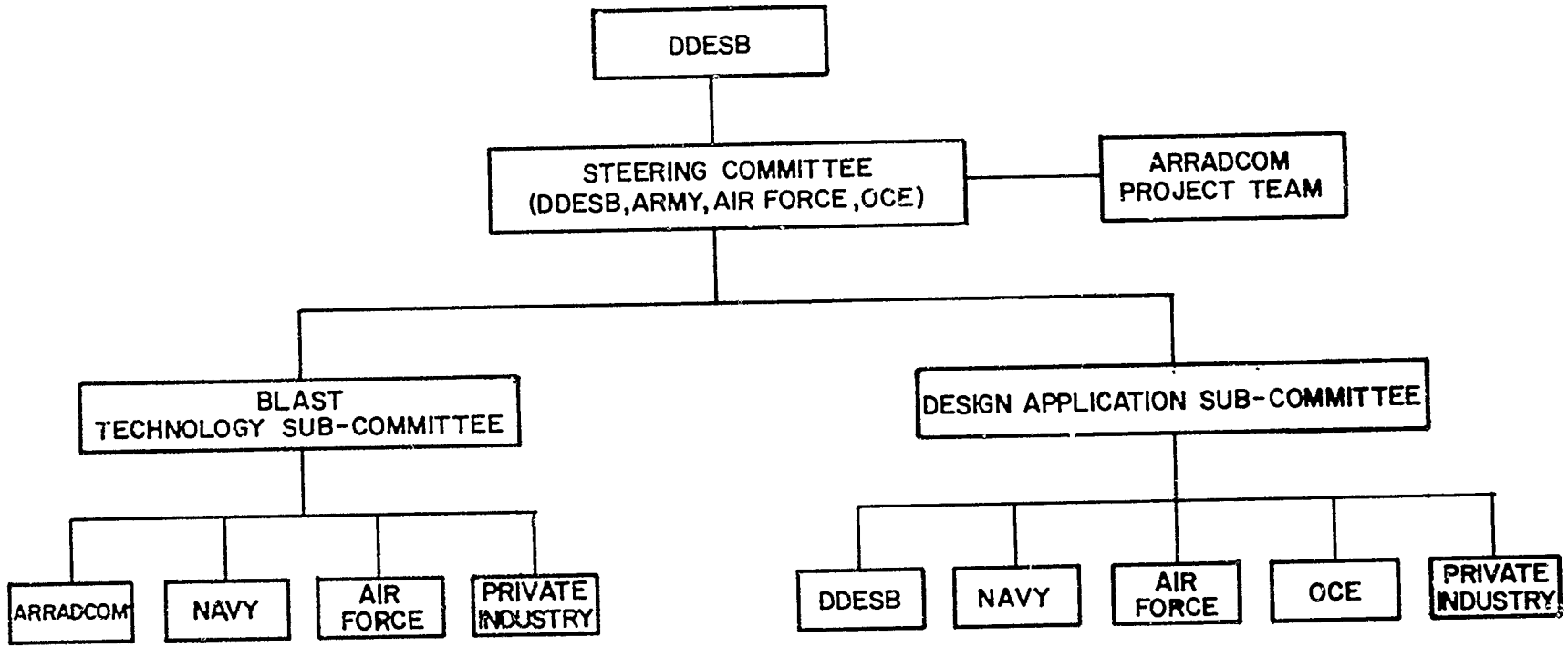

Figure 1 Organization Chart for revision of the Protective Design Manual

STEERING COMMITTEE

Dr. T. Zaker, DDESB

W.L. Armstrong, NCEL

W.C. Buchholtz, AFESC

Lt. Col. W. Mills, COE

Major S. Hawn, AFESC

L.W. Saffian, ARRADCOM

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H.S. Napadensky, IITRI

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N. Dobbs, A&W

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H.D. Nickerson, NFEC

Cpt. P.L. Rosengren, AFESC

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Figure 2. STEERING AND SUB-COMMITTEE MEMBERS

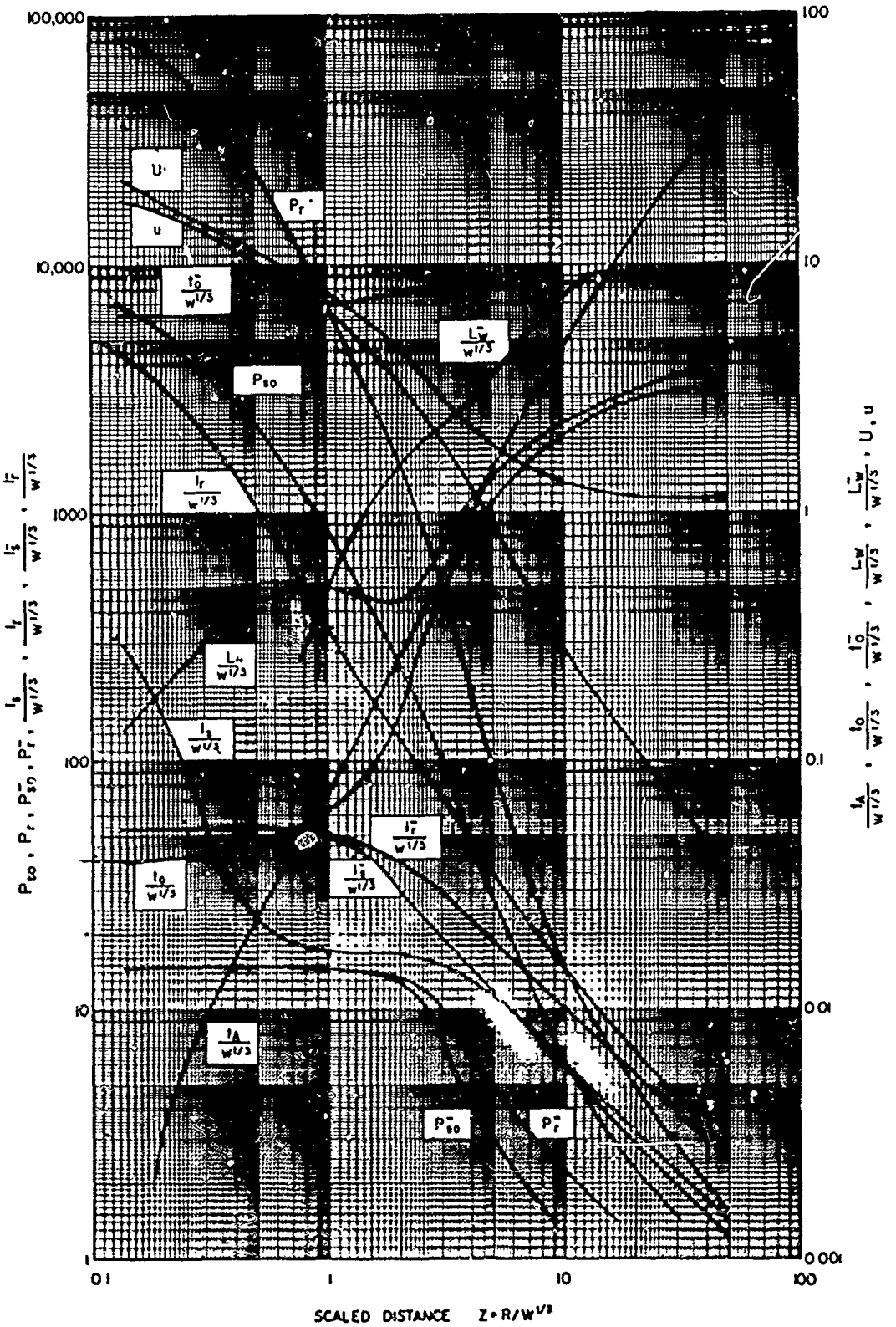

Figure 3 Blast Parameter for Spherical Free Air Burst of TNT

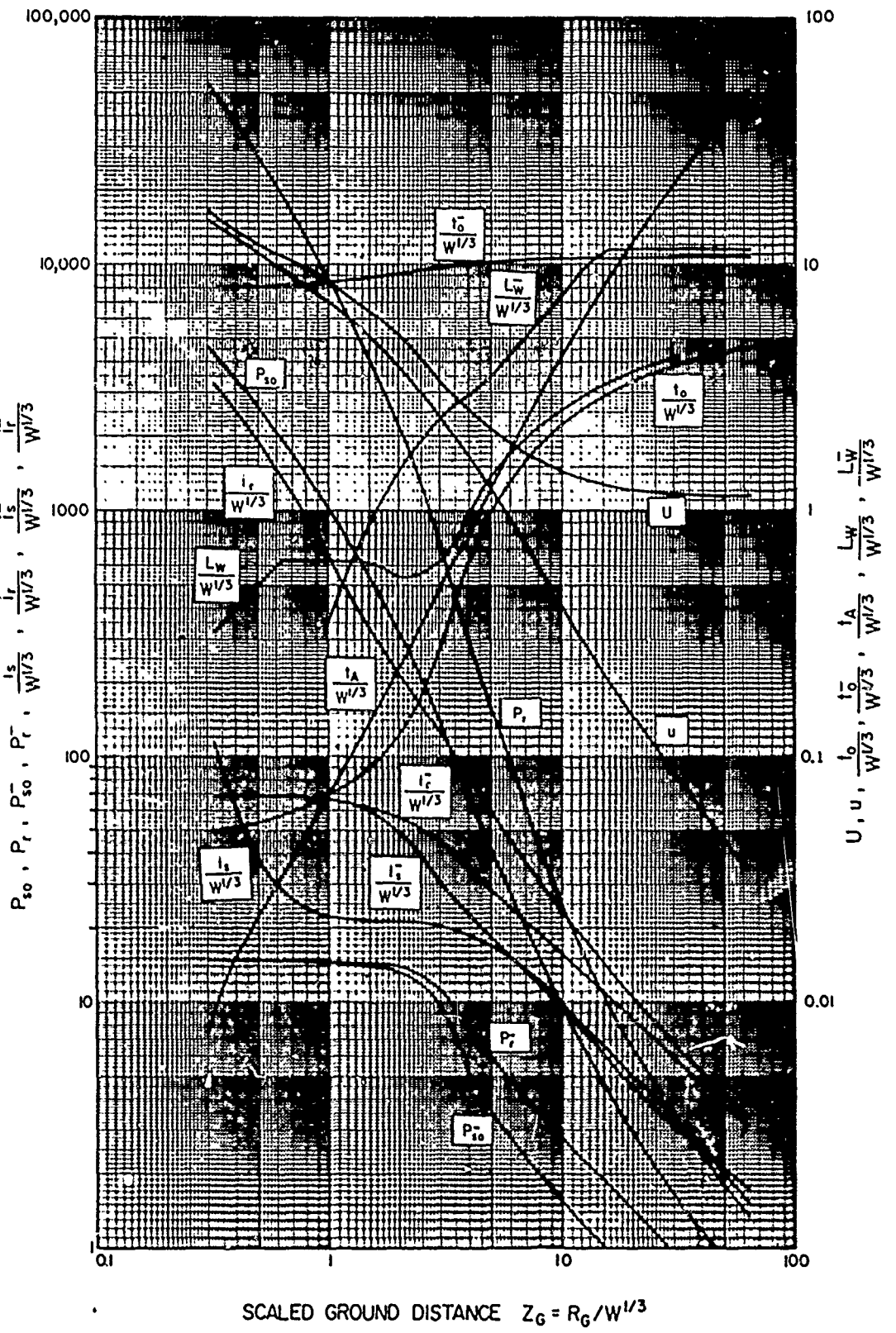

Figure 4 Blast Parameters for Hemispherical Surface Burst of TNT

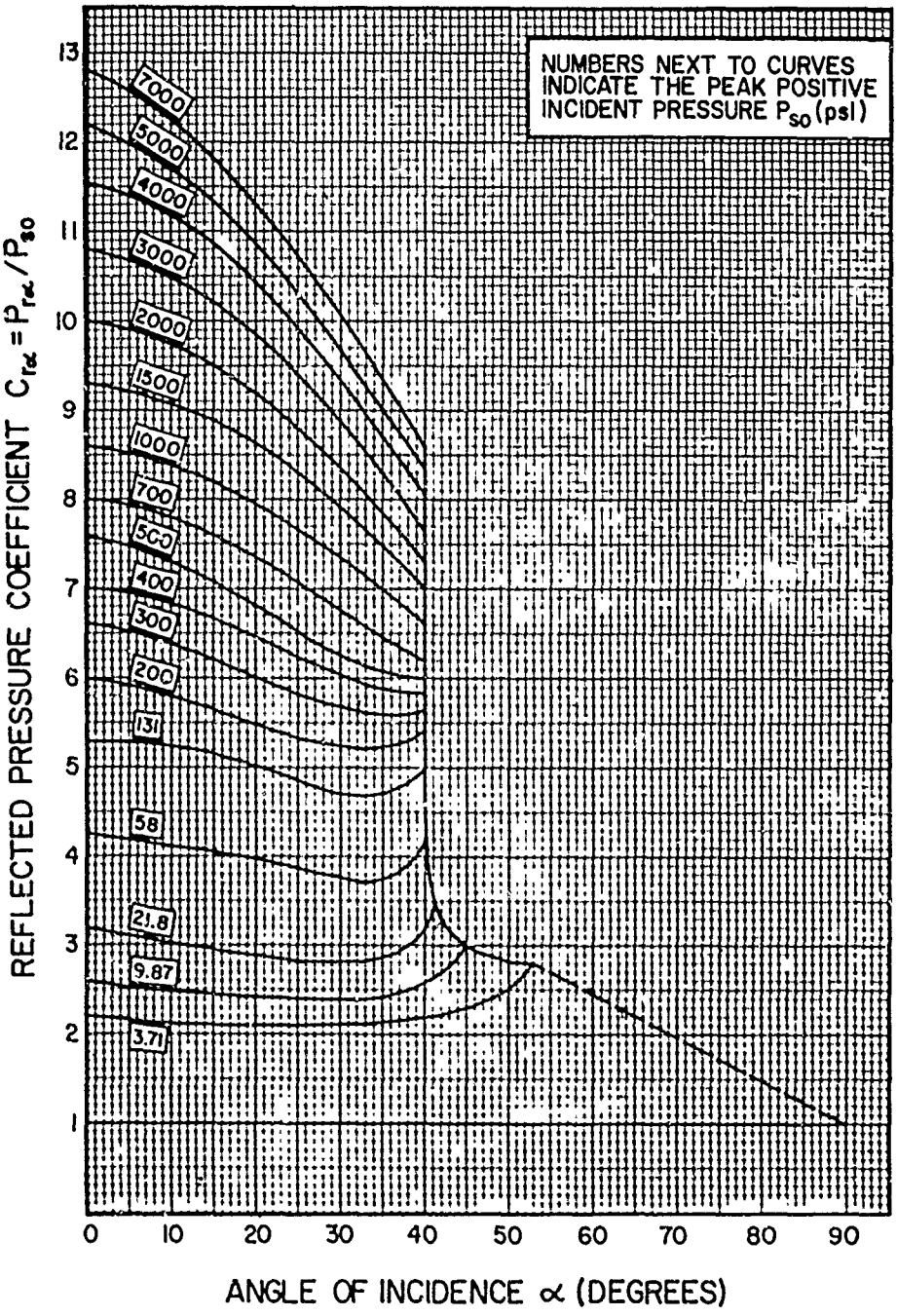

Figure 5 Reflected Pressure Coefficient vs. Angle of Incidence

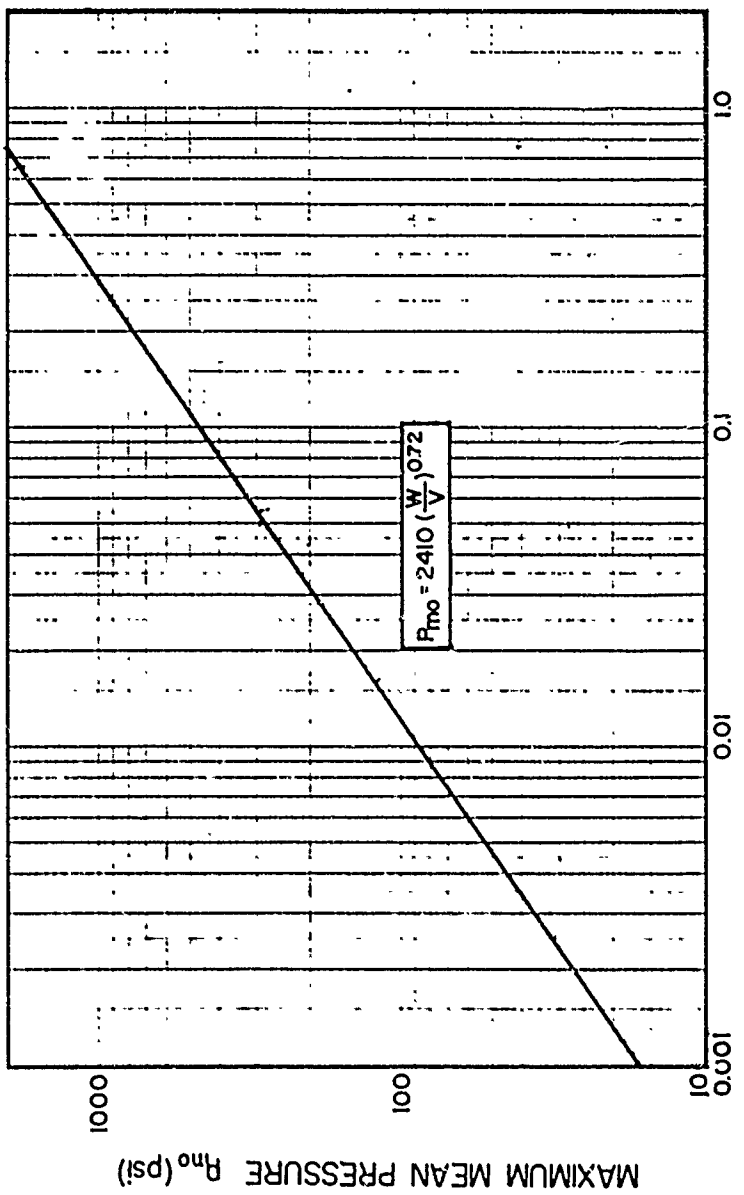

Figure 6 Maximum Mean Pressure in a Partially Vented Chamber

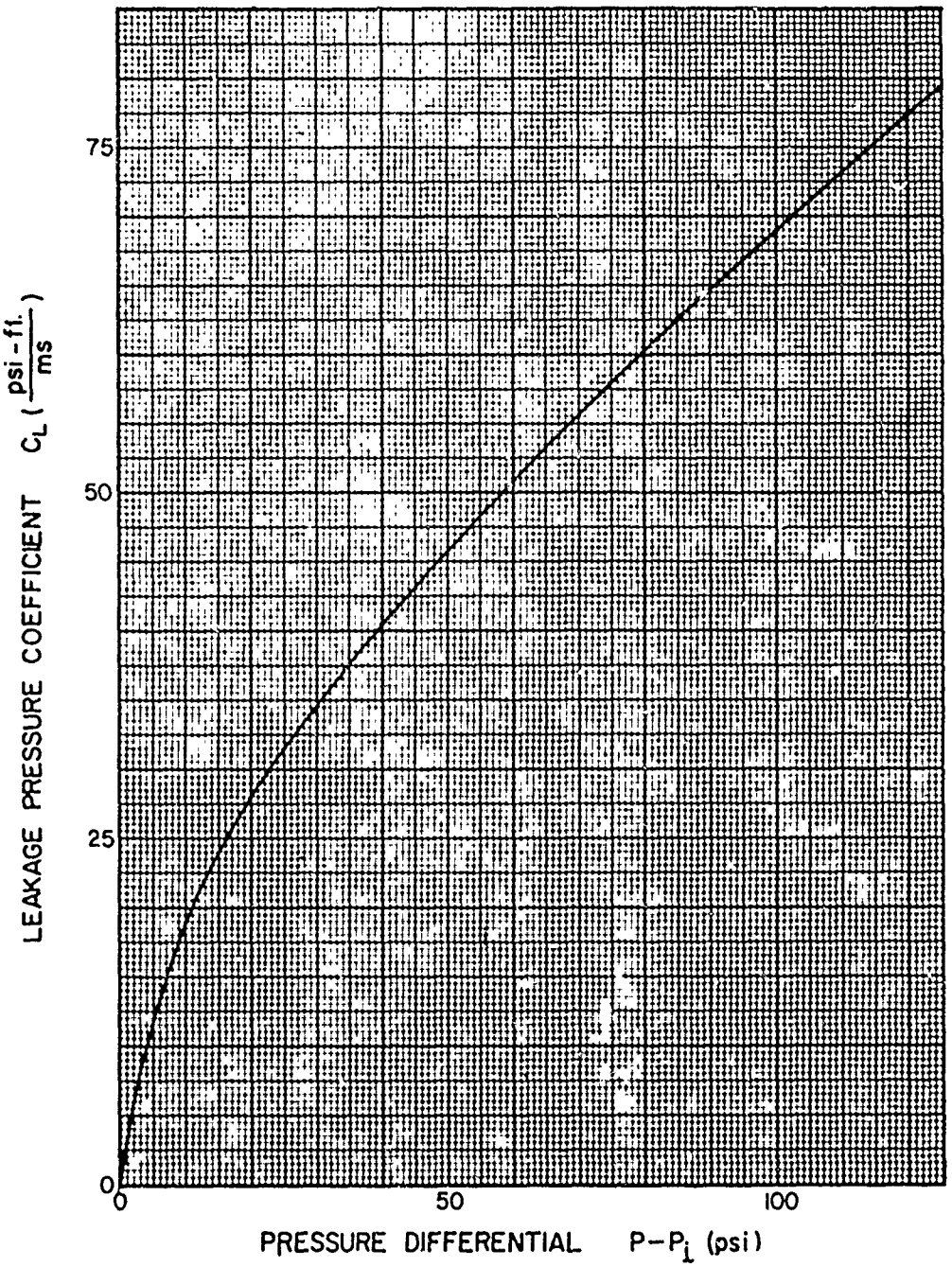

Figure 7 Leakage Pressure Coefficient vs. Pressure Differential

1. Full containment and below ground cells and single-revetted barricades.

2. Overturning of structures subjected to blast loads.

3. Primary fragment penetration and secondary fragment impact.

4. Multiple explosion sources, simultaneous and sequential detonations.

5. Design of structural steel buildings.

6. Pre-engineered and strengthened steel buildings; structural steel elements (ARRADCOM reports).

7. Computer analyses of frame structures and other structural elements.

8. Tests performed on cold-formed steel panels, window frames and glass, including performance specifications for blast windows.

9. TNT equivalencies of explosives and propellants.

10. Leakage pressures due to venting.

11. Ground shock effects.

12. Blast environment due to explosions within structures.

13. Blast environment within structures due to explosions outside the structure.

14. Blast door design. Results of ESKIMO test series.

15. Design of reinforced concrete flat slabs, beam and column.

16. Suppressive shielding design.

Figure 8. New data to be incorporated in the Protective Design Manual