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SAFETY LIBRARY PUBLICATION

June 1991
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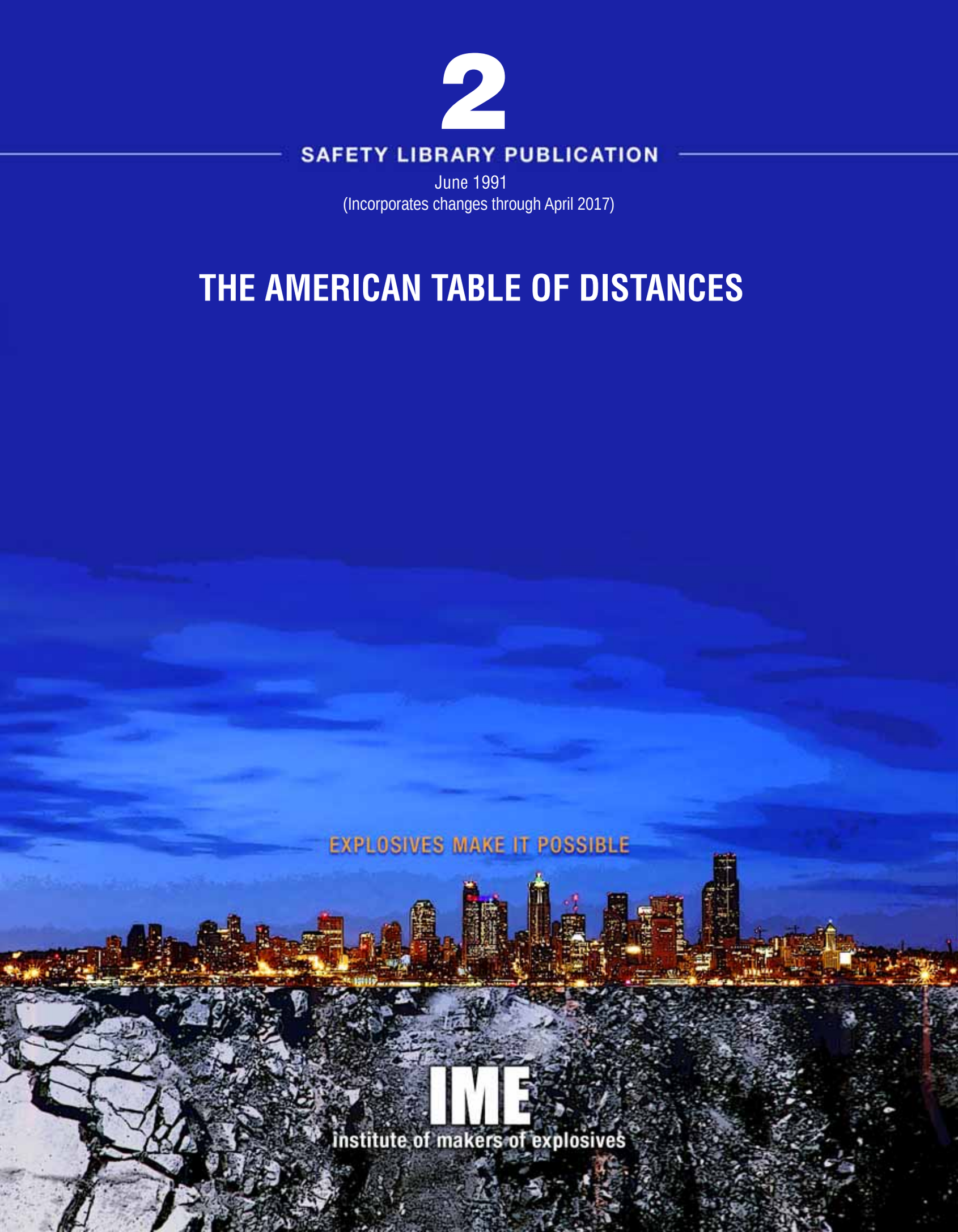
THE AMERICAN TABLE OF DISTANCES



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IME

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IME is a nonprofit association founded in 1913 to provide accurate information and comprehensive recommendations concerning the safety and security of commercial explosive materials. IME represents U.S. manufacturers and distributors of commercial explosive materials and oxidizers as well as other companies that provide related services. Although our member companies are based in North America, IME members operate globally with operations and distribution points on all continents except Antarctica.

Founded in 1913, IME was created to provide technically accurate information and recommendations concerning commercial explosive materials and to serve as a source of reliable information about their use. Committees of qualified representatives from IME member companies developed this information and significant portions of their recommendations are embodied here and in regulations of state and federal agencies.

The Institute's principal committees are: Environmental Affairs; Government Affairs, Legal Affairs; Safety and Health; Security; Technical; and Transportation and Distribution.

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SLP-2
American Table of Distances

FOREWORD

The original study to develop safe distances for the location of explosive storage magazines was begun in 1909, a time when a majority of explosive materials were transported by rail and explosive materials storage facilities were located near the railroad lines. The potential hazard to passenger carrying trains and residential areas near the railroad, should an explosion occur in the magazine, necessitated radical changes in magazine location.

A special committee of the Association of Manufacturers of Powder and High Explosives was appointed to study the problem and develop recommendations. After reviewing established foreign requirements, the committee determined that these regulations could not be utilized for conditions existing in the United States. The committee then decided to develop an American Table of Distances (ATD) based on empirical data gathered from explosions that had occurred in the field.

Information was gathered on a number of explosions ranging from very small amounts of explosive materials to some approximating one million pounds. The explosions studied covered a period of almost fifty years and occurred in manufacturing, transportation, and storage, both in the United States and abroad.

Based on the work of the special committee of the Association of Manufacturers of Powder and High Explosives, the American Table of Distances for inhabited buildings and public railways was established in December 1910.

When it became apparent that the distance table should also contain minimum safe distances for the location of explosive storage and manufacturing buildings from public highways, the special committee, in conjunction with the Institute of Makers of Explosives (founded in 1913), conducted additional studies. The highway distances were approved and adopted by the Institute of Makers of Explosives in 1914.

After the adoption of the American Table of Distances, the collection of data on explosions was continued. The table was reviewed in 1919 and again in 1939 to evaluate it and consider the data accumulated since the table was established. No significant revisions were made after either review.

CHANGES TO THE ATD

Another detailed study of the table was made in 1950 to distinguish between military explosives (bombs, projectiles, cased ammunition, etc.) and commercial explosive materials, which have virtually no missile hazard. The study also noted that the table was specifically designed to cover manufacture and permanent storage of explosive materials and was not applicable for the incidental handling or temporary storage of explosive materials being transported.

Based on tests conducted by governmental agencies and scientific laboratories much additional data on blast effects have been accumulated since 1950. The current edition of the ATD includes revisions and additions based on these findings, together with the excellent experience acquired after over 75 years of use.

In the study of explosion damage data, the criteria for inhabited buildings was the distance at which substantial structural damage took place. For example, such minor damage as the breaking of window glass and the shaking down of plaster was not considered. To address this distinction, IME developed a definition for substantial structural damage, from two points of view:

DAMAGE TO PROPERTY – It was concluded that no damage that was readily repairable should be considered "substantial."

RISK TO LIFE AND LIMB – It was concluded that unless some integral portion of the building was damaged, the occupants would not be subjected to serious risks.

Storage of large quantities of explosives in heavily populated or built-up areas should be avoided. While the tables provide adequate and reasonable protection for exposures in rural areas, the statistical nature of blast damage makes it inadvisable to subject multiple exposures to blasts at the distances prescribed. This consideration has led to an increase in distances required from major highways.

Barricade Distance Requirements

Air blast damage at distances in excess of a few tens of feet is little affected by revetment or natural barricades. However, missile hazards are substantially affected by barricades. Accumulated experience plus Department of Defense (DOD) studies of explosion-propelled missiles indicates that, at large distances, the doubling of the barricaded distance is not required. The current tables reflect this finding.

Distances to Main Highways

Blast effects on vehicles have been analyzed extensively by government agencies in connection with assessing effects of military weapons. This work has shown the recommended distances from stored explosives to heavily traveled, high-speed highways as given in the table are necessary. Consultation and advice from the Department of Defense Explosives Safety Board (DDESB) is gratefully acknowledged in our analysis of this problem.

The distances given in the table are not to be construed as superseding the distances in any federal, state or municipal laws, ordinances, or regulations.

Table of Recommended Separation Distances (Appendix I)

Fundamental to proper application of the American Table of Distances for Storage of Explosive Materials is the question of whether adjacent stores of explodable materials can propagate from an explosion at one source. If propagation can occur, the respective weights must be summed in determining safe distances from dwellings, highways, and passenger railways. Appendix I comprises such non-propagating distances with definitions, explanations, and examples. Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents is printed on pages 10 through 14.

NOTE:

Use the *American Table of Distances for Storage of Explosive Materials* to determine minimum safe distances from inhabited dwellings, highways, passenger railways, and between explosive materials magazines.

Use Appendix I, *Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents,* to determine minimum non-propagating distances to ANFO, blasting agents and ammonium nitrate.

Use the greater of the distances shown in the American Table of Distances or in the Table of Recommended Separation Distances to determine the required separation between a magazine for storage of explosives and a magazine for storage of blasting agents.

Quantitative Risk Assessment (QRA)

The ATD has stood the test of time, having been the standard for commercial explosives storage in the U.S. for over 100 years. Although detonations of explosives in magazines are extremely rare events, they have occurred. No fatalities or serious injuries have ever occurred within the distances specified by the ATD in any of these events. Nonetheless, in 2005, the IME embarked on the development of a comprehensive QRA software model for a wide variety of commercial explosives activities, including storage. The need to have standards for other commercial explosives activities, the growing influence of QRA around the world, and a unique opportunity to share technology developed by the DDESB were major factors in IME's decision. In 2007, IME and APT Research, Inc, released the software model IMESAFR V1.0. IMESAFR takes into account the probability of an event [P(e)] occurring and predicts consequences of an explosion in great detail. IMESAFR V1.0 was updated by IMESAFR V2.0 in 2013 providing a more user-friendly interface, additional evaluation parameters, and improved analysis based upon additional testing completed subsequent to the initial release of IMESAFR.

In most storage scenarios, the ATD provides a simple and safe means of limiting risk to extremely low levels, and is often required by regulation. However, QRA is often useful in situations where the regulations do not present a valid solution or an entity engages in a wide variety of activities with varying P(e) but wants to maintain an equivalent level of risk across all activities. QRA is also helpful with scenarios involving unique circumstances, extremely high or low exposures of people, or risk levels near tolerable amounts. QRA provides the explosives risk manager with a whole new set of tools with which to consider risk.

The use of QRA for explosives risk management has increased dramatically since the Swiss started using it in the 1960's. Today, the DDESB and many other national and state regulators use QRA to manage explosives risk.

IME recommends that the most current version of IMESAFR be used for QRA of commercial explosives activities.

American Table of Distances for Storage of Explosive Materials as Revised and Approved by the Institute of Makers of Explosives – June 1991

Quantity of Explosive Materials [1,2,3,4]		Distances in Feet							
		Inhabited Buildings [9]		Public Highways with Traffic Volume of less than 3,000 Vehicles/Day [11]		Passenger Railways- Public Highways with Traffic Volume of more than 3,000 Vehicles/Day [10, 11]		Separation of Magazines [12]	
Pounds Over	Pounds Not Over	Barricaded [6,7,8]	Unbarricaded	Barricaded [6,7,8]	Unbarricaded	Barricaded [6,7,8]	Unbarricaded	Barricaded [6,7,8]	Unbarricaded
0	5	70	140	30	60	51	102	6	12
5	10	90	180	35	70	64	128	8	16
10	20	110	220	45	90	81	162	10	20
20	30	125	250	50	100	93	186	11	22
30	40	140	280	55	110	103	206	12	24
40	50	150	300	60	120	110	220	14	28
50	75	170	340	70	140	127	254	15	30
75	100	190	380	75	150	139	278	16	32
100	125	200	400	80	160	150	300	18	36
125	150	215	430	85	170	159	318	19	38
150	200	235	470	95	190	175	350	21	42
200	250	255	510	105	210	189	378	23	46
250	300	270	540	110	220	201	402	24	48
300	400	295	590	120	240	221	442	27	54
400	500	320	640	130	260	238	476	29	58
500	600	340	680	135	270	253	506	31	62
600	700	355	710	145	290	266	532	32	64
700	800	375	750	150	300	278	556	33	66
800	900	390	780	155	310	289	578	35	70
900	1,000	400	800	160	320	300	600	36	72
1,000	1,200	425	850	165	330	318	636	39	78
1,200	1,400	450	900	170	340	336	672	41	82
1,400	1,600	470	940	175	350	351	702	43	86
1,600	1,800	490	980	180	360	366	732	44	88
1,800	2,000	505	1,010	185	370	378	756	45	90
2,000	2,500	545	1,090	190	380	408	816	49	98
2,500	3,000	580	1,160	195	390	432	864	52	104
3,000	4,000	635	1,270	210	420	474	948	58	116
4,000	5,000	685	1,370	225	450	513	1,026	61	122
5,000	6,000	730	1,460	235	470	546	1,092	65	130
6,000	7,000	770	1,540	245	490	573	1,146	68	136
7,000	8,000	800	1,600	250	500	600	1,200	72	144
8,000	9,000	835	1,670	255	510	624	1,248	75	150
9,000	10,000	865	1,730	260	520	645	1,290	78	156
10,000	12,000	875	1,750	270	540	687	1,374	82	164

American Table of Distances for Storage of Explosive Materials
as Revised and Approved by the Institute of Makers of Explosives – June 1991 (Continued)

Quantity of Explosive Materials [1,2,3,4]		Distances in Feet							
		Inhabited Buildings [9]		Public Highways with Traffic Volume of less than 3,000 Vehicles/Day [11]		Passenger Railways-Public Highways with Traffic Volume of more than 3,000 Vehicles/Day [10, 11]		Separation of Magazines [12]	
Pounds Over	Pounds Not Over	Barricaded [6,7,8]	Unbarricaded	Barricaded [6,7,8]	Unbarricaded	Barricaded [6,7,8]	Unbarricaded	Barricaded [6,7,8]	Unbarricaded
12,000	14,000	885	1,770	275	550	723	1,446	87	174
14,000	16,000	900	1,800	280	560	756	1,512	90	180
16,000	18,000	940	1,880	285	570	786	1,572	94	188
18,000	20,000	975	1,950	290	580	813	1,626	98	196
20,000	25,000	1,055	2,000	315	630	876	1,752	105	210
25,000	30,000	1,130	2,000	340	680	933	1,866	112	224
30,000	35,000	1,205	2,000	360	720	981	1,962	119	238
35,000	40,000	1,275	2,000	380	760	1,026	2,000	124	248
40,000	45,000	1,340	2,000	400	800	1,068	2,000	129	258
45,000	50,000	1,400	2,000	420	840	1,104	2,000	135	270
50,000	55,000	1,460	2,000	440	880	1,140	2,000	140	280
55,000	60,000	1,515	2,000	455	910	1,173	2,000	145	290
60,000	65,000	1,565	2,000	470	940	1,206	2,000	150	300
65,000	70,000	1,610	2,000	485	970	1,236	2,000	155	310
70,000	75,000	1,655	2,000	500	1,000	1,263	2,000	160	320
75,000	80,000	1,695	2,000	510	1,020	1,293	2,000	165	330
80,000	85,000	1,730	2,000	520	1,040	1,317	2,000	170	340
85,000	90,000	1,760	2,000	530	1,060	1,344	2,000	175	350
90,000	95,000	1,790	2,000	540	1,080	1,368	2,000	180	360
95,000	100,000	1,815	2,000	545	1,090	1,392	2,000	185	370
100,000	110,000	1,835	2,000	550	1,100	1,437	2,000	195	390
110,000	120,000	1,855	2,000	555	1,110	1,479	2,000	205	410
120,000	130,000	1,875	2,000	560	1,120	1,521	2,000	215	430
130,000	140,000	1,890	2,000	565	1,130	1,557	2,000	225	450
140,000	150,000	1,900	2,000	570	1,140	1,593	2,000	235	470
150,000	160,000	1,935	2,000	580	1,160	1,629	2,000	245	490
160,000	170,000	1,965	2,000	590	1,180	1,662	2,000	255	510
170,000	180,000	1,990	2,000	600	1,200	1,695	2,000	265	530
180,000	190,000	2,010	2,010	605	1,210	1,725	2,000	275	550
190,000	200,000	2,030	2,030	610	1,220	1,755	2,000	285	570
200,000	210,000	2,055	2,055	620	1,240	1,782	2,000	295	590
210,000	230,000	2,100	2,100	635	1,270	1,836	2,000	315	630
230,000	250,000	2,155	2,155	650	1,300	1,890	2,000	335	670
250,000	275,000	2,215	2,215	670	1,340	1,950	2,000	360	720
275,000	300,000	2,275	2,275	690	1,380	2,000	2,000	385	770

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Explanatory Notes Essential to the Application of the American Table of Distances for Storage of Explosive Materials

NOTE 1 – "Explosive materials" means explosives, blasting agents and detonators.

NOTE 2 – "Explosives" means any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion. The term includes, but is not limited to, dynamite and other high explosives, black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, and igniters. A list of explosives determined to be within the coverage of 18 U.S.C. Chapter 40, "*Importation, Manufacturer, Distribution and Storage of Explosive Materials*" is issued at least annually by the director of the Bureau of Alcohol, Tobacco, Firearms and Explosives of the Department of Justice. For quantity and distance purposes, detonating cord of 50 grains per foot should be calculated as equivalent to 8 lbs. of high explosives per 1,000 feet. Heavier or lighter core loads should be rated proportionately.

NOTE 3 – "Blasting agents" means any material or mixture, consisting of fuel and oxidizer, intended for blasting not otherwise defined as an explosive: provided, that the finished product, as mixed for use or shipment, cannot be detonated by means of a No. 8 test blasting cap when unconfined.

NOTE 4 – "Detonator" means any device containing any initiating or primary explosive that is used for initiating detonation. A detonator may not contain more than 10 grams of total explosives by weight, excluding ignition or delay charges. The term includes, but is not limited to, electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuses, detonating cord delay connectors, and nonelectric instantaneous and delay blasting caps which use detonating cord, shock tube, or any other replacement for electric leg wires. Where actual explosive weight of detonators is unknown, detonators in strengths through No. 8 cap should be rated at 2.2 lbs. of explosives per 1,000 caps. For strengths higher than No. 8 cap, consult the manufacturer.

NOTE 5 – "Magazine" means any building, structure, or container, other than an explosives manufacturing building, approved for the storage of explosive materials.

NOTE 6 – "Natural Barricade" means natural features of the ground, such as hills, or timber of sufficient density that the surrounding exposures which require protection cannot be seen from the magazine when the trees are bare of leaves.

NOTE 7 – "Artificial Barricade" means an artificial mound or revetted wall of earth of a minimum thickness of three feet.

NOTE 8 – "Barricaded" means the effective screening of a building containing explosive materials from the magazine or other building, railway, or highway by a natural or an artificial barrier. A straight line from the top of any sidewall of the building containing explosive materials to the eave line of any magazine or other building or to a point 12 feet above the center of a railway or highway shall pass through such barrier.

NOTE 9 – "Inhabited Building" means a building regularly occupied in whole or part as a habitation for human beings, or any church, schoolhouse, railroad station, store, or other structure where people are accustomed to assemble, except:

(a) any building occupied in connection with the manufacture, transportation, storage, or use of explosive materials;

(b) any office or repair shop, which is a part of the premises of an explosives manufacturer and is used in connection with the manufacture, transportation, storage, or use of explosive materials (see ATF Ruling 75-20);

(c) any structure used to store items other than explosive materials that is visited on a regular basis by one individual (see ATF Ruling 2005-3);

(d) any buildings occupied by licensed explosives manufacturers in connection with the manufacture, transportation, storage, or use of explosive materials with respect to magazines located on their own premises (see ATF Ruling 2005-3); or

(e) any buildings occupied by licensed explosives manufacturers in connection with the manufacture, transportation, storage, or use of explosives materials with respect to magazines located on property owned by another licensee (see ATF Ruling 2005-3).

NOTE 10 – "Railway" means any steam, electric, or other railroad or railway which carries passengers for hire.

NOTE 11 – "Highway" means any public street, public alley, or public road.

NOTE 12 – When two or more storage magazines are located on the same property, each magazine must comply with the minimum distances specified from inhabited buildings, railways, and highways, and, in addition, they should be separated from each other by not less than the distances shown for "Separation of Magazines," except that the quantity of explosive materials contained in detonator magazines shall govern in regard to the spacing of said detonator magazines from magazines containing other explosive materials. If any two or more magazines are separated from each other by less than the specified "Separation of Magazines" distances, then such two or more magazines, as a group, must be considered as one magazine, and the total quantity of explosive materials stored in such group must be treated as if stored in a single magazine located on the site of any magazine of the group, and must comply with the minimum of distances specified from other magazines, inhabited buildings, railways, and highways.

NOTE 13 – Storage in excess of 300,000 lbs. of explosive materials, in one magazine is generally not required for commercial enterprises.

NOTE 14 – This Table applies only to the manufacture and permanent storage of commercial explosive materials. It is not applicable to transportation of explosives or any handling or temporary storage necessary or incident thereto. It is not intended to apply to bombs, projectiles, or other heavily encased explosives.

NOTE 15 – When a manufacturing building on an explosive materials plant site is designed to contain explosive materials, such building shall be located from inhabited buildings, public highways and passenger railways in accordance with the American Table of Distances based on the maximum quantity of explosive materials permitted to be in the building at one time.

NOTE 16 – Where metric conversion is required, the following conversion factors should be used:

- To convert feet to meters, multiply the number of feet by 0.3048
- To convert kilograms to pounds, multiply the number of kilograms by 2.2046

Example:

Determine inhabited building distance (IBD) barricaded for 200 kg of explosives:

1. Multiply 200 kg by 2.2046 to obtain the number of pounds, which is 441.
2. Using the ATD find the appropriate weight range. In this case, it would be the range of 400 – 500 lbs (see Figure 1).
3. Determine the distance in feet, in this case 320 feet (see Figure 1), and multiply by 0.3048 to determine the IBD (barricaded) in meters, which is 97.5 meters.

So, for 200 kg of explosives, the IBD (barricaded) is 97.5 meters

Quantity of Explosive Materials [1,2,3,4]		Inhabited Buildings [9]		
Pounds Over	Pounds Not Over	Barricaded [6,7,8]	Unbarricaded	B
0	5	70	140	
5	10	90	180	
10	20	110	220	
20	30	125	250	
30	40	140	280	
40	50	150	300	
50	75	170	340	
75	100	190	380	
100	125	200	400	
125	150	215	430	
150	200	235	470	
200	250	255	510	
250	300	270	540	
300	400	295	590	
400	500	320	640	
500	600	340	680	
600	700	355	710	

Figure 1

AMERICAN TABLE OF DISTANCES

The American Table of Distances applies to the manufacture and permanent storage of *commercial* explosive materials. The distances specified are those measured from the explosive materials storage facility to the inhabited building, highway, or passenger railway, irrespective of property lines.

The American Table of Distances covers all *commercial* materials, including, but not limited to, high explosives, blasting agents, detonators, initiating systems and explosives materials in process. The table is not designed to be altered or adjusted to accommodate varying explosive characteristics such as blast effect, weight strength, density, bulk strength, detonation velocity, etc.

The American Table of Distances should not be used to determine safe distances for blasting work, the firing of explosive charges for testing or quality control work, or the open detonation of waste explosive materials. The American Table of Distances may be used as a guide for developing distances for the unconfined, open burning of waste explosive materials where the probability of transition from burning to high order detonation is improbable.

APPENDIX A
RECOMMENDED SEPARATION DISTANCES OF AMMONIUM NITRATE AND BLASTING AGENTS FROM EXPLOSIVES OR BLASTING AGENTS

Chapter 1 – Derivation of the Table

1-1 A test program sponsored by industry with cooperation of the Manufacturing Chemists' Association and the Institute of Makers of Explosives and conducted by the Bureau of Mines developed data on the relative sensitivity of ammonium nitrate (AN) and ammonium nitrate-fuel oil (ANFO) to sympathetic detonation. These data were applied to the existing American Table of Distances for Storage of Explosives to develop the following table of recommended separation distances for ammonium nitrate and blasting agents from stores of high explosives or blasting agents.

1-2 The American Table of Distances for barricaded storage of explosives has been proven adequate through the years, and no data were developed in the test programs that would suggest that this table should be modified for explosives. On the other hand, a factor of 2 has been suggested in the past for increasing the distances listed in the American Table of Distances when the magazines are unbarricaded. The results, employing two charge sizes of AN and one charge size of ANFO, gave ratios of unbarricaded to barricaded distances of 4.2 to 7.4, for an average of about 6 which was taken as the appropriate factor. Thus, unbarricaded stores of AN or ANFO not in bullet-resistant magazines should have 6 times the separation distances as barricaded stores.

1-3 The relative sensitivity of AN and ANFO to dynamite was obtained by examining the relative K factors for 50 percent propagation distances when the cube root of the weight was employed in the usual equation:

$$S=KW^{1/3}$$

This equation allowed comparison of 1,600-pound dynamite acceptors with 5,400-pound AN and ANFO acceptors; results from these charges are believed to be the most reliable available. The ratio of K factors for dynamite and AN was 6.27 which was rounded to 6; the ratio for dynamite and ANFO was 1.6. These factors were applied to the American Table of Distances by thus reducing the distance for barricaded ammonium nitrate to 1/6 the corresponding distance for explosives in the American Table of Distances and for ANFO to 6/10.

1-4 One point should be emphasized: the distances in the table are for separation of stores only. No change should be made in the American Table of Distances with respect to inhabited buildings, passenger railways, and public highways, as the blast effect from ANFO is not importantly less than for high explosives, but the blast effect from AN is about one-half that from high explosives. The blast effect is little modified by the presence of barricades, but the American Table of Distances for separation of stores from inhabited buildings, passenger railways, and public highways for unbarricaded stores provides an additional safety factor and should be retained.

Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents

Donor Weight		*Minimum Separation Distance of Acceptor when Barricaded[2] (ft.)*		*Minimum Thickness of Artificial Barricades[5] (in.)*
Pounds Over	*Pounds Not Over*	*Ammonium Nitrate[3]*	*Blasting Agent[4]*	
	100	3	11	12
100	300	4	14	12
300	600	5	18	12
600	1,000	6	22	12
1,000	1,600	7	25	12
1,600	2,000	8	29	12
2,000	3,000	9	32	15
3,000	4,000	10	36	15
4,000	6,000	11	40	15
6,000	8,000	12	43	20
8,000	10,000	13	47	20
10,000	12,000	14	50	20
12,000	16,000	15	54	25
16,000	20,000	16	58	25
20,000	25,000	18	65	25
25,000	30,000	19	68	30
30,000	35,000	20	72	30
35,000	40,000	21	76	30
40,000	45,000	22	79	35
45,000	50,000	23	83	35
50,000	55,000	24	86	35
55,000	60,000	25	90	35
60,000	70,000	26	94	40
70,000	80,000	28	101	40
80,000	90,000	30	108	40
90,000	100,000	32	115	40
100,000	120,000	34	122	50
120,000	140,000	37	133	50
140,000	160,000	40	144	50
160,000	180,000	44	158	50
180,000	200,000	48	173	50
200,000	220,000	52	187	60
220,000	250,000	56	202	60
250,000	275,000	60	216	60
275,000	300,000	64	230	60

See notes following and on page 3.

Notes to Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents

NOTE 1 – Recommended separation distances to prevent explosion of ammonium nitrate and ammonium nitrate-based blasting agents by propagation from nearby stores of high explosives or blasting agents referred to in the Table as the "donor." Ammonium nitrate, by itself, is not considered to be a donor when applying this Table. Ammonium nitrate, ammonium nitrate-fuel oil or combinations thereof are acceptors. If stores of ammonium nitrate are located within the sympathetic detonation distance of explosives or blasting agents, one-half the mass of the ammonium nitrate should be included in the mass of the donor.

NOTE 2 – When the ammonium nitrate and/or blasting agents are not barricaded with the prescribed minimum thickness, the distances shown in the Table shall be multiplied by six. These distances allow for the possibility of high velocity metal fragments from mixers, hoppers, truck bodies, sheet metal structures, metal containers, and the like which may enclose the "donor." Where storage is in bullet-resistant magazines[1] recommended for explosives or where the storage is protected by a bullet-resistant wall, distances and barricade thicknesses in excess of those prescribed in the American Table of Distances are not required.

NOTE 3 – The distances in the Table apply to ammonium nitrate and ammonium nitrate based materials that show "negative" (-) result in the UN Test Series 2 Gap Test and show "positive" (+) result in the UN Test Series 1 Gap Test. Ammonium nitrate and ammonium nitrate based materials that are DOT hazard Class 1 sensitive shall be stored at separation distances determined by the American Table of Distances.

NOTE 4 – These distances apply to blasting agents, which pass the insensitivity test prescribed in regulations of the U.S. Department of Transportation and the U.S. Department of Justice, Bureau of Alcohol, Tobacco, Firearms and Explosives.

NOTE 5 – Earth, or sand dikes, or enclosures filled with the prescribed minimum thickness of earth or sand are acceptable artificial barricades. Natural barricades, such as hills or timber of sufficient density that the surrounding exposures which require protection cannot be seen from the "donor" when the trees are bare of leaves, are also acceptable.

NOTE 6 – For determining the distances to be maintained from inhabited buildings, passenger railways, and public highways, use the American Table of Distances for Storage of Explosive Materials.

[1] For construction of bullet-resistant magazines see Bureau of Alcohol, Tobacco, Firearms and Explosives, Department of Justice, Publication ATF P 5400.7 (9/00), Federal Explosives Law and Regulations

Chapter 2 – Guide to Use of Table of Recommended Separation Distances of Ammonium Nitrate and Blasting Agents from Explosives or Blasting Agents

2-1 Sketch location of all potential donor and acceptor materials together with the *maximum* mass of material to be allowed in that vicinity. (Potential donors are high explosives, blasting agents, and combination of masses of detonating materials. Potential acceptors are high explosives, blasting agents, and ammonium nitrate.)

2-2 Consider separately each donor mass in combination with each acceptor mass. If the masses are closer than table allowance (distances measured between nearest edges), the combination of masses becomes a new potential donor of weight equal to the total mass. When individual masses are considered as donors, distances to potential acceptors shall be measured between edges. When combined masses within propagating distance of each other are considered as a donor, the appropriate distance to the edge of potential acceptors shall be computed as a weighted distance from the combined masses. (Use of weighted distances requires a variance from ATF.)

Calculation of weighted distance from combined masses:

Let M_2, M_3…….M_n be donor masses to be combined.
M_1 is a potential acceptor mass.
D_{12} is distance from M1 to M2 (edge to edge).
D_{13} is distance from M_1 to M_3 (edge to edge), etc.
To find weighted distance [$D_1(_{2,3,}\ldots\ldots_n)$] from combined masses to M_1, add the products of the individual masses and distances and divide the total by the sum of the masses thus:

$$D_1(_{2,3,}\ldots\ldots_n) = \frac{M_2 \text{ x } D_{12} + M_3 \text{ x } D_{13}\ldots + M_n \text{ x } D_{1n}}{M_2 + M_3\ldots + M_n} \quad (1)$$

Propagation is possible if either an individual donor mass is less than the tabulated distance from an acceptor or a combined mass is less than the weighted distance from an acceptor.

2-3 In determining the distances separating highways, railroads, and inhabited buildings from potential explosions (see American Table of Distances for Storage of Explosive Materials), the sum of all masses which may propagate (i.e., lie at distances less than prescribed in the table) from *either* individual *or* combined donor masses are included. However, when the ammonium nitrate must be included, only 50 percent of its weight shall be used because of its reduced blast effects.

In applying the American Table of Distances to distances from highways, railroads, and inhabited buildings, distances are measured from the nearest edge of potentially explodable material as prescribed in the American Table of Distances, Note 5. (See American Table of Distances for Storage of Explosive Materials on pages 4 through 7.)

2-4 When all or part of a potential donor comprises high explosives, storage in bullet-resistant magazines is required. Safe distances to stores in bullet-resistant magazines may be obtained from the inter-magazine distances prescribed in the American Table of Distances.

2-5 Barricades must not have line-of-sight openings between potential donors and acceptors which permit blast or missiles to move directly between masses.

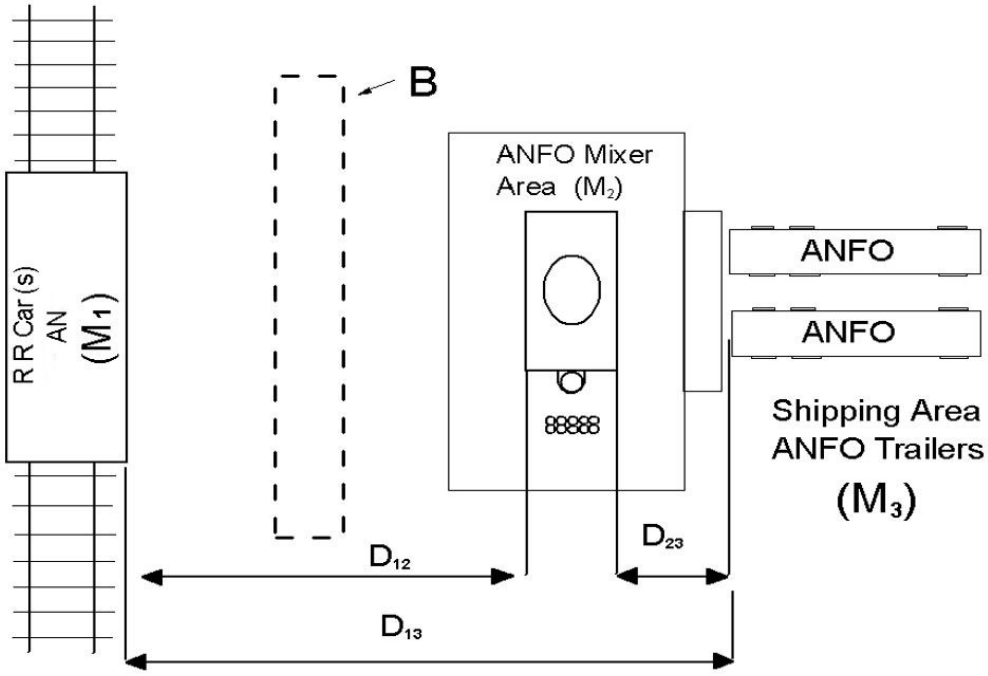


Figure 1.

Example 1 **ANFO Mix Plant (Figure 1)**

M_1	100,000	lbs. AN Prills (maximum)
M_2	2,500	lbs. ANFO (maximum)
M_3	80,000	lbs. ANFO (maximum)
D_{12}	20	ft.
D_{23}	20	ft.
D_{13}	50	ft.

No other stores on site; no barricade exists.

Potential Donor	Potential acceptor	Distance On Site	Table Distance, Minimum Required (ft.)	Propagation Possible?
M_2 (2,500 lbs.)	M_1	20	9 x 6 = 54	Yes
M_3 (80,000 lbs.)	M_1	50	28 x 6 = 168	Yes
M_3 (80,000 lbs.)	M_2	20	101 x 6 = 606	Yes

Conclusion:

The maximum amount of blasting agent to be considered for public protection at this site is sum of all masses, reducing AN mass by 50 percent as indicated in Paragraph 23.

100,000 x 50% = 50,000
2,500
80,000
132,500 pounds

In accordance with the American Table of Distances, the required separation distance from an inhabited building (unbarricaded) is 2,000 feet.

Example 2 **ANFO Mix Plant (Figure 1)**

M_1	100,000	lbs. AN Prills (maximum)
M_2	2,500	lbs. ANFO (maximum)
M_3	80,000	lbs. ANFO (maximum)
D_{12}	20	ft.
D_{23}	20	ft.
D_{13}	50	ft.

No other stores on site; a 4-foot thick earth barricade exists at B (Figure 1).

Potential Donor	Potential Acceptor	Distance On Site (ft.)	Table Distance, Minimum Required (ft.)	Propagation Possible?
M_2 (2,500 lbs.)	M_1	20	9	No
M_3 (80,000 lbs.)	M_1	50	28	No
M_3 (80,000 lbs.)	M_2	20	6 x 101 = 606	Yes
Combined M_2 + M_3 (82,500 lbs.)	M_1	49*	30	No

Note – ATF variance required for weighted distances.

Conclusion:

The maximum amount of blasting agent to be considered for public protection at this site is the sum of M_2 plus M_3 or 82,500 pounds. In accordance with the American Table of Distances, the required separation distance from an inhabited building (unbarricaded) is 2,000 feet. If a natural or artificial barricade protects the building, the required distance is 1,730 feet.

*Compute weighted distance to combined mass by equation 1 (Note – ATF variance required):

$$\frac{2{,}500 \times 20 + 80{,}000 \times 50}{2{,}500 + 80{,}000} = 49 \text{ feet}$$

APPENDIX B
LOCATION OF MAGAZINES
NEAR OVERHEAD ELECTRICAL TRANSMISSION LINES

Magazines should be located from overhead transmission lines at a distance greater than the distance between the poles or towers supporting the lines. Service lines of all types should, except for telephone connections and similar low-voltage intercom or alarm systems, be run underground from a point at least 50 feet away from the explosive storage magazines.

NOTES

NOTES

A-P-T RESEARCH, INC.

IMESAFR

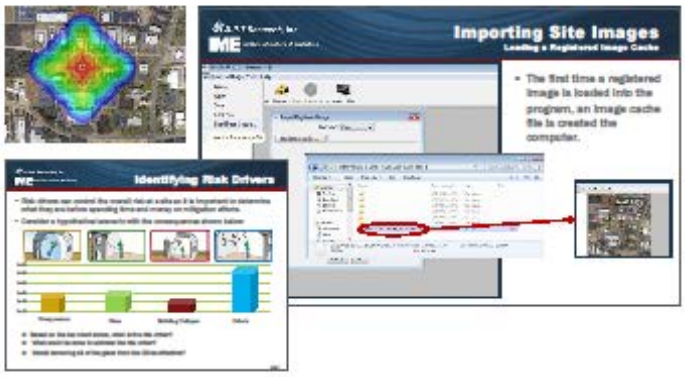
Institute of Makers of Explosives Safety Analysis for Risk

What is IMESAFR?

Institute of Makers of Explosives (IME) Safety Analysis for Risk (IMESAFR) is a software model that was developed through a joint effort by IME and A-P-T Research, Inc.

IMESAFR is a probabilistic risk assessment tool used to calculate risk to personnel from explosives facilities. This software not only calculates Quantity Distances (QD) based on the American Table of Distances and other QD regulations, it can determine a level of safety based upon risk.

IMESAFR uses the donor structure and activity, the structure of the exposed sites, and duration of exposed personnel to determine a level of safety. The program provides users with the ability to work in metric or imperial measures, and allows users to import maps or drawings of their site to assist with visualizing facility layouts and results.



Why was IMESAFR developed?

IMESAFR was developed to provide a more comprehensive assessment of the overall risk of explosives operations. The commercial explosives industry in the United States uses the American Table of Distances (ATD) as the basis for safe siting of explosives storage facilities. ATD siting involves the evaluation of a specific magazine and inhabited building or public highway, which are referred to as a Potential Explosion Site (PES)/Exposed Site (ES) pair in IMESAFR. This evaluation yields the recommended separation distance based on the factors that affect risk, including whether a barricade exists. Although the same criteria can be applied to explosives manufacturing operations, the ATD was intended for use in limited permanent storage situations. In addition to permanent storage situations, IMESAFR accounts for other activities such as manufacturing, assembly, and loading and unloading.

IMESAFR Training Course

The course is presented over three days with eight hours of mixed lecture and discussion each day for a total of 24 classroom hours. Daily class hours are from 8am to 5pm with an hour for lunch and breaks mid-morning and mid-afternoon. A competency test will be given at the end of the course.

Class Size: minimum of 10, maximum of 25.

Where

The class is normally held at the APT Safety Engineering and Analysis Center (SEAC) in Huntsville, AL, conveniently located in Cummings' Research Park near Redstone Arsenal.
See www.apt-research.com/contacts/contactUs.html for detailed directions.

The class may also be offered at other locations. On-site training courses can be arranged, as well as courses that run in conjunction with conferences and meetings.

Course Content

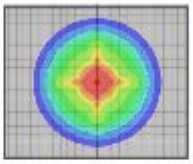
The IMESAFR Training Course will guide the user through the overall user interface of the IMESAFR Software. Some of the topics discussed are listed below.

- A background on the concepts and terminology used in the IMESAFR risk assessment software.
- A thorough guide on using input screens and choosing the proper input selection.
- A description of the capabilities of IMESAFR including menu options, functions of the tool bar, help menu and generating reports.
- An overview of the 26-step process used by IMESAFR to familiarize the user with the exposure and consequence analysis.
- Multiple examples (some worked individually and some as a group) demonstrating the various capabilities of IMESAFR.
- Practical applications of the software and its use in the risk management process.

Course Outline

1. Overview
2. QD Concepts & Background
3. QRA Concepts & Background
4. IMESAFR Features
5. Class Exercise 1
6. Risk Management
7. Advanced Tools
8. Architecture - Part 1
9. Architecture - Part 2
10. IMESAFR Protocols
11. Linking Architecture to Testing
12. Class Exercise 2
13. Approval Process
14. Input Decisions
15. Group Exercise
16. Test

Each student is responsible for bringing a laptop to training. A training book is included in the course fee.



Schedule

www.apt-research.com/capabilities/training.html

CEU

Upon completion of this course, attendees will be credited with 2.0 Continuing Education Units (CEU).

Cost

New IMESAFR 2.0:
- Non IME member: US$1500
- IME member: US$750

Upgrade IMESAFR 2.0:
- Non IME member: US$750
- IME member: US$375

Training voucher: US$1500

Registration Information

To register for a class in Huntsville or if you are interested in setting up a training course at a location other than Huntsville, please contact:

Dean Nichols
256.327.3373
imesafrtraining@apt-research.com

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institute of makers of explosives

The Institute of Makers of Explosives
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DESTRUCTION OF COMMERCIAL EXPLOSIVE MATERIALS

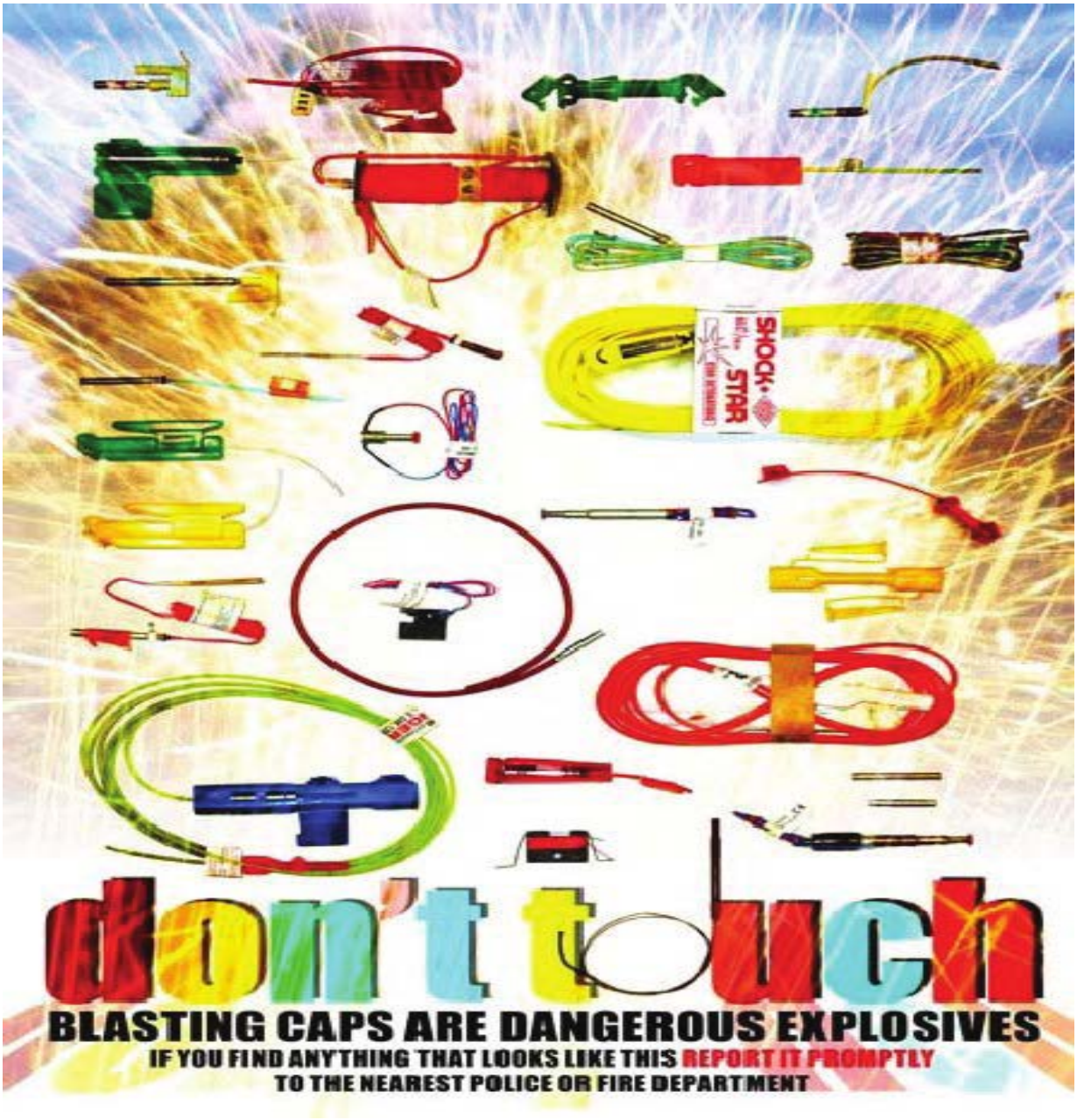
At times it may be necessary to destroy commercial explosive materials. These may consist of explosives or blasting agents from containers that have been broken during transportation or may be materials that have exceeded their recommended shelf life or are believed to be overage or are no longer needed.

Due to the many developments in explosive technology over the past few years, the appearance and characteristics of products have undergone marked changes. To be sure that you are familiar with the properties of the product that you plan to destroy, the manufacturer of that product should be consulted for the most current product information and the recommended method of disposal and/or destruction.

The member companies of the Institute of Makers of Explosives have agreed to supply advice and assistance in destroying explosives. If the manufacturer is known, seek his assistance. If the manufacturer is not known, a member company of the Institute of Makers of Explosives may provide advice or assistance.

The above policy of IME member companies relates only to commercial explosive materials. It does not include handling improvised explosive devices or bombs, military ordnance, military explosives, or homemade explosive materials.

IME member companies also cannot become involved in destroying explosive materials, which have been used for illegal purposes, are reportedly stolen property or are considered as evidence in any potential civil litigation or criminal prosecution.



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Printed in the USA