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This report concerns the types of injuries that will be produced by a nuclear explosion. The first topic to be covered will be scales of destruction, or how different sizes of bombs will produce different mixes of injuries and at what ranges. This part has a little math and geometry in it but is only five minutes long. Don't go to sleep yet! The second topic will be types and ranges of injuries caused by the blast portion of the bomb. This will cover injuries caused strictly by the over-pressure, throwing the body from the static pressure, injuries from hurled objects, and injuries from collapsing buildings. The third topic will cover immediate burns caused by the heat from the bomb itself and secondary burns from items ignited by the bomb. The fourth topic is ionizing radiation, prompt (immediate) and secondary (fallout).

Many films that you see about the effects of nuclear weapons are based on the experiance gained from Hiroshima and Nagasaki. Some people say that there is nothing to be learned from there since today the weapons are hundreds and thousands of times more powerful. Those films can be informative IF you understand that a bomb is a sherical phenomenon. People are used to thinking linearly 1+1=2, 2+2=4, etc. But spheres aren't like that. Let's look at some math for a bit here.

One dimension. All this is, is addition, 1+1=2, 2+2=4, 4+4=8, 8+8=16, etc.

If we want to increase the distance that we can reach with a stick all we have to do is increase the length of the stick by the same factor - in other words to double the distance/reach you just double length, triple the distance/reach, triple the length, ten times the distance/reach, ten times the length. That's simple, everybody understands that! However...

Two demensions, now we are talking of area, this is multiplication now! 1x1=1, 2x2=4, 4x4=16, 8x8=64, 64x64=4,096, etc. The term "SQUARED" is used, which is just a number multiplied by itself. 2 squared = 4, 4 squared = 16, 8 squared = 64, 64 squared is 4,096, etc. Think of this as pouring a bucket of paint over a flat floor and figuring out how many cans of paint we need to cover a larger circle than just a single can would cover.

If we want to increase the size of a circle that we are going to paint we have to use the formula of a circle's area which is Area = Pi times radius times radius or A = Pi x R x R or A = 3.1416 x R-squared. Here if we have a circle of one unit of radius (foot, meter, yard, whatever) we need "X" amount of paint to cover that area 3.1416 x 1 x 1 = "X". If our circle's radius increases by a factor of 2 we need 4 times "X" amount of paint, 3.1416 x 2 x 2 = 4"X", for three times the radius we need 9 times "X" amount of paint, 3.1416 x 3 x 3 = 9"X". For ten times the radius, 100 "X" amount of paint, 3.14.16 x 10 x 10 = 100"X". That's a little more difficult.

Three dimensions! Here's where we lose people. If you are sleep prone, I'll try to wake you after I talk about the math a bit. We are still using multiplication, just more of it! To figure out the Volume of a box we multiply Height times Width times Depth, or V = H x W x D. For calculating the volume of a shpere we take four divided three times Pi times radius times radius times radius, or Volume = 4/3 x Pi x R x R x R, or V = 1.3333 x 3.1416 x R x R x R, or V = 4.1888888 times R cubed. Cubed is just a number multiplied by itself twice. 1 cubed = 1x1x1 = 1, 2 cubed = 2x2x2

=8, 3 cubed = 3x3x3 = 9, 4 cubed = 4x4x4 = 64, 10 cubed = 10x10x10 = 1,000

Now that we know all of that!!! the rest is easy....

A standard rule of thumb for recalculating blast effects for various sizes of bombs is to take the megatonage of the new bomb divide by the megatonage of the old bomb, take the cube root of the results and multiply that times the radius of blast effect. Example to compare a 1 KT (0.001 MT) to a 1,000 KT (1MT) 1,000 divided by 1 = 1,000. The cube root of 1,000 is 10 (10x10x10=1,000). Therefore you can take the blast effect at X feet (or miles) for a 1 KT and multiply that distance by 10 to get approx. the same effect for a 1,000 KT bomb. Other common multipliers would be

Mulitplier/divider	cube/cube root	1 KT multiplier	1 MT divider
2	2x2x2=8	8 KT	125 KT (0.125MT)
3	3x3x3=27	27 KT	37 KT
4	4x4x4=64	64 KT	16 KT
5	5x5x5=125	125 KT	8 KT
6	6x6x6=216	216 KT	4 KT
7	7x7x7=343	343 KT	3 KT
8	8x8x8=512	512 KT	2 KT
9	9x9x9=729	729 KT	1 1/3 KT
10	10x10x10=1,000	1,000 KT (1 MT)	1 KT

So this shows that if you want to double the damage distance for a given size of bomb you need to increase the power by a factor of 8. If you want to double that distance again you need a bomb that is 8x8 or 64 times as powerful. This is why you can get the same amount of damage done with 10-40 KT bombs spread out as you can with a 1,000 KT (1 MT) bomb. So if we look at Hiroshima with 20KT and say okay what will a 1MT (1,000KT) bomb do? Well 1,000/20 = 50. Now then, what times what times what = 50, well 3.7 cubed is 50.653 so an effect one mile from GZ at Hiroshima will be the same effect at 3.7 miles for a 1MT. Now this is for blast effects not heat effects, we'll cover those later.

Okay any questions?

All right, that's the end of the math, you can wake up again!

Okay let's talk about blast injuries. To avoid confusion we need to talk about overpressure (static-pressure) and dynamic pressure. When you think about overpressure, think about a barometer, normal air pressure is about 15 P.S.I. Overpressure is simply the air pressure in excess of the normal atmospheric pressure. Overpressure is what would cause an empty sealed can to be crushed on all sides. Dynamic pressure is a wind. Dynamic pressure is the figure that we use to calculate the horsepower of a sail on a sailboat. Damage is caused by wind resistance. The dynamic pressure is proportional to the square of the wind speed and to the density of the air behind the shock front. In a nuclear blast the air density can be quite high and this is why just looking at the wind speed alone doesn't give the entire story. Also, the duration of the dynamic pressure comes into effect. Dynamic pressure is what would cause an empty sealed can to be blown into the next county. Think about a sheet of plywood placed perpendicular or parallel to a blast front. Ignoring the time it takes for the overpressure to get from the front to the back of the plywood, the overpressure shouldn't do much damage. Contrast that to the same sheet hit broadsides or sideways by dynamic pressure!

A further note on duration. Many things can take great stresses over very short periods of time. Example, a fast blow fuse can pass ten times its amperage rating for a fraction of a second. In overpressure this is why lung injuries occur at pressures that would not cause harm if the pressure were for only a second or two.

Ok, injuries in humans caused by the blast. Now when I talk about injuries from a specific effect I am talking about just that single effect. In real life, a victim might have some lung damage, some broken bones, 2nd degree burns, and some blood loss from flying glass shards. Each one seperately might not be lethal, but in combination they might be.

Let's start with overpressure. Overpressure is associated with ear and lung damage from fast-rising, long duration pressure pulses. If it were a slow rising pulse the body can equalize, as in scuba-diving. If it were short duration the parts could stand greater stress. You won't die from eardrum rupture, but it does reduce your abiltiies! 5 Pounds per Square Inch is where eardrum rupture starts. There is a great deal of variation in suscetabilty to damage. The very old are most susceptable. 50% of population rupture occurs at around 15-20 PSI for over 20 years old and around 30-35 PSI for under 20 years old. Again, there is a wide individual variance here. Also, some eardrum will spontaneously heal with only slight or partial hearing loss.
Lung damage begins at 12 (8-15) PSI. Severe lung damage occurs at 25 (20-30) PSI. Lethality begins at 40 (30-50) PSI, 50% lethal at 62 (50-75) PSI and 100% lethal 92 (75-115) PSI. P.549 "Persons who spontaneously survive for 24 to 48 hours in the absence of treatment, complications, or other injury usually recover and show little remaining lung hemmorrhage after 7 to 10 days. In very severe injuries under treatment, recurring lung hemorrhage has been reported as long as 5 to 10 days after injury.

Overpressure	20KT	200KT	2MT	20MT
1 PSI	3.5 miles	7.5 miles	16.5 miles	36 miles
2 PSI	2.1	4.6	10	21
5 PSI	1.1	2.5	5.4	12
40 PSI	.28	.6	1.3	2.8
62 PSI	.23	.5	1	2.3
92 PSI	.19	.4	.9	1.9

Any questions on overpressure?

Dynamic pressure injuries are typically measured in the speed (feet/second) at which a human body is thrown against something hard. Injuries here are cuncussion, skull, heel, foot, legs, and arm fractures. There is a great deal of variability in these injuries. A threshold of injuries standing up might occur at 10-12 ft/sec with fractures at 13-16 and while sitting the threshold may be 15-26 ft/sec. Skull fractures - "safe" 10 ft/sec, threshold 13, 50% at 18 ft/sec and 100% at 23. From total body impact - mostly "safe" 10 ft/sec., 1% fatal 21 ft/sec, 50% 54 ft/sec., and near 100% 138 ft/sec. These are assuming that the body is hurled perpendicular against a hard object.

Dynamic pressure	20KT	200KT	2MT	20MT
10 ft/sec	1.2 miles	3.0 miles	7.4 miles	17 miles
21 ft/sec	.9	2.4	6	14
54 ft/sec	.6	1.7	4	9.5

138 ft/sec	.3	.9	2.4	5.5

Well what about being blasted in an open field? You can be tumbled to death. There are no good figures on this since there is no actual data and only animal experiments have been used. The best guess is that 1% non-fatal injury would occur at 30 ft/sec. and 50% injured at 75 ft/sec. We really don't know.

Any questions on dynamic pressure?

Many casualties and deaths will occur from building collaspe. A typical house is calculated to have these characteristics. 50 PSI = 100% certian dead, 20 PSI = 50% killed - 35% trapped - 5% untrapped but seriously injured, 10 PSI = 10% killed - 35% trapped - 6% untrapped but seriously injured. 5 PSI = 1% killed - 10% trapped - 6% untrapped but seriously injured. Now those are from the British home office and for overpressure ONLY. I feel they are whistling in the dark, but perhaps they figure that a British house has stronger and heavier sidewalls if it uses structural brick or stone rather than using brick as a decorative siding as in America.

Injuries from heat can be burns from the flash or secondary fires. Flash burns and fires are HIGHLY variable due to landscape interference, dust and moisture in the air, and topography. While there is some damage from reflected light and heat, most of the damage is from line of sight to the point of explosion. Another complicating factor in heat related injuries is the speed at which the bomb releases its heat and how well the object or person relfects, absorbs or disipates the heat. Smaller bombs dump their heat quicker since there is less heat to dump. See chart.

Percentage of heat released	20 KT	200 KT	2 MT	20 MT
20%	.16 seconds	.4 seconds	1.15 seconds	3 seconds
50%	.35	.95	2.2	7
70%	.8	2.2	6	15

Whites reflect heat while blacks, blues, and purples absorb heat. Also, even though the object is stationary and doesn't move (by say failing to the ground and rolling) it can still release heat while more is coming in. That is why just looking at the calories per square centimeter at a certian distance does not tell the whole story. Examples, see P. 564 and P. 565. A third degree burn from a 10 MT ranges from 10.5 to 12.5 Calories per Square Centimeter depending on skin color and a 3rd degree from a 20 KT ranges from 6 to 8 Cal/SqCm. For those two bomb sizes 2nd degree burns range from 6.5 to 8.25 and 4 to 5 CSC. For 1st degree burns 3.5 to 4.5 and 2 to 2.5 CSC for 10MT and 20 KT. With the range of needed CSC linear for bombs in between those two sizes.

Degree of burn	20KT	200 KT	2 MT	20 MT
First	2.2 miles	6.2 miles	16 miles	35 miles
Second	1.7	4.8	12.5	30
Third	1.3	3.8	10.5	26.5

SIZE	35 KT	1.4 MT	20 MT
Paper bag burns	10 Cal/SqCm	13 Cal/SqCm	20 CSC
New blue jeans burn	12	27	44
white cotton shirt burns	32	48	85

Here is what range you would get from various bombs

Cal/SqCm	20 KT	200 KT	2 MT	20 MT
1	3.4 miles	9 miles	22 miles	
5	1.7	5	13	35
10	1.2	3.6	10.5	29
20	.85	2.6	8	23
50	.55	1.7	5.4	17
100	.4	1.2	4	13

Please remember these are assuming a clear sky, no rain, no dust, no haze, no smog, etc.

Injuries to eyes fall into two catagories. Permanent (retnal burns) and temporary flashblindness. You of course can suffer from both. Flashblindness is just like staring into a flashbulb, useful vision is lost for several seconds to several minutes. A retnal burn causes blindness on the point of the retina where the flash is seen. There is an emense variation here depending again on clarity of sky and also whether the pupil is wide open at night or fairly closed from mid-day sun. See page 571-574 for details.
There is one other eye "problem" that should be mentioned, Keratitis which is inflamation of the cornea. The symptoms are pain caused by light, a sensation that a foreign body is in the eye, lachrymation (unnatural tears), and redness. These symptoms lasted from a few hours to several days. At Hiroshima only 4% of those standing in the open within 1.25 miles of GZ suffered keratitis within 24 hours. An additional 1.5% had symptoms up to one month.

Wake up! I'm almost done.

The last and FINAL topic is radiation. Immediate radiation from the the blast is significant only from smaller bombs since the deadly other effects outdistance the radiation effects in larger bombs.

REMS	20 KT	200 KT	2 MT	20 MT
1	1.7 miles	2.1 miles	2.8 miles	4 miles
10	1.4	1.8	2.4	3.6
100	1.05	1.45	2.1	3.2
400	.9	1.3	1.8	3
1,000	.8	1.15	1.7	2.8
10,000	.54	.85	1.3	2.3
100,000	.32	.56	1.8	1.68
1,000,000	.16	.33	.59	.97

The reason that 10,000 REMS and higher is included in this chart is that it is possible to build shelters to withstand 200 PSI overpressure. These are usually buried enough to have Protection Factors of over 1 million. See FIGHTING CHANCE: 10 feet to Survival and FIGHTING CHANCE newsletter.

Strike Any Key To Continue