ASMRB House Rules

Version 1.5
January 9, 2000

1.0 Introduction

In general, the rules expressed in 'Danger International' are the base from which our changes have been made. We also endorse and encourage the use of the Snap Shot rule, the Set (Tracking) rule, the Reloading rules, the Group Hits and Damage Range rules, and all of the various Optional Effects of Damage rules (except perhaps Bleeding). We specifically warn against the use (except as fantastic magical effects) of Armor Piercing, Penetrating, and Hardening, however.

2.0 Movement

The full combat move of a character is figured as follows:

$$\textbf{inches per phase} = \frac{2 * (\textbf{inches}\text{, basic} + \textbf{inches}\text{, purchased})}{\textbf{Speed}\text{, phases}}$$

Example: Biker Bob, with a Speed of 3 and +1" of running purchased, would have 14 / 3 = 4.67" full combat move per phase, which rounds to 5".

3.0 Encumbrance

Use the following chart to determine encumbrance penalties to 'agility' skills (mostly DEX-based skills). Entries are given in kilograms, showing the maximum load for the listed encumbrance penalty:

	STR														
mod	**5**	**8**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**23**	**25**	**28**
0	2.3	2.8	3.1	3.4	3.7	3.9	4.2	4.5	4.9	5.2	5.6	6.0	6.3	7.9	9.1	11.2
-1	4.5	5.6	6.3	6.9	7.4	7.9	8.4	9.1	9.7	10.4	11.1	11.9	12.5	15.8	18.1	22.2
-2	9.1	11.1	12.5	13.7	14.7	15.8	16.9	18.1	19.4	21	22	24	25	32	36	44
-3	17.7	22	25	27	29	31	33	35	38	41	44	47	50	62	71	88
-4	35	44	50	54	57	62	66	70	76	81	87	93	100	123	141	174
-5	70	87	100	107	115	123	132	141	152	163	174	187	200	246	283	348

The chart is constructed based on a $3.125 \times 2^{(STR-10)/10}$ curve, and may be expanded indefinitely; note that a 10 point increase in STR moves the listed figures up 1 row. In figuring carried load, the mass of worn clothing, and ordinary load bearing equipment (belts, backpacks, ammo pouches, holsters, etc.) may be ignored.

Modifiers to the Defensive Combat Value (DCV) are figured by dividing the normal maximum carrying capacity (in kilograms) of the character by the 'best' usual DCV: typically, DCV from Dexterity and any skill levels which can be applied.

STR	5	8	10	11	12	13	14	15	16	17	18	19	20	23	25	28
CCAP, kg	50	76	100	115	132	152	174	200	230	264	303	348	400	606	800	1212

Example: Lady Paulonia Kindoren, with a STR of 13 and a 'best' DCV of 9, bearing a load of 25 kg, has a penalty of -3 to all DEX-based skills. Her DCV is reduced by 1.

3.1 Size for Concealment Purposes

When hiding weapons, etc. on characters, use the following chart to notate weapon size:

length, cm	10-13	14-15	16-17	18-19	20-24	25-30	31-40	+10 cm
size	0	1	2	3	4	5	6	+1

This assumes typical revolvers, automatic pistols, pump shotguns, etc. For weapons which (if carried loaded) have a protruding magazine or feed system, add 1 to the size from the above chart. Some fudging upwards is appropriate for weapons and items with other bulky, hard to conceal shapes.

Example: the M14 rifle is 112 cm long; with a 20 round magazine loaded, it has a size of 15.

4.0 Maximum DCV

The number of skill levels applied to DCV against ranged attacks (except Speed Ø weapons) may not be more than half of the basic (i.e., derived from DEX) DCV.

Example: a character with a DCV of 5 from DEX may not apply more than 2 skill levels to DCV vs. ranged attacks.

5.0 DCV Minimum from Velocity

Objects in relative motion have a minimum DCV figured as follows:

$$\mathbf{DCV_{minimum}} = 2 * \log_2(\mathbf{v})$$

v = *velocity*, inches/segment

This represents having to lead the target; thus the referee may adjust this figure downwards for some target courses (such as directly at the firing position), or for some weapon types which markedly reduce the amount of lead required (such as lasers)

Example: a Reichenberg R-111 flying at 650 kph (180 meters per second) has a minimum DCV of 13 to most characters firing machine-guns from the ground.

6.0 Time to Target

If a moving target is fired on with a weapon having an arrival delay of more than 1 second, and the target's motion is relatively predictable within the period of the delay, then an OCV penalty is applied, figured as follows:

$$\mathbf{OCV\ penalty} = \log_2(\mathbf{delay},\ \text{seconds})$$

If the target's motion is unpredictable within the delay period, then the attacker will have to choose a particular hex to engage.

Example: an 81mm mortar crew is firing on a railway locomotive at a range of 2000 meters; the locomotive is moving at 40 kph (10 meters per second). The locomotive's speed gives it a minimum DCV of 4. At 2000 meters range, an 81mm mortar shell has a flight time of approximately 30 seconds - thus subtracting 5 from the firing crew's OCV.

7.0 Targeting Aids for Ranged Weapons

A variety of methods and devices are available to improve the accuracy (both OCV and Range Mods) of small arms and some archery weapons. Remember that Brace and Set maneuvers each normally double the Range Mod of the weapon. The following chart summarizes the game characteristics of various features and accessories:

No Stock:	attacker does not receive x2 Range Mod from Brace, but still receives OCV bonus for Brace; mounted weapons (on tripods, etc.) are exempt from this rule (typ.: pistols, folded stocks when folded)
Bipod or Tripod:	only subtract 1/4 Range Mod penalty for autofire (instead of 1/2) when employed (which is usually when prone, ergo braced)
Rangefinder:	+1" Range Mod (or +10% Range Mod, if larger) for Set *or* Brace, only when using sights which provide a Range Mod bonus (note that this is the measured range bonus in general)
Gyroscopic Stabilization:	+1 OCV *and* +3" Range Mod (or +50% Range Mod, if larger) for Set *or* Brace; no 1/2 Range Mod penalty for autofire (typ.: modern tank guns, recent attack helicopter turrets)
No Sight:	attacker receives only +1 OCV for Set *and* Brace together (typ.: zip guns, some pocket pistols)
Fixed Sight:	+1 OCV for Set *or* Brace (typ.: most pistols)
Battle Sight:	+1 OCV for Set *or* Brace, +1" Range Mod for Set *and* Brace (typ.: SMGs & some assault rifles)
Standard (or Leaf) Sight:	+1 OCV *and* +1" Range Mod (or +10% Range Mod, if larger) for Set *or* Brace (typ.: unscoped hunting rifles, older infantry rifles)
Unitary Scope:	+1 OCV *and* +1" Range Mod (or +10% Range Mod, if larger) for Set *or* Brace, Set becomes a 1/2 Phase maneuver (typ.: some very modern assault rifles, SMGs, and shotguns)
Telescopic Scope:	+2 OCV *and* +2" Range Mod (or +25% Range Mod, if larger) for Set *or* Brace
Electronic Scope:	+3 OCV *and* +3" Range Mod (or +50% Range Mod, if larger) for Set *or* Brace; already includes Rangefinder effects (typ.: modern tank gunnery fire control systems)
Cyberlink to Smartgun:	as 'Electronic Scope' plus Set becomes a Ø Phase maneuver
Dot Projector:	Set becomes Ø Phase action (still on one target only); R_{vis}, meters = 1000 * (**output**, watts)0.5 in daylight; for visibility in other conditions apply the following multipliers to the 'daylight' range:

condition/equipment	multiplier	notes
HeNe, circa 1970, red	x0.45	output < 0.5 mW
HeNe, circa 1995, red	x0.45	output < 3 mW
diode, ca. 1990, red	x0.25	output < 5 mW
diode, ca. 1995, yellow	x0.9	output < 5 mW
diode, ca. 2000, green	x1	output < 20 mW
diode, cheap (any date)	x0.5	
YAG/diode, ca. 1990, red	x0.25	output < 25 mW
YAG/diode, ca. 1990, green	x0.94	output < 25 mW
YAG/diode, ca. 2000, red	x0.25	output < 250 mW
YAG/diode, ca. 2000, green	x0.94	output < 250 mW
shade or cloudy	x2	
fully overcast + shade	x4	
indoors, bright	x10	
indoors, dim	x30	
night, moonlight	x100	
night, dark	x200	
total dark	x400	

A PER roll is needed to see the projected aimpoint of a dot projector (in combat). Outputs listed are for typical scope sized systems; and might be up to twice as much for larger/bulkier devices, and halved for small 'penlight' sizes. Future laser dot projectors (post 2010) are likely to be color agile systems with high outputs, possibly up to many whole Watts -- who can say?

Helium-neon (HeNe) lasers are the earliest dot projectors available; they break easily and have low output power, but do have excellent beam characteristics. Output doubles from 1970 to 1980, then levels off until circa 1995. 'Smaller' sizes of HeNe lasers are not available until 1995.

Diode laser output should double every 1.5 years from the date of introduction to a maximum of about 500 milliwatts. YAG/diode lasers are generally 10-20 times more expensive than diode laser of similar size, but have higher output power and better beam characteristics; they are also more fragile. Output of YAG/diode lasers doubles every 3 years from circa 1990 to circa 2000. Note that weapons with 'fixed' dot projectors will not obtain much benefit beyond 20 times the 'usual' Range Mod of the weapon, due to bullet drop.

Example: a diode laser dot projector, from circa 1990, produces just under 5 milliwatts of coherent red light. It has a visibility of about 17 meters in full daylight, . If attached to a typical -1/3" Range Mod pistol, with a fixed mounting system, it would be useful out to 60" at most in less well lit conditions. A 'cheap' version of this same dot projector would only have an 8.5 meter visibility in full daylight.

8.0 Double Fire

Characters conducting Double Fire are at 1/2 DCV, and fire at -2 OCV on each target. Double fire takes a full Phase to accomplish. Single action revolvers may only Double Fire if the character makes a Fast Draw skill roll.

Example: Jesus Morales, with a DEX of 20, is threatened by a nearby surly biker, and double fires on him with a Glock 22 pistol. Jesus has an OCV of 10 from DEX and skill, and a DCV of 7; the weapon provides +1 OCV due to its accuracy bonus, and has a -1 per 3" Range Mod. The biker is 2 hexes away, so no range penalties are taken. Jesus's OCV on the biker is 9; his DCV is halved to 4.

9.0 Automatic Fire

9.1 Weapon Accuracy Bonuses During Automatic Fire

Most weapons conducting automatic fire do not get any positive basic OCV bonus from accuracy. Exceptions are salvo fire weapons, and weapons using some stabilizing equipment or system: bipod, tripod, ring or yoke mount, or gyroscopic stabilization, for example.

Example: Zhenia Gorkova is firing a silenced M11/9mm Ingram submachinegun at an executive bodyguard 6 meters away; the bodyguard has a DCV of 4. She has an OCV of 9 from DEX and skill levels. The weapon is listed as having a -1 per 2" Range Mod, +1 OCV accuracy, and fires 20 round bursts. On autofire, when not braced or set, the weapon will be -1 per 1", with no OCV bonus from accuracy. Thus Zhenia will be down 2 OCV for range, up 6 OCV for the rate of fire, for a net +4 OCV; she will have a total OCV of 13 on the bodyguard, making her 9 up. She needs a 20 or less to hit, and gets another hit for each point she makes the attack roll by. Rolling an 11, she hits the bodyguard 9 times.

9.2 Rate of Fire

Use the following table for the effects of various rates of fire (given in rounds per minute):

Rds. Fired	Min. RPM	OCV	# of hits	Range Mod	notes
3	150	+0	1 per 3	halved	
3	300	+0	1 per 2	halved	controlled burst
5	300	+2	1 per 2	halved	
10	600	+4	1 per 2	halved	
20	1200	+6	1 per 1	halved	
40	2400	+8	1 per 1	halved	
80	4800	+10	2 per 1	halved	
160	9600	+12	2 per 1	halved	
320	19200	+14	3 per 1	halved	
etc.	etc.	etc.	etc.	etc.	
3	1800	+0	1 per 1	normal	salvo fire
5	3600	+0	2 per 1	normal	salvo fire
10	7200	+0	3 per 1	normal	salvo fire
etc.	etc.	etc.	etc.	etc.	

'Salvo fire' is possible only with weapons which mechanically fire the listed rounds before the recoil has been transferred to the attacker. Currently, only the experimental G11 rifle uses this method of operation.

Example: Arlan the cyborg vampire hip-fires an M134 Minigun (operating at 4000 RPM) at an escaping vampire-hunter. Arlan has a DEX of 23, and 3 combat levels which apply to this weapon; he is, however, *unfamiliar with its operation. The vampire hunter is 20 hexes away, and has a DCV of 5. The M134 Minigun has a OCV bonus of Ø, and -1/4" Range Mods; it has no sights. Arlan is easily strong enough to fire the weapon. Firing a 40 round burst, Arlan's Range Mod is halved to -1/2", for a -9 penalty to OCV. Arlan's OCV total is therefore 5 (from DEX) + 3 (from skill) - 3 (from unfamiliarity) + 8 (from Autofire at 4000 RPM) - 9 (from Range Mods) = 4. Thus his attack roll is 10-. Arlan rolls a 7 and obtains 3 hits on his latest victim; with the same die roll, if he had been familiar with the weapon* and *had Braced (for x2 Range Mods), he would have gotten 11 hits.*

9.3 Autofire into Several Hexes/Suppression Fire

This combat maneuver allows characters firing automatic weapons to 'hose down' an area with bullets; any target in the area being fired into may be hit. If the character declares 'Suppression,' this attack continues each segment until the character's next phase. To conduct this attack, the firing character designates an arc of hexes, and figures all attack modifiers (from range, autofire, etc.) at the important ranges; in addition, there is a modifier based on the arc width at any given range:

Arc WidTH (hexes)	1	2	4	8	16	32	64	etc.
OCV Modifier	-4	-6	-8	-10	-12	-14	-16	etc.

This attack can still achieve multiple hits if the attack roll is made sufficiently, as per standard autofire.

All 'autofire into several hexes,' whether for 1 or more segments, is conducted at the end of the segment (DEX Ø). The firing character may choose to designate individual targets for immediate resolution (at the attacker's DEX), *or* for avoidance, at a cost of -2 OCV per designated target, applied to all the attack rolls being made that phase by the firing character.

Example: the Chai Fa Souliapon, mystic Thai adventurer, fires her M2 carbine (+1 OCV, -1/4" Range Mod, fires 10 rd. bursts) at a group of onrushing tong members 3 hexes away, in an arc 4 hexes wide. Her own OCV from DEX and skill levels is 6; the tong members have DCVs of 5. Her OCV for this attack will be 6 (from DEX & skill) + 0 (weapon OCV on auto) - 1 (from Range Mod, halved for autofire) + 4 (for 10 round burst) - 8 (for 4 hex wide arc) = 1. Souliapon's attack roll for each target is 7-; each 2 points she makes the attack rolls by results in another hit on a tong member.

10.0 Tracers

Attacks conducted with tracer ammunition are considered `Set' once more than two tracers are fired as part of a single autofire attack, or a continuous suppression fire attack.

Example: Dietrich has Braced, and is shoulder firing a Stoner Mk 23 machinegun at a fleeing VC suspect 300 meters away. He has an OCV of 9 from DEX and skill levels. Every fourth round in his linked ammunition is a tracer, and the weapon fires 10 round bursts due to its 750 RPM operating rate. The weapon is listed as having a -1 per 5" Range Mod, +1 OCV, and a standard sight. Since he is autofiring, the basic OCV bonus of +1 is ignored. The sight, however, adds +1" to range mod and +1 OCV when the firer is Set or Braced. Thus the attack will be conducted with a -1 per 28" Range Mod; at 150 hexes distance, he will lose 5 OCV from range, but gains 2 OCV from the Set and Brace. Dietrich's final OCV for the attack is 6. The victim of his attack has a DCV of 3; thus Dietrich needs to roll a 14- to hit, and will get an additional hit for every 2 points he rolls under this number. He rolls a 10, and gets three hits.

11.0 Multiple Projectile Attacks

Weapons such as shotguns, canister shot, etc., which produce a conical pattern require special rules to describe their effect. After finding the damage characteristics of an individual projectile (DC, Pc, Speed Class, and Stun Mod), use the following formula to determine the number of hits in the first Damage Range (DMG RNG):

$$\textbf{number of hit groups} = \log_2(\mathbf{N}) + 1$$

N = *number* of projectiles

The Damage Range must be derived from the reported or observed performance of the weapon. In general, the length of the first Damage Range is the distance at which the shot group has spread to a 0.5 meter wide pattern. The effect of range on these weapons is summarized as follows:

range	damage	notes
up to 1 x damage range	as at muzzle	single location
up to 2 x damage range	-1 group	separate locations
up to 3 x damage range	-2 groups	separate locations
up to 4 x damage range	-2 groups	separate locations, attack all targets in a hex
up to 6 x damage range	-3 groups	separate locations, attack all targets in 1.5 hexes
up to 8 x damage range	-4 groups	separate locations, attack all targets in 2 hexes
up to 12 x damage range	-5 groups	separate locations, attack all targets in 3 hexes
up to 16 x damage range	-6 groups	separate locations, attack all targets in 4 hexes
up to 24 x damage range	-7 groups	separate locations, attack all targets in 6 hexes
etc.	etc.	etc.

When attacking 'all targets within a hex' (or hexes), the hex DCV of 3 should be engaged to hit each target; the individual targets within the hex (or hexes) may add the DCV bonuses from Dodge, Martial Dodge, DCV Minimum from Velocity, and Cover to the hex DCV for purposes of avoiding attacks. When firing at human sized targets using 'attack all targets in a hex' (or hexes) rules, subtract -1 from OCV if only 2 damage groups are remaining, and -2 OCV if only 1 damage group is remaining.

Example: Cherry Blossom, Biker Bob's little elf buddy, fires a 12 gauge shotgun (4 damage groups at muzzle) at several dodging gentlemen partially visible behind a car in a hex in the fourth damage range (thus subtracting 2 groups). The referee rules the car adds +2 DCV to the gentlemen. He has an OCV of 6 at that range, -1 due to only 2 groups being left at that range; the gentlemen will have DCVs of 8 (3 for hex engagement, +2 for Cover, +3 for normal Dodge). Thus Cherry must roll an 8- to hit on each gentleman.

Following the 'group hits stun modifier' rule, each group above 1 adds +1 to the Stun Modifier.

Example: the CAW tungsten buckshot round contains 8 projectiles, each 7 mm diameter and 3.63 grams mass. The muzzle velocity from a 27" barrel is 564 meters per second. An individual pellet is thus a 1d6+1K attack, Piercing 7, Speed Class 2, and -1 Stun Modifier. At the muzzle, 4 'group' hits will be taken, each of which will do 1d6+1K damage, with the same Speed Class of 2 and Piercing of 7, but a +2 Stun Modifier.

This round produces a man high pattern (2 meters high) at 150 meters, according to published reports. This gives a damage range of 18 hexes (1/4 of 150 meters = 37.5 meters ~ 18"). In the first range gate, out to 18 hexes, the CAW buckshot round would hit with 4 groups, with a +2 Stun Modifier; in the next range gate, 19 to 36 hexes, 3 groups would hit, with a +1 Stun Modifier; in the next, 37 to 54 hexes, a Stun Modifier of Ø for 2 groups; in the next range gate, 55 to 72 hexes, still 2 groups with a Stun Modifier of Ø, but attacking an entire hex with -1 OCV; and in the final gate, 73 to 108 hexes, a single group with a -1 Stun Modifier, and a -2 OCV, engaging each target in one and a half hexes (3 meters wide).

12.0 Recoil and Strength Minimums

For every 5 points of STR under the Recoil Strength Min required to fire a weapon, there is a -2 OCV modifier in the firing character's *next* phase (and this phase if conducting an auto fire or double fire attack), and a 1d6 normal attack this phase. Also, if the STR Min is over 30, add an additional 1d6, increasing by 1d6 for every 5 points of STR Min over 30. Only a character's PD characteristic may be used to defend against this damage.

The OCV penalty suffered in the following phase may be avoided by taking a 1/2 phase maneuver to regain control of the weapon.

The recoil energy of a firearm is found by:

$$\textbf{recoil energy}\text{, joules} = (\mathbf{m_p} * \mathbf{v_p} / 1000)2 / (2 * \mathbf{m_w})$$

$\mathbf{m_p}$ = *mass* of projectile, grams
$\mathbf{v_p}$ = *velocity* of projectile in m/second
$\mathbf{m_w}$ = *mass* of weapon in kilograms

The basic Recoil Strength Minimum is calculated from the recoil energy as follows:

$$\textbf{Recoil STR}_{\mathbf{min}} = 5 * \log_2(\textbf{recoil energy}\text{, joules})$$

The actual Recoil Strength Minimum will depend upon the construction and operation of the weapon, and the method of employment. Apply the following modifiers to the basic value derived above:

action	mod	type of action	notes
	-1	non-automatic	bolt action rifles, revolvers, muskets, etc.
	-3	automatic	most semi and full automatic firearms
	-5	recoil delay	exotic recoil absorbing systems
muzzle brake	**mod**	**features**	**notes**
	-1	simple muzzle brake	found on some pistols, SMGs or assault rifles
	-3	complex muzzle brake	found on some very heavy rifles or machine guns
	-2	gyro stabilization	nbsp;
	-1	customized	stock fitting, custom grips, etc.
rate of fire	**mod**	**rounds/phase**	**notes**
	+5	3 to 5	300 RPM minimum
	+10	10	600 RPM minimum
	+15	20	1200 RPM minimum
	+20	40	2400 RPM minimum
	etc.	etc.	etc.
employment	**mod**	**how employed**	**notes**
	-5	two handed	
	-5	attacker Braced	
	-5	stock on shoulder, while Braced	

Most ranged weapons also have a Suspension Strength Minimum; this is determined as:

$$\textbf{Suspension STR}_{min} = (\log_2(\textbf{mass}_{weapon}, \text{loaded}) * 5) + \textbf{employment mod}$$

mod	employment
+5	one handed
0	two handed
-5	attacker Braced
-5	stock on shoulder, while Braced

The effects of insufficient strength when firing a weapon exceeding the Suspension Strength Minimum are the same as for Recoil Strength Minimum, except no damage is done. Both strength minimums should be calculated for each weapon, but only the larger should be noted -- if they are identical, use the Recoil Minimum. Our firing tables mark weapons having a larger Recoil Minimum with an asterisk, those with a larger Suspension Minimum are left unmarked. Obviously, in low-gravity or zero gravity environments, Suspension Strength Minimum should be reduced or ignored.

Example: the Charter Arms Bulldog Pug revolver has a mass of 0.54 kg, and it fires a 13 gram bullet at 300 meters per second (in .44 Special caliber). The recoil energy is 14.1 joules, and the basic Recoil STR Min is 19. Its action reduces this to a 'mere' 18 Recoil STR Min if fired one-handed, or a 14 Recoil STR Min if fired two handed. Madame Hong, with a STR of 10, will take a 0.5d6 normal attack each time she fires it two-handed, and will suffer a -2 OCV penalty her next phase. The Suspension STR Minimum is 0 one-handed, or -5 two handed, and would thus not be noted on the firing tables.

Example: the McMillan M-87 bolt action .50 cal rifle has a mass of 10 kilograms, and it fires a 40.5 gram bullet at 930 meters per second. The recoil energy is 71 joules, and the base Recoil STR Min is 30. The weapon's non-automatic action and complex muzzle brake reduce the STR Min to 27; when fire two handed from a Braced (prone) position, with the stock against the attacker's shoulder, the Recoil STR Min is 12. Madame Hong will suffer a 0.5d6 normal attack, and will be -2 OCV on her next phase. The Suspension STR Min is 7 when fired as described, and would not be noted on the firing table.

Example: Biker Bob (STR 18) hip-fires a full-auto (5 round) burst from a modified Panther Assault Cannon. The 24.5 kg weapon requires a Recoil STR of 26 to fire on single shot, 2 handed and Braced; since Bob is not Bracing, and is firing a 5 round burst, the actual Recoil STR Min for this shot is 36. Due to the 18 point STR shortfall he will take 2d6 + 2d6 = 4d6 of normal damage; he will be -8 OCV this and the next phase. Again, Suspension STR Min is "only" 23 when used two handed, and not noted in the firing tables.

12.1 Determining Range Modifiers

In order to generate Range Mods for small arms, an effective range must be known for the weapon being considered. Unfortunately, there are no standardized, official, used-in-all-countries methods of computing effective range. Different sources can differ by 30-50% on the value for effective range of a given weapon. Different methods are used to determine effective range for different classes of weapons. Thus, four procedures are presented to generate Range Mods for small arms. Select the procedure which seems appropriate for the weapon being simulated.

For each procedure, the 'total OCV' is the sum of the **weapon OCV modifiers** *and* **sight OCV modifiers** for Set *and* Brace. Round resulting fractions up or down at the referee's discretion.

12.1.1. Pistols

Pistols, and stockless weapons fired at moving human sized targets:

$$\mathbf{R_{Mod}}\text{, hexes} = \frac{(\ \textbf{effective range}\text{, meters}\ )}{4 * (2 + \mathbf{OCV_{total}})} - \textbf{sight } \mathbf{R_{Mods}} \text{ for Set and Brace}$$

*Example: a Smith and Wesson M&P .38 Special (+1 OCV) is fitted with fixed sights (+1 OCV for Set or Brace). The effective range is given as 50 meters. Therefore, the total Range Mod for this weapon is 50/(4 * (2 + 1 + 2)) = 2.5 hexes. We will round this to -1 per 2 hexes (though an argument could be made for -1 per 3 hexes).*

12.1.2. Submachineguns

Submachineguns, and stocked weapons fired single shot at stationary head and torso sized targets:

$$\mathbf{R_{Mod}}\text{, hexes} = \frac{(\ \textbf{effective range}\text{, meters}\ )}{8 * (2 + \mathbf{OCV_{total}})} - \textbf{sight } \mathbf{R_{Mods}} \text{ for Set and Brace}$$

*Example: the Uzi (+2 OCV single shot) is normally fitted with a battle sights (+1 OCV for Set or Brace, +1" Range Mod for Set and Brace). Its effective range is given as 200 meters; thus the Range Mod is 200/(8 * (2 + 2 + 2)) - 1 = 3.17 hexes ~ -1 per 3 hexes.*

12.1.3. Rifles

Rifles, and stocked weapons fired single shot at stationary man-sized targets:

$$\mathbf{R_{Mod}}\text{, hexes} = \frac{(\ \textbf{effective range}\text{, meters}\ )}{8 * (5 + \mathbf{OCV_{total}})} - \textbf{sight } \mathbf{R_{Mods}} \text{ for Set and Brace}$$

*Example: an M14 rifle (+1 OCV) fitted with a standard sight (+1 OCV and +1" Range Mod for Set or Brace) has a maximum effective range of 700 meters. The total Range Mod is 700/(8 * (5 + 1 + 2)) - 2 = -1 per 8.94 ~ -1 per 8". Note that the 700 meter effective range is considered optimistic . . . some sources give values as low as 550 meters; thus the large 'round down.'*

*Example: an M21 sniper rifle (+1 OCV) fitted with an ART telescopic scope (+2 OCV and +2" Range Mod for Set or Brace) has a maximum effective range of 1000 meters. The total Range Mod is 1000/(8 * (5 + 1 + 4)) - 4 = -1 per 8.5" ~ -1 per 9".*

12.1.4. Machine-guns

Machine-guns: as procedure #3, but taking Bipod (or Tripod/Mounted) and Auto Fire OCV bonuses into account.

*Example: the M60 machinegun (+1 OCV) is fitted with standard sights (+1 OCV and +1" Range Mod for Set or Brace) and a Bipod (only subtract 1/4 Range Mod penalty for autofire). It fires at a cyclic rate of 550 RPM, close enough to 600 RPM for 10 round bursts (+4 OCV), and is given an effective range of 800 meters. The initial Range Mod will be 800/(8 * (5 + 1 + 4 + 2)) = 8.33". To figure the actual Range Mod, multiply 8.33" by 4/3 (the inverse of the Bipod Range Mod effect), giving 11.1"; finally 11.1 - 2 = 9.1", rounds to -1 per 9".*

13.0 Defenses

The DEF value of a given material is a measure of the specific energy required to destroy a given volume of the material. The tensile strength, hardness, density, and other properties of a material determine the DEF and Speed Class values.

13.1 Armor Materials

The Armor Materials list attached provides information about the defensive properties of various substances, in order to determine their DEF and Speed Class. The columns are:

Material:	by name, in various categories
DEF 1 cm:	the DEF value of a 1 centimeter thickness of the material
Speed:	the Speed Class
gm/cm^3:	the specific gravity (density)
layer, cm:	the thickness of a standard layer, for 'woven' or fabric materials
DEF layer:	the DEF value of 1 layer
kg/m^2:	the mass of a square meter of one layer
comments:	information for identifying the substance and its properties

Note that a 1 meter thickness of a material has a DEF value 23.3 greater than a 1 centimeter thickness.

In general, mesh/solid composites (such as fiberglass or reinforced concrete) have the Speed Class of the matrix (the binding material).

Mail mesh at 40% coverage(dense weave, such as double mail) has 4.6 less DEF than the solid material from which it is composed, plus an amount of DEF equal to the Speed Class of the solid material. 20% mesh mail (ordinary, or international, mail) will have 8.1 less DEF than the solid, still plus DEF equal to the Speed Class. Mail, like most flexible armor, has a Speed Class of Ø itself.

Example: flush with nuyen after a successful run, Agamemnon the Troll samurai orders a titanium mail hauberk. Double linked (40%), of course. The resulting armor has a DEF of (20 - 4.6) + 2 = 17.4 ~ 17, and is Speed Class Ø. This material will weight 9 kilograms per square meter; a troll sized hauberk covers 1.95 square meters. Thus, Agamemnon's armor will have a mass of 17.55 kilograms.

13.2 Aggregate Armor Value

Targets protected by multiple layers of armor material will figure the cumulative DEF of their protection as follows:

if both DEF are the same:	add 4 points to DEF
if DEF difference is 1 point:	add 3 points to better DEF
if DEF difference is 2 or 3 points:	add 2 points to better DEF
if DEF difference is 4, 5, 6 or 7 points:	add 1 point to better DEF
if DEF difference is 8 points or more:	use better DEF value, unmodified

Complex, multiple material situations can be adjudicated by remembering that each doubling in the real amount of armor (as measured by thickness of a given material) adds 3.5 to the DEF. Speed Class of the aggregate protection can be averaged, rounding in favor of the material contributing the most DEF.

Example: the men of G Detachment, 1st ANGLICO, while traveling in an M113 APC, on a road known to be mined, place four layers of M69 ballistic nylon flak vests (individually DEF 12, Speed Class Ø) on the floor of the vehicle. The normal belly armor consists of 1.2 cm of Kaiser 5083 aluminum-magnesium alloy (16 DEF, Speed Class 1). Four layers of flak vests have 7 DEF more than 1 layer, thus the vests would total 19 DEF. Since the belly armor is 3 points less than this, 2 points are added to the DEF of the vests, for a total DEF value of 21. The referee rules that the net Speed Class of the belly armor, as a whole, is Ø, since most of the protective value comes from Speed Class Ø ballistic nylon. Note that this process requires over 50 M69 flak vests.

13.3 Area Values for Armor Coverage

When determining the mass of vehicle or body armor, the following area values should be used as guidelines. Body armor areas for average human adult male sizes are given (178 cm tall, 70 kg mass); generic 'very small' sizes (150 cm tall, 50 kg mass) are 20% less;

'small' sizes (164 cm tall, 60 kg mass) are 10% less, 'large' sizes (190 cm tall, 80 kg mass) are 10% more, and 'extra large' sizes (200 cm tall, 90 kg mass) are 20% more. Standard *Shadowrun* troll sizing (210 cm tall, 130 kg mass) adds 50% to human average. In case of doubt, round up.

armor piece	hit locations	area, m^2
basic covert tee-shirt vest	10-12	0.4
basic military vest	9-12	0.8 - 1.0
extended tactical vest	9-13	1.1
doorgunner vest	9-14	1.2
jacket, hip length, includes collar	7-13	1.4
hauberk, close fitting	7-14	1.3
overcoat	7-14	2.25
sleeves only, per pair	7-8	0.5
trousers	13-16	1.5
boots, per pair	17-18	0.3
helmet - M1 'pot' style	5	0.15
helmet - PASGT 'fritz' style	4-5	0.18
2 door, 4 seat compact car *1	body	12
	all windows total	3.5
4 door sedan *2	body	21.5
	all windows total	5.5

*1: this is based on the Austin Mini-Cooper 1275S; in the original vehicle, 250 kilograms of passengers, armor, and cargo could be carried; windows and floor are not armored)

*2: this example is based on a Mercedes-Benz 240D; as such, 500 kilograms of passengers, armor, and cargo could be carried; the windows and floor are not armored)

Example: the M69 vest is made of about 14 layers of ballistic nylon, and covers locations 9, 10, 11, and 12. Ballistic nylon is 0.28 kg per square meter, so one layer has a mass of about 0.24 kg. 14 layers would therefore be 3.36 kg; the listed mass of the actual vest is 3.78 kg in medium size - close enough for jazz, since the actual vest includes a bulky collar.

13.4 Armor vs. Stun

Use the reduced value (after Speed Class and Piercing modifiers) of any armor against the Body and Stun of an attack. If the reduced armor value falls to zero, then the character does not apply his or her own PD or ED against the stun of the attack (unless the character has Pain Resistance).

Example: Lt. Wilson (PD 5), wearing a PASGT Kevlar vest (14 DEF, Speed Class Ø), is hit by a 7.62x39mm bullet fired from an AK-47 (2d6 damage, +1 Stun, Piercing 6, Speed Class 2). The bullet strikes the chest for 8 points Body damage; the Speed Class difference and Piercing value of the bullet subtract 12 from the vest, leaving 2 DEF. 6 Body, and 30 Stun, get past the vest (Stun = (8x(3+1)) - 2). Since there was still a positive amount of resistant defense remaining, Lt. Wilson applies his own PD of 5 to the Stun past the vest: thus the final result is 6 Body and 25 Stun lost by the character.

When resolving non-penetrating attacks (did no BOD to the character) versus rigid armor (i.e. most materials with Speed Class 1 or better), double the reduced value DEF of the armor before subtracting it from the Stun done by the attack.

In cases where the armor is entirely out of contact with the character's body, such as large suits of powered armor, the referee should in many circumstances rule that no Stun will be done at all by a non-penetrating attack. On the other hand, crew of vehicles and powered armor suits should take Stun equal to the BOD taken by the suit or vehicle (after Damage Ignorance, that is) on penetrating hits: this represents 'being shaken up.' Only natural PD or other 'internal' (to the character) defenses can be applied against this Stun.

14.0 Damage Ignorance

Damage Ignorance is purely a function of mass, and is determined by the following formula:

Damage Ignorance, pts. = log2(**mass**, kg / 100 kg)

Damage Ignorance is subtracted from the Body of attacks which penetrate a target's defenses, except in the case of attacks which affect the target based on multiples of BOD; when resolving those attacks, Damage Ignorance is *added* to the target's BOD.

For purposes of determining Stun from Killing Attacks, Damage Ignorance is subtracted from the rolled damage before applying location modifiers and defenses. When determining Normal Stun, remove the largest remaining die from the roll for each point of Damage Ignorance, before defenses.

This game mechanic might not be applied to objects smaller than 100 kg mass, at the referee's discretion (they have it hard enough already), and may not work too well for large objects with substantial internal subdivisions with appreciable DEF values (such as battleships, for example).

Example: while time traveling, Billy Joe Gotez shoots a 1600 kg Bardelot, a sort of saber-toothed Arctic rat of the far future (BODY 18, CON 18, STUN 42, 12 PD, 3 DEF/Speed Ø skin & gristle, 4 points Damage Ignorance, and Pain Resistance), in the head with his .44 Magnum (2d6 damage, Speed Class 1, Piercing 4, +1 Stun Mod). He rolls a 9 for the damage.

Due to the Speed Class difference and the Piercing value of the bullet, the Bardelot will receive no benefit from its DEF. The creature takes (9 - 4) x 2 = 10 Body damage, and ((9-4) x (5+1)) - 12 = 18 Stun. The creature is not Stunned or Knocked Out; however, it was Impaired . . . Note that without the Damage Ignorance rule in place, the Bardelot would have taken 18 Body and 42 Stun, and would be pretty likely instantly dead.

Example: the mage Unsug the Obnoxious attempts to Transform the aircraft carrier Enterprise (89,600 tons mass, 19 Damage Ignorance, 13 BODY) into a shark. Unsug does 52 points of Transform, which must exceed the BODY + Damage Ignorance of the ship by a multiple of 2 for success, and thus fails.

Creatures with Damage Ignorance which are subjected to **whole body** radiation attacks (such as those caused by atomic weapons) should *add* half of their Damage Ignorance to the number of DC for the roll for Body taken directly; this does not affect the Stat Reductions caused by radiation, however.

Example: due to a nearby atomic explosion in downtown Tokyo, the rampaging monster Gothmog (1200 tons, 13 Damage Ignorance) is subjected to DC 12 radiation: it will take 25 dice of damage from this; it can apply the better of its PD or ED to the Stun only.

15.0 Vehicle Penetration Tables & Damage Modifiers for Vehicles

See the attached generic examples for the format employed in presenting penetration tables. These are constructed as follows: entries 3 through 15 are always 'no effect;' the remaining entries above 15 are equal in number to the total of the vehicle's BODY and Damage Ignorance. This total can be juggled by 1 or 2 points as needed, so as to be able to divide the entries above 15, and below the last entry, into 3 equal groups: minor damage, major damage, and critical damage. The last entry on the table is always 'subtract 1 from the penetrating DC, and roll twice with the new penetrating DC.' Note that any crew member or passenger taking multiple damage effects from a single penetration is only affected by the attack with the highest DC.

For any results on the penetration table lower than 16, or for any minor damage, or for any result of crew, cargo, passengers, hangars, void structure, etc., halve the amount of Body taken after armor and Damage Ignorance.

Note that Damage Ignorance is not applied to the 'penetrating DC' for purposes of rolling on the penetration table, but Stun Modifiers are.

Example: the aircraft carrier Enterprise (89,600 tons mass, 19 Damage Ignorance, 13 BODY) will have a penetration table ending approximately at 15 + 19 + 13 = location 47; the actual chart ends at location 46, so that entries 16 through 45 can be divided evenly by 3. The minor, major, and critical damage sections will each have 10 entries. A 2000 pound bomb explodes inside the vessel (thus ignoring DEF), for 23 points of damage, with a +2 Stun Mod. After applying the 19 points of Damage Ignorance, 6 Body is done to the ship - unless cargo, crew, etc. are struck, in which case only 3 Body would be done. The penetration table will be consulted using 3d6 + 25, resulting in entries ranging from 28 (a major damage entry) to 43 (a critical damage entry).

Example: a Curtiss C-46 Commando transport airplane is hit four times by a12.7mm DshK38 machinegun. The Speed Class and Piercing of the machinegun's bullets negate any armor value the aircraft has. The bullets do 3d6K damage, with a +1 Stun Modifier. The plane has 16 BODY and 8 points of Damage Ignorance. The damage effects are resolved as follows:

Dmg rolled	3d6	+ DC_{Pen}	+ Stun Mod	= total	Chart Result	BOD lost
10	13	+ 10	+ 1	= 24	major cargo (x1/2)	1
11	7	+ 11	+ 1	= 19	minor engine (x1/2)	1
12	12	+ 12	+ 1	= 25	major structure	4
13	8	+ 13	+ 1	= 22	minor system (x1/2)	2
						8 total Body

16.0 Damage and Penetration Calculations

The destructive performance of projectiles and explosives, and the perforation resistance of armor, are not currently described by a single complete theory. Terminal ballistic simulations employ several empirical descriptions and modeling rules to provide estimations of the interaction of 'threat' and protection.

The basic description of damage potential is known as Cranz' Model Law. Developed in the 1920s during a study of explosive effects, this relationship proved applicable to a wide range of ballistic effects as well. The central statement of Cranz' Law is that the energy applied to displace target material is proportional to the displaced volume times a specific energy characteristic of the material. This material characteristic generally has larger values for 'better' armor substances.

Another useful relationship states that the cavity diameter formed in armor by a perforating projectile is proportional to the projectile diameter.

For ballistic projectile attacks at high velocities, both Cranz' Law and the cavity relationship require adjustment due to the change in dynamic mechanical processes in both the projectile and the target. During the transition from rigid perforation, to shattering perforation, and finally to plastic (hydrodynamic) perforation as velocity increases, the cavity diameter gradually increases by a factor of 2; also, up to 20% of the kinetic energy of a ballistic projectile is expended in breaking up the projectile itself. However, the energy required to displace a given volume of armor decreases as more favorable dynamic processes occur.

At very low velocities, under 25 meters per second or so, the ability of most materials to mechanically deform over wide areas comes into play, increasing the affected volume and decreasing the possible penetration.

This system uses 'Damage Class' (DC) as the measure of destructive energy. The Damage Class scale is based on powers of two, with 25 joules chosen as DC Ø; each doubling of this energy adds 1 DC.

Note that only the highest Damage Class effect of an attack with multiple effects should by applied against a target's Body, after all armor penetration. If two effects have the same Damage Class, add 1 to that DC and apply the result. This rule mostly affects explosive shells.

Example: a delay-fused artillery shell strikes Gothmog, a giant monster ravaging downtown Tokyo. The shell is listed as having a 6d6K attack due to its kinetic energy, with a Piercing value of 5, fired at Speed Class 2; and an explosive damage value of 16d6 normal. Gothmog has DEF of 25, Speed Class 1 armored hide.

His armor is reduced by 8 points (due to the Piercing and Speed Class of the shell) to 17. The 6d6K kinetic energy portion of the attack is rolled for 22 points; thus 5 points gets past his hide. Once inside the monster, the shell explodes; the normal 16d6 explosion is increased to a DC 20 Killing attack due to being an internal explosion. The resulting 6.5d6K roll results in 21 points of damage. Thus Gothmog takes 21 Body, not 26 Body, before subtracting his Damage Ignorance of 13 . . . net result, 8 BOD lost.

The effects of velocity on penetration ability are simulated by assigning a Speed Class to all attacks and defenses. Each level of Speed Class difference represents 3 points of 'Piercing' against DEF for the attack, if the attacking Speed Class is *greater*. Only Speed Class Ø attacks lose 'Piercing' against DEF with a higher Speed Class.

Speed Class	velocity range	typical damage vector
SØ	up to 25 m/sec	hand to hand attacks, thrown weapons
S1	26 - 500 m/sec	shotguns, pistols, SMGs, archery weapons
S2	501 - 1,200 m/sec	rifles, machine guns, autocannons, WW2 tank guns
S3	1,201 - 3,000 m/sec	modern tank guns, explosively formed projectiles
S4	3,001 - 12,000 m/sec	shaped charges, railguns, orbital deadfall ordnance
S5	over 12,000 m/sec	meteors, ASAT weapons

Example: a Hellfire missile warhead detonates in contact with the hull of a BMP armored personnel carrier. The missile's shaped charge warhead is a Speed Class 4 attack; the BMP's steel hull is Speed Class 2. Thus, the Hellfire missile will subtract 6 points from the 16 DEF of the BMP's hull, due to Speed Class advantage.

16.1 Ballistic Projectile Attacks

This section (16) deals with projectiles which produce damage from the kinetic energy of their flight, and which undergo no explosive form changes until after penetrating armor. Note that, against ballistic projectiles, sloped armor gains protection as follows:

$$\textbf{additional DEF} \text{ for target} = 3.5 * \log_2(1 / \text{cosine } \theta)$$

θ = *angle* inclined from vertical, degrees

This DEF bonus may also apply versus some non-ballistic attacks, as well. This value may increase by 1 or 2 DEF for certain types of projectiles (esp. APDS) at large angles (over 45deg.).

16.1.1 Damage Class

For projectiles, Damage Class is found with these formulae:

$$\mathbf{DC} = \log_2(\mathbf{E} / 25)$$

E = *energy*, joules

$\mathbf{E} = (\mathbf{m} * \mathbf{v}^2) / 2000$

m = *mass*, grams
v = *velocity*, meters per second

Round fractions of .9 or less ***down***. Almost all ballistic projectile attacks are resolved as Killing Attacks.

Example: a BRI sabot slug, with a mass of 28.8 grams, is fired from a 12 gauge shotgun at a velocity of 560 meters per second. The muzzle energy is 4516 joules, or DC 7, normally rolled as 2d6+1.

16.1.2 Piercing

Normally, armor penetration is assumed if the Damage Class (DC) of the attack is greater than the defense value (DEF) of the target. However, the penetrating performance of a particular attack can be affected by the dimensions, form, material, construction, etc. of the projectile. The 'Piercing' (Pc) of an impacting projectile is subtracted from the DEF of the target. The basic formula for determining Piercing values is:

$$\mathbf{Pc} = 3 * \log_2((8 * \mathbf{m}) / (11 * \pi * \mathbf{d}^3))$$

m = *mass*, grams
d = *diameter*, centimeters

This yields the Piercing value for lead core, metal jacketed ammunition directly. For other types of projectile construction apply the following modifiers:

mod	typical material
-3	wood, plastic, rubber
-2	radically expanding projectiles (i.e., jacketed hollow point)
-1	unjacketed soft (unalloyed) lead
0	full metal jacket, hard lead, generic HE rounds
+1	solid copper
+2	solid bronze, steel flechettes, steel core rounds, generic AP rounds
+3	tungsten or tungsten carbide core, depleted uranium, African Grand Slam

Note that when perforating multiple defenses, a projectile retains its full Piercing value as long as it retains its basic form. Also, negative Piercing values are certainly possible - they add to the target's DEF (if any - negative Piercing will not provide resistant defense against a Killing attack). A normal (non-killing) attack with negative Piercing would increase the target's PD by the amount of the Piercing.

Example: the AP round fired by the KPV autocannon is a 64.4 gram, 14.5 mm diameter projectile with a hard steel core. It thus has a Piercing value of 9.

16.1.3 Stun Modifier

The Stun Modifier represents the tissue destruction and shock affect of an attack on a living target. When determining the Stun Modifier of soft or tumbling projectiles, use this formula:

$$\textbf{Stun Modifier} = \log_2((8 * \mathbf{m}) / (11 * \pi * \mathbf{d}))$$

m = *mass*, grams
d = *diameter*, centimeters

The Stun Modifier of hard, non-expanding, or armor piercing projectiles is calculated as follows:

$$\textbf{Stun Modifier} = \log_2(2 * \mathbf{d}^2)$$

d = *diameter*, centimeters

Some types of projectiles adjust either of the above basic figures as follows:

mod	projectile type
+1	radically expanding projectiles, generic HE rounds or exploding bullets
+2	jacketed multiple projectile rounds (Glaser, Mag-Safe, etc.)

The efficiency of jacketed hollow point bullets is a subject of some uncertainty in the technical press; generally, the older the design, and the lower the muzzle velocity, the less likely it is that a JHP round will gain the +1 for 'radically expanding.'

Example: a typical .44 Magnum bullet with a mass of 15 grams produces a Stun Modifier of +1.64, which for consistency is rounded down to +1.

Example: the AP projectile for the KPV autocannon, with a mass of 64.4 grams and a diameter of 14.5 mm, will produce a Stun Modifier of +2.07, which rounds to +2.

16.2 Chemical Energy Attacks

This section describes the effects of attacks by explosives, fragments, shaped charges, and explosively formed projectiles (EFPs).

16.2.1 Explosions

The damage class in the core hex of an explosion is found using this formula:

$$\textbf{DC} = 13 + 1.2(\log_2(\textbf{yield}))$$

yield = *kilograms TNT* equivalent

This is the 1 meter radius, or 'in-hex' damage. Damage at range is adjusted by one of the following calculations:

Unconfined areas

$$\textbf{DC at range} = \textbf{core DC} - (3 * \log_2(\textbf{range}, \text{ meters}))$$

Areas confined to 2 dimensions

(example: underneath a low ceiling)

$$\textbf{DC at range} = \textbf{core DC} - (2 * \log_2(\textbf{range}, \text{ meters}))$$

Areas confined to 1 dimension

(example: a pipe, or a long hallway)

$$\textbf{DC at range} = \textbf{core DC} - \log_2(\textbf{range}, \text{ meters})$$

Persons exposed to explosions can also reduce the damage they receive by taking shelter or assuming protective positions, as follows:

reduction	action	reduction	cover
-1 DC	dodge	-1 DC	half cover
-2 DC	crouch	-2 DC	full cover
-3 DC	prone	-3 DC	half shelter
		-4 DC	full shelter

Explosions 'at range' will be Piercing Ø, Speed Ø, rolled as 'normal' (non-Killing) damage. Explosions in contact with the target are rolled as 'Killing' attacks, modified as follows:

contact condition	add. damage	add. piercing	add. stun
simple contact; ground placed untamped	+1 DC	2 Pc	+1 Stun
well-placed contact; elevated untamped	+2 DC	4 Pc	+1 Stun
tamped; 'squash head' (HESH or HEP)	+3 DC	6 Pc	+2 Stun
internal (inside armor or target)	+4 DC	8 Pc	+2 Stun

Any explosion which comes within 3 points of penetrating a barrier will cause some amount of spalling on the far side of the barrier.

Example: the M229 HE warhead for the 2.75" rocket has a mass of 7.7 kg, assumed to be equivalent to TNT. The core damage is 19d6 normal dice; if detonated in the open, at 8 meters range the damage will be 10d6.

16.2.2 Shaped Charges

The Damage Class value of a shaped charge is:

$$\mathbf{DC} = 9 + (3 * \log_2(\mathbf{d}))$$

d = *diameter*, centimeters

This will be resolved as a Killing Attack. The Piercing value of a shaped charge is based on the precision of its construction:

mod	shaped charge construction
+3	dual purpose (i.e., includes fragmentation), cheap
+6	standard
+9	improved (best current)
+12	advanced

All shaped charge attacks are Speed Class 4.

The calculation for Stun Modifier of shaped charges is:

$$\textbf{Stun Modifier} = \log_2(4 * \mathbf{d}^2)$$

d = *diameter*, centimeters

The secondary explosion produced by a shaped charge is:

$$\mathbf{DC} = 2 + (3 * \log_2(\mathbf{d}))$$

d = *diameter*, centimeters

This explosion is produced on the 'outside' of the target, and follows the usual rules for explosions from section 16.21; the effect of a successful (i.e., penetrating) attack by a shaped charge into an enclosed vehicle (on the other side of the perforated barrier) is a DC 3 explosion for each point of damage past the barrier.

Example: the HEAP warhead for the 90mm recoilless rifle produces a 6d6K attack, with 6 Piercing, a Stun Modifier of +8, and a secondary HE effect of 15d6 normal (core explosion damage).

Example: the M3 shaped demolition charge is an 18 kg, 22 cm diameter weapon. It will produce a 7d6+1K attack, with 3 Piercing, a Stun Modifier of +11, and a secondary HE effect of 18d6 normal (core explosion damage). It will penetrate approximately 1.6 meters of reinforced concrete.

16.2.3 Explosively Formed Projectiles

The damage done by an EFP is calculated by this formula:

$$\mathbf{DC} = 3 * \log_2(\mathbf{d})$$

d = *diameter*, centimeters

This will be resolved as a Killing Attack. Piercing values are taken from the following table:

mod	EFP construction
+5	standard steel liner
+6	standard tantalum liner
+8	advanced steel liner (maximum performance)
+9	advanced tantalum liner (best current)
+11	very advanced tantalum liner (maximum performance)

All EFPs are Speed Class 3. The calculation for Stun Modifier of EFPs is:

$$\mathbf{Stun\ Modifier} = \log_2(\mathbf{d}^2 / 8)$$

d = *diameter*, centimeters

For comparison purposes, a 1 centimeter diameter EFP fires a 0.33 gram projectile with about 0.66 grams of explosives.

Example: the MBB 20 cm diameter off route mine has a mass of about 8 kg, and will produce a 6d6+1K damage projectile, with 5 Piercing, and a Stun Modifier of +5.

16.2.4 Fragmentation

The damage class of explosively propelled fragments is derived using the formulae in Section 16.1, using the mass and velocity of the individual fragments. If actual fragment characteristics are not know (as is likely), approximations can be found:

$$\mathbf{fragment\ velocity}, \text{m/sec} = 1700 * \ln(\mathbf{m}_{weapon} / \mathbf{m}_{fragments,total}) * (\mathbf{RE})^{0.5}$$

ln = natural logarithm
RE = *relative effectiveness* of explosive filler

Relative effectiveness of the explosive filler in modern weapons may be assumed to be 1.25 if the actual value is unknown. For calculations in the *Shadowrun* campaign, use a RE of 1.8; for *2300AD*, use RE of 2.0.

If the mass of the individual fragments is unknown, use 3.2 grams; this number is not too accurate for weapons with a total mass under 10 kilograms. Typical modern hand grenades project fragments of about 0.5 grams mass.

The Speed Class of fragments is never larger than 2; if a value of 3 or more is produced with the velocity formula above, reduce the Speed Class to 2. Piercing values for fragments is usually Ø for properly designed weapons; impromptu fragmentation or secondary missiles will almost never have piercing values above Ø, and will usually have lower Speed Class as well. The Stun Modifier for individual fragments is usually -1, but the 'group hits stun modifier' rule is used.

Example: the M117 aircraft bomb has a total mass of 374 kg, with a filling of 180 kg of Minol-2 (RE = 1.3). It produces fragments with an initial velocity of 1300 meters per second, with a Speed Class of only 2. Assuming the fragments to be 3.2 grams each, they will do 2d6 damage. Piercing value will be Ø, and the Stun Mod will be -1.

Fragments may achieve hits out to a distance known as the effective range, or burst radius. As a general rule, for explosive/fragmentation weapons with a total mass of 10 kilograms or more, the burst radius will be:

$$\mathbf{effective\ range}, \text{m} = (\mathbf{m}_{weapon,total}, \text{ kilograms})^{0.6}$$

The burst radii of weapons below 10 kilograms mass will tend to be greater than the values produced by this equation.

All fragmentation weapons have an OCV based on the density of fragments at the effective range. Typical values range from Ø for small modern weapons such as hand grenades, to -9 for old aircraft bombs. Specifically, an OCV of Ø represents a pattern density of 1 fragment per square meter. For weapons producing a spherical fragmentation pattern, the surface area of the burst zone will be:

$$\mathbf{surface\ area}, \text{meters}^2 = 4 * \pi * (\mathbf{effective\ range}, \text{meters})^2$$

The pattern density is therefore:

$$\mathbf{pattern\ density}, \text{frags/meter}^2 = \#_{fragments,total} / \mathbf{surface\ area}$$

The OCV at the effective range can thus be easily calculated:

$$\textbf{OCV} = 2 * \log_2 (\textbf{pattern density}, \text{ frags/square meter})$$

For weapons with non-spherical burst zones (Claymore mines, and other directional charges), the calculation of the surface area will of course change to the appropriate geometrical formula.

All fragmentation attacks are given an effective range, and an OCV at that range. For spherical fragmentation patterns (such as are produced by hand grenades, for example) each halving of the distance from the effective range adds 4 to the OCV. Planar fragmentation (as in claymore mines, for example) adds 4 to the OCV for each halving of the effective range, until the point at which the pattern's narrowest dimension (usually height) becomes smaller than the target: from that point on, each halving of the range only adds 2 to the OCV. For convenient figuring of whole OCV bonuses, note the following:

OCV mod	fraction of range
+1 OCV	0.84 x any given range
+2 OCV	0.71 x any given range
+3 OCV	0.60 x any given range
+4 OCV	0.50 x any given range

Each x 1/2 multiple of human size subtracts 4 OCV; each x 2 multiple of human size adds 4 OCV; technically, the OCV modifier is:

$$\textbf{Area mod to OCV} = 4 * \log_2 (\textbf{area}, \text{ m}^2).$$

A hex has an area of about 4 x human size (about 4 square meters). 'Human size' is figured as 1 square meter of area normal to the fragmentation path. 'In-hex' range is assumed to be 1 meter; direct contact adds +2 OCV more than 'in-hex' range. Each die of Unluck adds +1 to the OCV; each die of Luck subtracts -1 OCV.

Fragmentation attacks are made against a DCV of Ø; neither DEX-based DCV nor skill levels raise this number. Characters in Dodge will gain the usual bonus to DCV for that maneuver (+3 or +5 for some martial artists). Also, the following DCV modifiers for position should be used:

action	DCV mod	usage notes
Crouch:	+1 DCV;	can be combined with Dodge or Diving for Cover; Crouched characters get only 1/2 of their usual movement.
Prone:	+2 DCV;	can be combined with Dodge or Diving for Cover; Prone characters must take a 1/2 phase to get to their feet.

To resolve the attack, compare the OCV of the weapon at the range of the target to the DCV of the target, and make an attack roll. If the roll is *successful*, one or more fragment groups strike the target; if the attack roll is *unsuccessful*, no fragments strike the target. For each 2 points the attack roll is made by, one additional fragment group strikes the target.

Note that fragments use the 'group hits Stun mod' rule: every group above the first which strikes the target adds +1 to the Stun modifier of each group.

Example: Major Thornton is standing next to his car when an M26 fragmentation grenade explodes 1 hex away. The M26 has an effective fragmentation range of 8 hexes, and a listed OCV of -2. At 1 hex range, the Major is at 1/2 x 1/2 x 1/2 of the effective range; the attack thus adds 3 x 4 = +12 to the listed OCV, resulting in an OCV of 12 - 2 = 10. A 7d6 normal explosion is also produced; after resolving the blast damage, the referee determines that since the character was not in Dodge, his DCV is Ø. The referee, making the attack roll of 21-, comes up with a 13: only 5 frag groups strike the Major. The groups are listed as doing 1 point of damage, with a -1 Stun modifier; the 'group hits' rule will adjust the Stun mod to -1 + 4 = +3. For role-playing purposes, it should be noticed that each extra fragment group above the first represents a doubling of the number of nominal, actual fragments striking the target; thus the referee might describe the effect of this attack by noting

that the character has been punctured between 9 and 16 times! As a typical modern fragmentation hand grenade produces from 400 to 1200 fragments, Major Thornton can consider himself lucky.

The referee rules that the portion of the car within 1 hex range of the grenade is a three times man sized object for the purposes of this attack, thus adding 6 to the OCV of the attack. Making the attack roll of 27- (since the car also has a DCV of Ø), the referee rolls an 10, and the car is struck by 9 frag groups. With a Piercing value of Ø, and doing only one point of damage, the fragments are unlikely to penetrate even a cheap plastic car body; again for role-playing purposes is should be noted that a few hundred 'dings' have been put in *the car's body (between 129 and 256 'dings', if a count is made). Other portions of the car, further away than 1 hex from the grenade, will take another few dozen hits.*

17.0 Nuclear Weapons

Nuclear weapons produce three primary immediate damage effects: blast, thermal (flash), and radiation; cratering, radioactive fallout, and firestorms are secondary effects of most nuclear explosions. The following calculations all use these variables:

Y	Explosive yield equivalent 'Y' expressed in tons of TNT.
R	Range from the explosion center, 'R', expressed in meters.
D	Atmospheric density 'D' expressed as multiples of standard sea level air density (1.293 kg per cubic meter); if the density is unknown, pressure relative to standard sea level pressure may be used.
A	Atmospheric clarity attenuation factor 'A', found on the chart below:

conditions	'A' factor
vacuum	infinite
very clear	30,000 m
clear	10,000 m
haze	3,000 m
thin fog	1,000 m
fog	300 m

Three general types of nuclear weapons are considered here: fission and fission/fusion; pure fusion; and antimatter (CT). All 'real-world' weapons are essentially of the 'fission or fission-fusion' variety. For fission, fission-fusion, and pure fusion bombs a further distinction must be made, based on the yield class of the weapon:

Low Yield:	less than 1 kiloton
Medium Yield:	greater than 1 kiloton, less than 30 megatons
High Yield:	greater than 30 megatons

17.1 Fission or Fission-fusion Devices

The damage classes of various effects are calculated as follows:

damage effect			formula
Blast		DC_X	$= 24 + {}^{6}/_{5} \log_2(\mathbf{Y}) - 3*\log_2(\mathbf{R})$
Thermal		DC_T	$= 22 + {}^{9}/_{10} \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - \mathbf{R}/\mathbf{A}$
Radiation (Hard)	[low yield]	DC_R	$= 16 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/200)$
	[medium yield]		$= 16 + 5(\mathbf{Y})0.1 - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/200)$
	[high yield]		$= 19 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/200)$
Radiation (Med.)		DC_R	$= 18 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/120)$
Radiation (Soft)		DC_R	$= 24 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - 2*(\mathbf{R}*\mathbf{D})$

These values can be affected by two further factors: non-standard design or construction, and placement. Total all of the following bonuses which apply:

Design Type	Blast	Therm	Hard Rad	Med Rad	Soft Rad
neutron enhanced	+0 DC	+0 DC	+3 DC	+4 DC	+0 DC
radiation enhanced	+0 DC	+0 DC	+2 DC	+0 DC	+0 DC
fallout enhanced	+0 DC	+0 DC	+1 DC	-1 DC	+0 + fallout

Placement	Blast	Therm	Hard Rad	Med Rad	Soft Rad
sub-surface	+2 DC	none	none	none	none/fallout
surface	+1 DC	+0 DC	+0 DC	+0 DC	+0 + fallout
air (<30km)	+0 DC	+0 DC	+0 DC	+0 DC	+0 DC
high air (<110km)	-1 DC	-1to10 DC	-1 DC	+1 DC	+0 DC
vacuum	none	-10 DC	-1 DC	+1 DC	+0 DC

17.2 Pure Fusion Devices

The damage classes of various effects are calculated as follows:

damage effect			formula
Blast		**DC_X**	$= 24 + {}^6/_5 \log_2(\mathbf{Y}) - 3*\log_2(\mathbf{R})$
THermal		**DC_T**	$= 22 + {}^9/_{10} \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - \mathbf{R}/\mathbf{A}$
Radiation (Hard)	[low yield]	**DC_R**	$= 16 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/200)$
	[medium yield]		$= 16 + 5*(\mathbf{Y})0.1 - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/200)$
	[high yield]		$= 19 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/200)$
Radiation (Med.)		**DC_R**	$= 21 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/120)$
Radiation (Soft)		**DC_R**	$= 24 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - 2(\mathbf{R}*\mathbf{D})$

These values will be affected by placement:

Placement	Blast	Therm	Hard Rad	Med Rad	Soft Rad
sub-surface	+2 DC	none	none	none	none/fallout
surface	+1 DC	+0 DC	+0 DC	+0 DC	+0 + fallout
air (<30km)	+0 DC	+0 DC	+0 DC	+0 DC	+0 DC
high air (<110km)	-1 DC	-1to10 DC	-1 DC	+1 DC	+0 DC
vacuum	none	-10 DC	-1 DC	+1 DC	+0 DC

17.3 Antimatter (CT) Devices

The damage classes of various effects are calculated as follows:

damage effect		formula
Blast		$\mathbf{DC_X} = 23 + {}^6/_5 \log_2(\mathbf{Y}) - 3*\log_2(\mathbf{R})$
THermal		$\mathbf{DC_T} = 21 + {}^9/_{10} \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - \mathbf{R}/\mathbf{A}$
Radiation	(Hard)	$\mathbf{DC_R} = 23 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/2000)$
	(Med.)	$\mathbf{DC_R} = 22 + \log_2(\mathbf{Y}) - 2*\log_2(\mathbf{R}) - ((\mathbf{R}*\mathbf{D})/120)$
	(Soft)	essentially none, as hard and medium radiation is predominant at all ranges

These values will be affected by placement:

Placement	Blast	Therm	Hard Rad	Med Rad	Soft Rad
sub-surface	+2 DC	none	none	none	none/fallout
surface	+1 DC	+1 DC	+0 DC	+0 DC	none + fallout
air (<30km)	+0 DC	+0 DC	+0 DC	+0 DC	none
high air (<110km)	-1 DC	-1to10 DC	+1 DC	-1 DC	none
vacuum	none	-10 DC	+0 DC	+1 DC	none

17.4 Nuclear Weapons - Radiation Effects

The primary, initial emission of radiation from a nuclear explosion consists of gamma rays, neutrons, energetic particles, and X-rays. These are divided into three groups: Hard Radiation: high-energy gamma rays; Medium Radiation: neutrons, low-energy gamma rays; and Soft Radiation: X-rays, beta particles.

All of the radiation damage produced by pure fusion bombs, antimatter bombs, and 'medium' neutron radiation is essentially immediate - the delivery interval is typically measured in milliseconds or microseconds.

For fission and fission-fusion weapons detonated in atmosphere, the 'hard' radiation damage is delivered over a short (but not instantaneous) period of time. Characters exposed for more than 1/2 of the interval in which high-energy gamma rays are being produced will receive the damage listed above. The hard radiation exposure interval is:

exposure interval, seconds $= (\mathbf{Y})^{0.5} / 200$

This will be modified by the placement of the bomb:

Placement	Time Factor
sub-surface	n/a
surface	x 1.414
air (<30km)	x 1
high air (<110 km)	x 0.1
vacuum	x 0

Characters who can obtain cover in some fraction of this time will take one less DC for each halving of their exposure time. One suggested game mechanic for determining the delay in obtaining cover is to require the character to make a DEX roll, with the 'Diving for Cover' distance modifiers; making the roll exactly results in the character getting 'under cover' in 1 second, halved for each 2 points the roll is made by. Gamma radiation from fission and CT bombs is 'prompt,' i.e. no significant delay occurs between detonation and full exposure.

Example: Commander Thomas and CPO Michellin are standing in the open at roughly sea level after firing a 'Davy Crockett' M388 nuclear weapon at a surface target 500 meters away. The weapon is a fission device with a yield of 1000 tons; at this range the medium radiation is rated at DC 6; the bomb produces hard radiation with a DC of 6 also. No soft radiation is experienced at this range. The hard radiation exposure interval is essentially instantaneous. The target is subjected to a Damage Class 36 blast, and Damage Class 34 `soft' radiation (obviously, soft is a relative term).

Protection from 'hard' radiation is afforded primarily by mass: every 300 kg per square meter will reduce radiation damage by 1 DC. Protection from 'medium' radiation is gained at -1 DC per 200 kg per square meter. Protection from 'soft' radiation and residual radiation (i.e., fallout: low-energy gamma rays, beta particles and alpha particles) is gained at -1 DC per 100 kg per square meter. Note that this protection increases linearly, and rounds in ordinary fashion.

Example: the turret roof of the T-72 tank weighs about 280 kg per square meter, and thus has protective values of -1 DC vs. hard radiation, -1 DC vs. medium radiation, and -3 DC vs. soft radiation. Note that this does not include the effect of the neutron-absorbent anti-radiation liner.

After all protective conditions have been applied, apply *only* the radiation damage (either hard, medium, or soft) with the highest remaining damage class; if two classes are equal, apply radiation damage of +1 DC over either one.

Example: as the 'Davy Crockett' bomb produces DC 6 gamma radiation damage and DC 6 neutron damage at 500 meters range, both Commander Thomas and CPO Michellin will take DC 7 radiation damage.

Some sample protection values are:

protection structure		hard	medium	soft
Morrow Project 'Mars' vehicle		-3 DC	-11 DC	-9 DC
tank:	M60	-2 DC	-8 DC	-5 DC
	M48A2	-1 DC	-2 DC	-4 DC
Commando V-150		-1 DC	-1 DC	-2 DC
M113A1 armored personnel carrier		-0 DC	-1 DC	-1 DC
multistory building:	upper floor	-2 DC	-3 DC	-6 DC
	ground floor	-1 DC	-2 DC	-3 DC
frame building:	ground floor	-0 DC	-0 DC	-0 DC
	basement	-1 DC	-2 DC	-3 DC
foxhole		-1 DC	-2 DC	-3 DC
shelter w/1m earth cover		-2 DC	-12 DC	-6 DC

Note that some of these example protection values do not match the results obtained with the above guidelines, due to neutron absorbing liners; the subject of radiation protection will be covered in more detail at some future time, when a more complete coverage of atmospheric transmission, scattering effects, and fallout will be produced by the ASMRB.

It is important to remember that nuclear radiation is scattered by the atmosphere and by contact with objects; therefore, characters must be nearly entirely enclosed by protective structures or devices in order to be protected.

The effect of radiation damage on characters is summarized on the Radiation Effects chart. The direct immediate radiation damage should be rolled as 'normal' dice. The Stun portion of this damage is applied immediately; characters may apply the better of their PD or ED to this portion of the damage. For game purposes, the Body portion of this attack is applied after the period of time listed under 'BOD Delay,' with no defense, and a x2 Body Multiplier (it is assumed to affect the 'Vitals'). Note that the Stun taken by the character may not be less than the final amount of Body lost.

The long term effects of radiation damage are simulated by reducing the Characteristic Maximums; this reduction occurs (for game purposes) after the listed 'Stat Delay,' and is (usually) permanent. The same die rolls should be used for both the direct Body damage and the reduction in characteristic maximums. As a note, the U.S. Army considers 50 rads or so to be a 'war emergency only' dose; 1000 rads is considered a pretty sure thing lethal dose, with a 99% death rate. All medical effects associated with lesser dosages will also experienced at higher dosages.

Example: both Commander Thomas and CPO Michellin have taken DC 7 radiation damage from their 'Davy Crockett' bomb. Both have a BOD and CON of 18 normally, a PD of 8, and 36 Stun. After 15 minutes, each will take a 7d6 attack. Thomas takes 6 Body and 18 Stun, which becomes 12 Body and 12 Stun; Michellin takes 7 Body and 26 Stun, which becomes 14 Body and 18 Stun. Michellin thus is Stunned but not unconscious.

Commander Thomas has also taken 8 Body from thermal damage (see section 12.5); thus he is at -2 BOD! Quick paramedic work by CPO Michellin soon stops Mr. Thomas from losing Body on post-segment 12; within a few hours Thomas is in a major hospital.

After 3 days in the hospital, Thomas has regained 3 Body due to medical treatment, and is at 1 BOD (missing 17 out of 18 BOD); at this time, the Stat reductions are applied. The important one here is the BOD reduction: an 18 was rolled, bringing his maximum BOD to 2. From BOD 2 to BOD 10 all characters spend 16 points; Thomas has spent an additional 16 to get his original BOD of 18. Thus his current BOD is (32 / 4) + 2 = 10. As Thomas is still down 17 Body, he is barely (just barely) alive, at 7 below Ø.

Also in the hospital, Chief Michellin has also recovered 3 Body, and is still down 9 points. Due to the damage class 7 attack, Michellin suffered a 26 point reduction in his BOD Maximum, to -6; there were 48 points 'spent' above this originally on the character's BOD of 18. (48 / 4) + (-6) = 6, Michellin's new BOD characteristic value. As he is still suffering from 9 points of damage, he also is barely alive, at 3 below Ø.

Note that immediate treatment with anti-radiation drugs might have reduced the radiation DC the boys suffered.

17.5 Nuclear Weapons - Thermal Effects

The thermal portion of nuclear explosion damage is caused by intense visible and infrared radiation.

The thermal damage occurs over a short (but not instantaneous) period of time when nuclear weapons are detonated within the atmosphere (in a vacuum, no delay is experienced with any type of nuclear weapon). Characters exposed for more than 1/2 of the interval in which the thermal effect is being produced will receive the full damage. The thermal exposure interval is derived as:

exposure interval, seconds = $(\mathbf{Y})^{0.5} / 200$

This will be modified by the placement of the bomb:

Placement	Time Factor
sub-surface	n/a
surface	x 1.414
air (<30km)	x 1
high air (<110 km)	x 0.1
vacuum	x 0

Characters who can obtain cover in some fraction of this time will take one less DC for each halving of their exposure time. One suggested game mechanic for determining the delay in obtaining cover is to require the character to make a DEX roll, with the 'Diving for Cover' distance modifiers; making the roll exactly results in the character getting 'under cover' in 1 second, halved for each 2 points the roll is made by. Of course, modifiers for surprise may also be appropriate.

Example: Commander Thomas, watching his 1 kiloton fission device explode on a surface target 500 meters away on a clear day, is exposed to a DC 13 thermal effect. The flash exposure interval is about 0.22 seconds. Chief Michellin, his assistant (DEX 18), dives for cover behind their jeep, and based on the player's roll of 11, the character gets 'covered' in under 0.5 seconds. As this is still more than 1/2 of the exposure interval, Chief Michellin is also exposed to DC 13 of thermal effect. The jeep itself, of course, is exposed to the full DC 13 thermal effect.

Protection from thermal effects can be determined by combining the following protection factors (T-DEF); note that, unlike other forms of armor in the Hero System, thermal damage protection is an 'all or nothing' situation: if any Body gets past the protection, then the target character takes *all* the Body (and Stun) of the attack, as a Normal Energy attack, against the 'worst' exposed area. However, location modifiers to Body and Stun are not used.

material	variant	protection value
Armor:	use 15 + 1/3 of 'normal' DEF, with modifiers for Water Content & Color only	
Fabric Thickness:	sheer	9 T-DEF
	thin (summer shirts)	10 T-DEF
	medium (shirts, summer pants)	11 T-DEF
	thick (pants)	12 T-DEF
	each x2 thickness	+1 T-DEF
Fabric Material:	normal (cotton, wool, rayon, etc.)	+0 T-DEF
	synthetics (nylon, polyester, etc.)	-1 T-DEF
	modern synthetics (gore-tex)	+1 T-DEF
	flameproofed (treated fabric)	+1 T-DEF
	fireproof (asbestos, nomex)	+2 T-DEF
Fabric Weave:	fine ('satin')	-1 T-DEF
	coarse ('canvas')	+1 T-DEF
Water Content:	damp	+1 T-DEF
	soaked	+2 T-DEF
Color:	black (dark gray)	+0 T-DEF
	dark (blue denim, olive drab)	+1 T-DEF
	medium (tan, red)	+2 T-DEF
	light (beige, pink)	+3 T-DEF
	white (cream)	+4 T-DEF
	silver	+5 T-DEF

Other conditions can increase or reduce the damage class of the thermal attack, if the T-DEF is 'penetrated':

factor		DC mod
Exposure:	full body	-0 DC
	1/2 (one side or upper half)	-1 DC
	1/4 (head and/or arms and/or legs)	-2 DC
	1/8 (arm or leg or hands or feet or head)	-3 DC
	1/16 (hand or foot)	-4 DC
Skin Color:	dark (African)	-0 DC
	light (Asian, European)	-1 DC
Size	each x2 human size (1 square meter)	+2 DC

Example: when exposed to the flash of the 'Davy Crockett' bomb, both Commander Thomas and CPO Michellin are exposed to DC 13 thermal flash. Thomas is wearing tropical fatigues, not damp or soaked, and is fully exposed; his skin is light colored. Medium cotton fabric in olive drab color is T-DEF 11 against thermal effects; as this is less than the DC 13 thermal attack, he will receive no defense from the clothing, which bursts into flame. However, his light skin color reduces the damage he takes by 1 DC, to DC 12; after applying his ED of 8 he takes 4 Body.

Commander Thomas's assistant, CPO Michellin, is wearing a fire-fighter's suit, fabricated of aluminum coated asbestos. This thick, coarse, silver-colored material provides Michellin with 20 T-DEF against thermal flash; he takes no damage from the DC 13 flash. If Michellin were not wearing the helmet portion of the fire-fighter's suit, he would have been exposed to 13 DC, -3 for head exposed only, -1 for light skin, for 9 DC against his ED of 6; thus 3 points of Body would be taken by the character.

Nuclear flash blindness, temporary or permanent, can be produced by the thermal effect of nuclear explosions. Characters in the open (whether or not they are looking towards the nuclear detonation) receive a negative modifier to visual perception rolls equal to twice the DC of the thermal damage they take. This modifier will be temporary, with a duration of a few hours or days, *unless* the character is actually observing the explosion directly. If produced by direct observation, nuclear flash modifiers are permanent. Permanent perception rolls of zero or less indicate total eyeball damage.

'Flash Protection' (as the Hero System power) will reduce the damage class for flash blindness purposes. The reduction in damage class for vision protective items is proportional to the base 2 logarithm of the transmission factor (1 minus the reflectivity). A few examples of eye protection are given for comparison purposes:

protection type	protection factor
sunglasses:	-1 to -3 DC
welder's goggles or masks:	-10 DC
SAC crew goggles:	-10 DC

If vision protection items are combined, their protective values are added directly together.

Example: Commander Thomas, observing his 1 kiloton fission device detonating, has been exposed to DC 13 thermal damage. He has a pair of aviator sunglasses (-2 DC) for eye protection, and is specifically watching *the blast; he takes a -22 to his visual perception roll. As his normal perception roll was 13-, the referee rules his eyes will (within a few hours) shrivel up and fall out; he is totally, immediately, and permanently blind.*

CPO Michellin, who is not looking directly at the blast, is wearing the gold-tinted visor of his aluminum coated asbestos fire-fighting suit (-2 DC), and a pair of tinted welder's goggles (-10 DC), for a net -12 DC against flash blindness. He therefore receives only DC 1 for flash blindness purposes, and will be -2 on visual perception rolls for a short while.

17.6 Nuclear Blast Effects

Nuclear blast is treated as a normal explosion per Section 16.21; the blast damage can be reduced by the protection modifiers given in that section - always assuming that any protective structures themselves are not destroyed by the explosion.

Note that the radius of the perceptible fireball in a standard atmosphere is equal to the damage class 20 distance from the explosion.

The delay period between the instant of detonation and the arrival of the first blast wave, at sea level on Earth, is found by:

delay time, seconds = **R** / 330 meters/second

Example: Commander Thomas is still standing in the open after firing the 'Davy Crockett' nuclear weapon at a target 500 meters away; CPO Michellin is by now crouched behind their jeep. The weapon is a fission device with a yield of 1000 tons. Thomas will take 9d6 normal damage from the blast effect, which will arrive about 1.5 seconds after detonation; rolling for the damage produces 10 Body and 32 Stun. Thomas has a PD of 12, and takes Ø Body and 20 Stun. Michellin, crouched with half cover, takes only 6d6 damage. The 'Davy Crockett' produces a fireball with a 40 meter radius.

18.0 Lasers

Laser output is of two types: continuous wave (CW) or pulse. In order to describe the damage effects of a laser, the wavelength, power output, and beam diameter must also be known. Various notable laser wavelengths are:

wavelength	band name	notes
< .01 nm	gamma ray	
.01 nm - 50 nm	X ray	
50 nm -300 nm	extreme UV	does not penetrate atmosphere well
300 nm - 0.3 µm	near UV	
0.3 µm - 1 µm	optical	visual continuum
1 µm - 3 µm	near IR	night vision gear; objects 400 - 500 C (750 - 950 F) radiate here
8 µm - 14 µm	far IR	thermal viewers; objects ≈ 27 C (≈ 80 F) radiate here (CO_2 = 10.4 µm)
1 mm - 1 cm	millimeter	masers, millimetric seekers & radars; < 300 GHz
> 1 cm	radio	radio, radar, masers; < 30 GHz

The effects are calculated as follows:

CW Lasers

DC (Killing)	= $\log_2$(**power**, watts / 1600)
Piercing	= 16 - **DC**
Speed Class	= not applicable (already taken into account)
Stun Modifier	= (**DC** / 2) - 2
Damage Range, inches	= (beam **diameter** / **wavelength**) * 2(**DC** / 2) / 3000

Pulse Lasers

DC (Killing)	= $\log_2$(**pulse energy**, joules / 25)
Piercing	= 10
Speed Class	= not applicable (already taken into account)
Stun Modifier	= (**DC** / 2) - 2
Damage Range, inches	= (beam **diameter** / **wavelength**) * 2(**DC** / 3) / 4000

Example: the Ares MP laser produces a 40 kilojoule pulse of 1 µm wavelength deep red light, 7.5 cm diameter at the 'muzzle.' This will be rolled as a DC 10 Killing Attack (3d6+1 K), 10 Piercing, Speed Class n/a, +3 Stun Modifier, and with a Damage Range of 200 inches. At point blank range, this will penetrate 3.6 cm of mild steel.

18.1 Damage Range for Lasers

All laser weapons have a damage range as calculated in section 18.0. For each doubling of the Damage Range, lasers lose 1 Damage Class, and 2 Piercing:

DC Modifier	= $\log_2$(**actual range**, inches / **Damage Range**)
Piercing Modifier	= 2 * $\log_2$(**actual range**, inches / **Damage Range**)

Example: the Ares MP laser, with a 200 inch Damage Range, will lose 1 DC and 2 Pc in the 201 to 400 inch gate, 2 DC and 4 PC in the 401 to 800 inch gate, etc.

19.0 Morbidity, Mortality and Critical Wounds

19.1 Losing Body Below Ø Body

Generally, the stat Body represents blood volume, resistance to shock, and just pure remaining bulk. The principal mechanical dangers which threaten life immediately after wounding are asphyxia and hemorrhage. Thus, the classic "Paramedic roll to stop Bleeding" is more generally:

- controlling major bleeding with tourniquets, manipulation of pressure points, pressure dressings, hemostats, etc.; note that internal hemorrhage can only be controlled by surgery (or magic!).
- ensuring an adequate airway (especially in comatose characters); performing CPR if needed.
- restoration of lost blood volume (in 'modern' campaigns) with whole blood, serum albumin, plasma (gamma globulin), saline, Ringer's lactate, etc.

Only #1 could conceivably be performed in the space of a phase or turn; the remainder could take 30 seconds to 10 minutes. Since indefinite stabilization is unlikely to result from rapid application of a pressure dressing alone, a new game mechanic is proposed, and the following definitions:

'Bleeding to Death'

This game mechanic (lose 1 BOD per post-segment 12) more generally represents any rapid or sudden worsening of the character's condition when death is near. Initially (within seconds after wounding) it usually will be massive blood loss; at later times this game mechanic represents major shock effects (up to coma, asphyxia, or circulatory collapse) requiring artificial respiration, CPR, or other 'heroic measures.'

'Modified Paramedic Roll'

The 'minus half the amount of Body below Ø' roll needed to control 'Bleeding to Death'.

Characters below Ø Body whose 'bleeding' is controlled by a successful modified Paramedic roll must be attended to again, within 5 or 10 minutes, or they will resume dying by losing a Body point immediately, and another every 12 seconds. The second Paramedic roll, to ***stabilize*** the character, does *not* take minuses for Body below Ø. If a character begins 'bleeding' again due to a lack of successful treatment, another modified Paramedic roll must be made, and then a further straight Paramedic roll must be made to stabilize the character. This process can continue until either the character runs out of Body points, or a stabilization roll has been made.

The stabilization roll takes nominally 1 minute (so up to 5 minutes can be taken, for a +1 to the Paramedic roll). The assumed equipment needed for the 'bleeding control' roll is a tourniquet, pressure dressing, or other method of stopping major bleeding; of course, the nature of the injury (physical trauma, thermal trauma, chemical trauma, or a radiation injury) may call for more, less, or different equipment. For the stabilization roll, a medic kit is the assumed equipment; attempting to stabilize a character with no equipment at all will cause a -2 modifier to the roll. Note that Class 2 Hemorrhage is considered to be 1.0 to 1.5 liters blood lost (out of 11 liters in an average man); it is at this level that shock begins to set in, with rapid breathing and pulse rate above 100. Class 3 Hemorrhage is about 2 liters lost; at this level the skin is cold, and cyanosis is visible. A "unit" of blood is about 1/2 liter.

Example: Cherry (Body 10) takes a 12 point bullet wound in the chest. He begins to lose Body at 1 per post-segment 12; fortunately, on the next turn, Mr. X, who only has an 8- familiarity with Paramedic, makes a -1 Paramedic roll anyway and controls Cherry's bleeding, probably with a big, basic bandage or field dressing. Five or six minutes later, it is time to prepare Cherry for transport to the ripperdoc; Mr. X fails his Paramedic roll and Cherry loses another Body point, and will lose one more each turn until a modified Paramedic roll is made. He has probably stopped breathing, and has lost a lot of blood; Mr. X obviously is beyond his medical depth.

Fortunately, the Pod is nearby with a 14- Paramedic roll (due to his cyber-enhanced brain) and a medic kit, and immediately makes a -2 modified Paramedic roll to stabilize Cherry again. After a few minutes of CPR or a high-tech equivalent, he easily makes his 14- Paramedic roll for stabilization. Cherry can now survive more or less indefinitely.

Characters who were in the 'Bleeding to Death' phase can expect one to four days (at least) of medical excitement, involving shock, and cardiovascular, hormonal, electrolytic, or other pathologic responses. Then there are infections, and nasty side effects of anesthesia, traction, or drugs - fun, fun, fun!

19.2 Critical Wounds

An extended treatment of vital tissue destruction is hereby proposed. The following mechanics apply primarily to human beings; presumably, creatures made of sterner stuff would modify some of the numbers involved. Characters damaged by Killing attacks in important locations must make Mortality rolls or die more or less immediately (regardless of their actual remaining Body):

Head wounds (locations 3-5) or Vitals wounds (location 13):

`roll* = 21 -` **`damage done`**`** -` **`Total Stun Mod`**`** + 1/5 of` **`BOD`** `characteristic`

* A roll of 6- always succeeds
** Limited to a maximum equal to the Damage Class of the attack.
*** Total Stun Mod is the attacking mod plus the location mod.

The severity of a 'failed' roll indicates trauma to one or more important organs or vessels of the affected area. A character failing the Mortality roll might still survive if surgical (*not* first aid) treatment is applied within seconds, or at most a minute or two - so, try and get shot in the emergency room if possible. There is normally nothing that can be done with a medic kit and Paramedic skill in the field for a person who fails a Mortality roll.

Example: Billy Joe Gotez (Body 21, Con 20, Stun 43) is shot in the chest and head by an AK-47, each hit for 7 BOD with a +1 Stun Mod. From the chest hit, he takes 28 Stun and is Stunned, but is not impaired, being an astoundingly tough guy. From the head hit, he is Stunned, impaired, and unconscious, and has to make a 13-

Mortality roll (~80% chance of surviving). Even if he makes the Mortality roll, he will have lost 21 Body, and be in serious need of a Paramedic roll.

19.3 Impairing and Disabling Wounds

A more detailed treatment of these effects is being considered.

Document last modified Wednesday, May 24, 2000