ARMOR AND PENETRATION IN COMMAND DECISION

The reason most of us started gaming World War II was probably tank warfare – certainly to judge by the early miniatures rules sets, which treated everything *but* tank versus tank combat as an afterthought. As a result, how game designers come up with the armor ratings of vehicles – as well as the penetration values of guns – is a subject of natural interest. What follows is an overview of my thinking about armor and penetration – which really hasn't hanged very much in the twenty years since the first edition of Command Decision saw print.

The purpose of this article is to give you an insight into my thinking, and an understanding of how the armor and penetration values got to be what they are, and why. The purpose of this article is not to stake a claim to any sort of position of infallibility with respect to these ratings. I'm comfortable with them--you may not be. That's okay. Reasonable people can disagree about things as ambiguous and difficult to quantify as this.

That's probably the most important thing I want to emphasize in this article: this isn't an exact science, and anyone who says it is, is (in my opinion) trying to sell you a bill of goods. More on that as the time comes.

ARMOR VALUE
The basic numeric formulae for evaluating armor protection really haven't changed all that much since the first edition of CD. The armor value of a vehicle is its armor thickness in centimeters, after adjusting for armor slope. The multipliers used for armor slope are:

> 15 degrees = x 1.25
> 30 degrees = x 1.5
> 45 degrees = x 1.75
> 60 degrees = x 2

Gee, Frank, that sounds fairly straightforward. When do we get to the touchy-feely stuff?

Well, for starters, what *is* the front armor thickness of a tank? Is it the average? No, not really. If half of your front armor is 20mm thick, and half of it is 60mm thick, and you get hit by a projectile which will penetrate 30mm, you aren't safe and sound behind your average thickness of 40mm; you're either safe behind 60mm, or you are dead, and it's a 50/50 chance.

Well, not really. It's a 50/50 chance *each hit*, but in a game turn covering up to 30 minutes, we assume a lot more than just a single hit, and so the chances you will avoid being hit in the vulnerable part of the vehicle decrease; with two hits, you have a 75% chance *at least one* of those hits will be on the thinner armor, and one may be all it takes.

So cut to the chase. The standard in CD has always been to use the weakest *significant* armor value of the vehicle. Is "significant" a value judgment? You bet. In general, though, I tend to discount lower front hull armor: most of it's pretty thin, and for a reason – there aren't many actual hits suffered there. The ground tends to cover it from close range very flat trajectory shots, and shots with a steeper angle of attack tend to miss it altogether.

Now, there is some averaging we do in **Command Decision: Test of Battle™** (CD TOB), which we didn't used to do. We used to take the weaker of the hull or turret armor, and that was the basic armor of the vehicle. If the turret was thicker, it got a second (higher) rating, used only in defilade, but the thicker turret armor never affected its defense in a normal combat situation. In CD TOB we average the hull and turret, with a bias toward the turret armor, in part because it's used by itself whenever the tank is in a defilade situation, and in part because I believe in many non-defilade situations a turret strike is more likely than a hull strike. Evidence of this is, quite frankly, mixed, so there's plenty of room for disagreement. That's what I found persuasive, however, and so that's how it's rated in the game.

The CD TOB front armor value is hull, plus two times turret, divided by three.

$A = (H + 2T)/3$

PENETRATION

This is where we put on our wizard robes, because this is all black arts stuff. If you think armor penetration is as simple as looking up a number on a table, put on your seat belt and get ready for a wild ride.

The first, most basic question, we need to answer is, "What do penetration numbers mean?"

It's my experience most gamers think if a weapon has a penetration of 75mm, it means it will punch through a 70mm plate and bounce off of an 80mm plate. Right?

 Not even close.

The British penetration tables are as good an example as any – all use similar methods, although the specific numbers vary a bit. So if the chart says it penetrates 75mm, that means if you shoot at a 75mm plate, it goes through, right?

Not exactly. What it means – *exactly* -- is 80% of the time it will put 20% of the mass of the shot through a 75mm plate.

Think about that for a moment.

The problem with the way most people think about armor penetration is they think of it in terms of a threshold event: a pass-fail, yes-no, on-off phenomenon. It isn't. There is a continuum of levels of success, starting with no effect on the armor at all, and then no penetration of the armor but some internal spalling, followed by fairly energetic spalling, followed by spalling and some shot mass coming through, followed by more and more shot mass coming through, up to effectively 100% of the mass. Since even these are not rigidly predictable results -- even in the controlled environment of a testing range -- we settle for four successes out of five as a reasonable description of penetration. But the point along the damage continuum which we choose to define as a "success" – passage of 20% of the shot mass through the armor – is actually fairly arbitrary.

"It's not arbitrary," I have heard it argued. "No, that's the point at which the anti-tank round can do significant damage to the tank."

Rubbish!

You don't kill a tank with percentages; you kill it with absolutes – absolute masses of metal injected into the interior with absolute amounts of energy. 20% of a 2-pound shot is not the same as 20% of a 20-pound shot, and we all know it. So from where does this bizarre standard come?

I am fairly certain it is legacy science, courtesy of naval ordnance designers. Warships come in all sizes, as do naval guns. You need a benchmark for performance against armor, and delivering enough of the warhead through to explode and cause damage is a very useful yardstick. Why? Because naval ordnance is not expected to sink an enemy ship with one shot…instead, it's expected to make its proportional contribution to the business of pounding the enemy ship slowly into scrap metal. That was the first rigorous testing of penetration ("perforation," the British liked to say in the old days) I'm aware of, and I suspect that since the method was already widely in use, it was just carried over to Army ordnance testing as well. Certainly coastal artillery (traditionally the more "scientific" wing of the artillery community) would have used this method.

But the standard of success against a tank isn't slow debilitation; it's a single round kill.

There is recognition of this issue in some World War II tests. Take the British 25-pounder, for example. The standard of success for most smaller guns was 80%, but the official listed penetration values of the 25-pounder are based on only a 50% standard of success. Why? Because a 25-pounder doesn't have to deliver proportionally as much of its mass through the armor to kill a tank as does a 2-pounder. Obviously. If it delivers just 10% of its mass through the armor, that's the same as the 2-pounder delivering 100% of its mass, and then some.

But how much, in an absolute sense, *does* a round have to over-penetrate its target in order to kill it? More modern tests suggest, in the case of hollow charge warheads, a round has to over-penetrate the target armor by between 100-150mm to have a reliable chance of killing the vehicle. That's a petty fair benchmark -- and it also provides a good

explanation of why most hand-carried World War II hollow-charge rounds were not very reliable at killing tanks, since their *total* penetration was about the required over-penetration value needed for a sure kill.

Right now in CD TOB, if you over-penetrate the enemy armor by 8 or more (80mm), you are guaranteed a kill against anything but an elite target. Everything below is something of a crap shoot (although if you over-penetrate it by 6 or 7, you have to like your chances). You can argue this is generous – well, I'm just a generous guy, I guess.

Maybe not all that generous. Remember, this is a platoon level game, and each turn is up to thirty minutes long. What we are modeling is not the likelihood of one round penetrating and knocking out one tank. We're using those performance measures, but only as a guide to what we're really interested in: whether or not a *platoon* of AFVs has been rendered combat ineffective by fire over the course of a turn.

You don't have to destroy every tank in a platoon to render it combat ineffective. You can also do that by blowing up one or two key AFVs – say the platoon leader's and perhaps the best tank crew's. We know that most damage done in combat by a platoon of tanks is usually done by one or two crews in that platoon; take them out, and the platoon is effectively off the board.

Another way to render a platoon combat ineffective is just to bang it up. Knock a tread off of one tank, jam the turret of another, injure crewmen in a third, and so forth. Enough low-level damage to the vehicles, and attrition of the crews, will render a platoon ineffective. In the game we call it "eliminated", but really, we don't care whether the tanks themselves have been knocked out and are burning, so long as the *platoon* stops doing annoying and dangerous things.

Are there still some tanks left which, if reorganized and re-motivated, could return to the fight? Sure. That's why we have the regroup rule.

Now, here are a few odds and ends to consider,

Angle of Strike
The British test fired guns against plates angled at 30 degrees, but did not add anything to the effective penetration of the gun for the added slope. Why? Because in a combat situation, you will seldom, if ever, engage an armored vehicle perfectly perpendicular to its armor. You'll always be shooting at a bit of an angle, and the British decided the 30 degrees was a good compromise, or battlefield average. Most other countries did something similar in their tests.

Is there a lot of hard science behind this 30 degree figure? No, there isn't. It's just an informed estimate, but I think it's a pretty sound one, so CD TOB penetration figures are also based on a 30 degree off-perpendicular strike.

Face Hardened Armor

Face-hardened (FH) armor and the different ammunition used to defeat it is also an issue worth touching on. Early war thin armor plate benefited considerably from face hardening, and whether or not a gun could deal with face hardened armor could be a big deal. (The way most countries dealt with it was by fitting a face hardened nose cap to keep the shot from breaking up when it hit, but not everyone had capped ammunition right from the start.) Later in the war, as armor got thicker, face hardening was less of an issue, partly for manufacturing reasons and partly because of the different way thicker armor reacts to impact. Not important here.

The question is, how best to cover all of this stuff, especially when you add in the fact rounds capable of defeating face hardened armor aren't really any better against non-face hardened armor. Having an FH armor prescript for face hardened stuff, and then different penetration numbers for every round, based on its performance against conventional and against face hardened, is the brute force way to do it. It's too many ugly numbers, however, for my taste. Instead, what we did was simply rate rounds for their performance against face hardened armor, and leave it at that.

There is some distortion there. It means tanks without face hardened armor actually get the benefit of having it – if they are facing enemy firing uncapped ammunition. As a practical matter this means Italian tanks may have a frontal armor value one too high when facing British uncapped shot. I can live with that – and you've now been informed, so you can fiddle with it if you like.

Unique Events
During the Mortain fighting, one US anti-tank gun crew took out a Panther with one shot to its glacis at close range. How? The gunner aimed for, and put the round through, the machine gun ball mount. Other gunners got belly hits on Panthers by bouncing rounds off the cobblestone street right in front of the enemy tank. Others regularly would aim at, and hit, the track of an advancing tank (provided it was close enough), and when the tank slewed to one side, they'd hit it with a follow-up round in the flank armor, before the driver could reverse to show the front again.

A whole company of Panthers was put out of action in one day in the east by a Soviet antitank rifle platoon. How? AP rounds through the commander's vision blocks and the gun sights. The tanks were still running, but they withdrew from action and were out of it for a couple days.

How do you incorporate this sort of thing in the game without getting bogged down in detail? We do it with two rules. First, the critical hit rule: if you roll a 10 at close range, no matter what the difference in armor and penetration, it's an automatic kill. At longer than close range, a natural 10 on antitank fire is always at least a force back. Second is the rule in which all attacks on AFV in a BUA from the same BUA template are treated as flank shots. These are far better ways to model these effects – in my opinion – than trying to account for every possibly unique event that can happen in combat.

Large Numbers

The standard for armor and penetration in CD TOB is A = cm … mostly. In fact, values above 10 are progressively and proportionally larger. This is less important to CD TOB than it will be to the modern version of the rules. For values from 10 to 20 (higher than anyone will need to worry about in WW II) for both armor and gun penetration, however, the following **_Top Secret_** game values are used.

Game	Cm
10	10
11	11
12	13
13	14
14	16
15	18
16	20
17	23
18	26
19	29
20	33

Oh… I told you the secret formula. Now, I'll have to kill you.