**Revised Comments on OS 696**

**By Nathan Okun (22 March 2012)**

First, for the 16” Mark 8 AP projectiles at 35 degrees:  In this version of OS 696, against the 11" Class "A" plate, it needs 1,490 ft/sec to pass the test (remain “effective” = British "fit to burst") after completely penetrating the plate, while against the 17" Class "A" plate, it needs 2,130 ft/sec to do so.  If you use my V1.21 power law for thickness penetrated in FACEHARD you get (2,130/1,490)1.21 = 1.541 and  if you use the raw thickness ratio, you get 17/11 = 1.545. Almost identical!!  Thus, whether they realized it or not, they were almost exactly using \*\*\*MY FACEHARD PROGRAM 1.21 VELOCITY EXPONENT\*\*\* to equate required penetration velocity to plate thickness in their specs!!!  Now isn’t that interesting!  Even though they used the “Standard Form” of the Thompson “F” Formula in their computations for armor penetration tables (the Ballistic Slide Rules, for example), they did NOT use it here in their test specs.  Reality overcomes theory when the “rubber meets the road” as with spec requirements!

Second, for the 16” 2,240-lb Mark 5 and 2,700-lb Mark 8 AP projectiles:  These have in this version of OS 696, as a typical example, the required velocities for effective penetration against the 17" Class "A" plate at 35 degrees obliquity were 2,330 for the Mark 5 and 2,130 for the Mark 8.  While the last Mark 8 version, the MOD 6, was slightly better than the last version of the Mark 5, the Mark 5 MOD 5 (the nominal 14" Mark 5 MOD 6 shells were actually refurbished US Army Coast Defense 356mm Mark 12 APC projectiles given to the Navy late in WWII and were the same as an earlier, somewhat inferior MOD of the Mark 5, so I do not count them here), the difference in quality -- as rated by changing the velocity needed to penetrate -- was not very much.  If, for this test, you compare the required downward velocity change – 2,130/2,330 = 0.09146 -- when increasing the projectile weight from 2240 lb to 2700 lb, using my FARCHARD's 1.21 velocity exponent (as they seem to be using, subconsciously it seems, as indicated in the first paragraph above), to adjust for the projectile weight increase – here 2,700/2,240 = 1.205357 -- you need the weight increase in the calculations to be adjusted by an exponent of 0.48052 to cancel out the given velocity drop used in the spec.  If the inverse KE ratio of W to V2 to cancel out changes to the each-other was truly valid in these Class "A" armor penetration computations -- as is actually the case with homogeneous armor (Class "B"/STS) penetrated by a pointed/oval-nosed projectile -- then the balancing weight W exponent here should be 1.21/2 = 0.605, since the previous paragraph shows that they were using my 1.21 V exponent.  Obviously, in their specs, as opposed again to theory, they realized that for Class “A” face-hardened armor, the weight increase was causing LESS of a change in penetration than the decrease in velocity did, so the Class "B" homogeneous armor's KE model was wrong, and they modified the specs accordingly (against ignoring theory to get realistic results).  In FACEHARD I make the weight exponent even smaller at 0.2, but the effects of the AP cap and allowed projectile nose damage (but not any major lower body damage, which would fail the spec) kind of blur things, so they were more conservative than me.

I find it interesting that in the actual acceptance specs for Class "A" armor, they were violating their theoretical "Act of God" Basic Rule that \*\*Penetration is Always a Function of Total Projectile Kinetic Energy (KE)\*\*, that is, the KE term [W\*V2] in all penetration formula must always be used as a single entity under all conditions, used by all of the homogeneous-armor-based penetration formulae that they and most everyone else adopted for use with face-hardened armor too. These include, but are not limited to, Dr. Allen V. Hershey’s WWII US Naval Proving Ground STS and Class “B” armor table/formula version of the Thompson “F” Formula built around the 3” US Army M79 AP Shot projectile, the French 1890 DeMarre Nickel-Steel Penetration Formula, the 1931 “Standard Form” of the US Navy post-WWI Thompson “F” Formula (used in most post-1931 US Navy penetration tables in one form or another and created by Dr. L.T.E. Thompson himself), the WWII Krupp “C” Penetration Formula, most British penetration programs used over the years as armor changed, the 1897 US Cleland Davis Harvey Armor Penetration Formulae (one for capped shells and one for uncapped shells), etc.  I do not understand why the reason for these required spec adjustments were not studied to see why they conflicted with the KE-based penetration theory used at the time.  It is obvious that there is a SERIOUS conflict with actual test results, including those incorporated into actual test specs, when these formulae were applied to face-hardened armor, but I can find no documents discussing this anywhere from any nation at any time.

It is amusing to me that what I discovered when I created FACEHARD was, to some extent, known by the US Navy and used in their basic projectile and armor test specs, but never acknowledged by them in any document that I have ever found.  Talk about “double think”!!