ARMED SERVICES BOARD OF CONTRACT APPEALS

Appeal of --	)	
	)	
American Ordnance LLC	)	ASBCA No. 54718
	)	
Under Contract No. DAAA09-98-G-0011	)	

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OPINION BY ADMINISTRATIVE JUDGE PAGE

This appeal arises under a delivery order from the Department of the Army, HQ Industrial Operations Command (IOC), Rock Island Arsenal (Army or government), to American Ordnance LLP (AO) for the load, assembly and pack of 155mm high explosive (HE) M107 projectiles. AO's claim relates to its efforts to produce M107 projectiles loaded with a high explosive known as Composition B (Comp B). AO alleges the government breached the implied warranty of specifications, improperly withheld superior knowledge, and/or breached the implied covenant of good faith and fair dealing. AO submitted a certified claim in the amount of $3,346,045, and charges that the government is responsible for 199 days of delay to the contract; it appealed the contracting officer's deemed denial of its claim. A seven-day hearing was held at Rock Island, Illinois; we consider entitlement only including the number of days of delay if any. The record consists of the parties' pleadings and briefs, Joint Stipulation of Facts, transcripts from the hearing, and the Rule 4 file comprised of tabs 1-495.[1]

[1] Tabs 318 through 373 of the Rule 4 file are blank.

FINDINGS OF FACT

1. On 22 July 1998, the Army and AO executed four documents[2]: 1) Facilities Use Contract No. DAAA09-98-E-0003; 2) Services Basic Ordering Agreement No. DAAA09-98-G-0012; 3) Supply BOA No. DAAA09-98-G-0011 (hereinafter "the BOA"); and, 4) an Advance Agreement on pricing and other issues (R4, tabs 1-3, 13). Under the parties' agreement, AO acquired the right to operate two government-owned, contractor-operated (GOCO) ammunition plants: the Iowa Army Ammunition Plant located in Middletown, Iowa (Iowa), and the Milan Army Ammunition Plant located in Milan, Tennessee (Milan) (*id.*).

2. The BOA contemplated that AO would load, assemble and pack (LAP) munitions and explosives, including the 155mm M107 rounds that are the subject of this appeal. The 155mm high explosive M107 projectile is a large caliber artillery shell, which is loaded and fired from the 155mm howitzer gun, and is produced for use by the United States Army, Marines and State Department approved customers. The M107 projectile is approximately twenty-seven inches long, weighs approximately 100 pounds when loaded with high explosive, and is used for blast effect, fragmentation, and mining. (R4, tab 75; app. br. at 5) The "load" portion of LAP pertains to the process by which an explosive is placed in the projectile. For the M107, this entails melting the government furnished explosive (either trinitrotoluene (TNT) or Comp B), applying a vacuum to the kettle in which the Comp B is melted in order to remove the air for a specific amount of time, pouring the melted explosive into the projectile, performing a controlled cooling of the explosive to prevent cast defects, x-raying the rounds, and finally, placing the projectiles through a post-cycle heat treatment to ensure maximum expansion of the explosive. The assemble portion pertains to putting the various components of the end item together. For the M107, this involves drilling explosive out of the fuse well in order to accept the fuse well liner, then threading in and swaging of the fuse well liner, placing a supplementary charge into the liner, weighing the projectile, stenciling the projectile, and placing a lifting plug in the nose of the projectile. The pack portion requirement for the M107 consists of placing the assembled projectile on a pallet (eight per pallet), placing a pallet top over the projectiles and banding the pallet top and bottom together with steel strapping. (R4, tab 1; tr. 1/51; gov't br. at 9-10)

3. All delivery orders constituted individual contracts that incorporated the provisions of the BOA. Under the BOA, technical data would be provided with each delivery order. (R4, tab 1 at 3, 7) The Army's Armament Research, Development, and Engineering Center (ARDEC) located at Picatinny Arsenal in Picatinny, New Jersey, had

[2] In ASBCA No. 54203 *et al.,* one issue the Army and AO were litigating was whether the BOA or DO 43 was the contract, an issue not relevant to the present appeal. These appeals were settled and withdrawn on 19 September 2007.

responsibility and authority over the specifications and drawings in AO's contracts (R4, tab 71 at 1073; app. br. at 6).

4. The government supplied AO with technical specifications for M107 projectiles under the BOA in Technical Data Package No. 12598444 (original TDP). The original TDP contained the technical specification MIL-P-60377B, which had been last updated on 8 December 1993 (hereafter the 1993 M107 specification). (R4, tab 44; Joint Stipulation (JS) ¶¶ 8, 9)

5. The Army's negotiation of the price matrix for the BOA and Advanced Agreement was based on the 1993 M107 specification supplied by the Army to AO. The price matrix included a catalog of prices under which the Army was entitled to purchase the production of TNT loaded M107 projectiles during a five-year period from 1999 to 2003 (JS ¶¶ 7, 11). During the price matrix negotiations, the parties initially reached an agreement on price for Comp B loaded M107 projectiles. But the government then changed the requirement and negotiated a price for TNT loaded M107 projectiles, as its customer wanted only TNT loaded rounds. (Tr. 5/71-72) Thus, in the final version of the Advance Agreement, which contains the price matrix, Comp B was removed as government-furnished material for the M107 projectile, leaving only TNT flake (R4, tab 13 at 308-09; app. reply br. at 14).

6. The 1993 M107 specification (and later the 2000 M107 specification) provided detailed requirements for the method and process of producing M107 projectiles, and contained a list of approved materials for producing both TNT and Comp B loaded M107 projectiles (JS ¶ 10; R4 tabs 44, 71, 480).

7. The 1993 M107 specification required First Article Testing (FAT) certification. The portion of FAT relevant to this appeal concerns the tests employed to determine base separation, the measure of separation between the shell casing and explosive charge. Base separation is an undesirable condition in munitions produced by the melt-pour, controlled cooling production process. Under the first test for base separation, every M107 projectile in an ovenload (roughly 2500 to 2700 shells) had to be viewed radiographically (using x-rays). If the radiographic test showed a base separation of the explosive cast from the metal parts base greater than 0.015 of an inch, that M107 projectile would be deemed to have a critical defect. Conversely, if the M107 projectile had equal to or less than a 0.015 of an inch gap but greater than zero, that M107 projectile would be selected as one of eight rounds to be subjected to the second test for base separation. (R4, tab 44 at 646, 662; JS ¶¶ 12-17; tr. 1/72-73)

8. The second test for base separation under the 1993 M107 specification required a notch process as follows:

> 4.5.3 Determination of base separation. After heat treatment the samples from each post cycle heat treatment lot shall be cooled to ambient temperature. The projectile shall be conditioned for a minimum of eight (8) hours at 75 ± 10ºF and sectioned at 75 ± 10ºF. A notch shall be cut from the base in the following manner: Cut parallel to the base approximately two (2) inches up from the base to the center of the projectile axis. Next cut through the base toward the nose perpendicular to aforementioned cut so as to remove a wedge of steel to expose explosive and metal parts interface. Gap measurement shall be made with one half (.5) inch wide feeler gage. Base separation shall be measured with the projectile in the nose down orientation.

(R4, tab 44 at 666) The second test for base separation, known as the "notch-only" test, applied to both TNT and Comp B loaded M107 projectiles. The Army considered any separation of the explosive cast (either TNT or Comp B) and the metal parts interface, that was outside of specified tolerances (*i.e.*, greater than 0.015 of an inch), a base separation failure. Any such base separation failure on an M107 projectile was considered a critical defect. (JS ¶¶ 20, 27, 28) The Army believed that base separation was the most critical of the defects that may occur in a round. If there is base separation, the trapped air in the base of the shell (underneath the cast) can be heated adiabatically. Adiabatic pressure is the pressure that occurs when the shell is rammed into the gun. If the pressure becomes too great, there is enough heat to cause the round to blow up and kill the gun crew. (Tr. 6/160-61)

The Melt/Pour Production Process

9. Both TNT and Comp B are loaded into M107 projectiles by means of a process generally known as the melt/pour process (tr. 1/43, 46-57). In the melt/pour process, prior to pouring molten Comp B, the M107 specification required that the contractor add either Lecithin or Pegosperse 400DS in a specific quantity (R4, tab 480). Lecithin and Pegosperse 400DS are additives for Comp B explosive that were added to the M107 specification by the Army to aid the even disbursement of the desensitizing wax when Comp B is melted. TNT does not require additives. (Tr. 1/47, 64-68)

10. After the high explosive is melted and poured, both Comp B and TNT loaded M107 projectiles are sent through a process known as controlled cooling. Comp B and TNT both shrink as they cool. The goal of this step in the production process is to keep the high explosive in the funnel in a molten state and to cool the round from the base of the metal parts up toward the nose. The purpose of keeping the explosive in the funnel molten is to feed that high explosive down through the funnel into the metal part as the cooling explosive cast shrinks, thereby keeping the explosive cast tight inside the metal

part. Controlled cooling must slowly remove the heat from the round. Otherwise, cast defects including base separation will occur. (Tr. 1/51-52)

11. A contractor has different options available for controlled cooling. AO used three different methods of controlled cooling M107 projectiles at its three production lines, Line 3A and Line 3 at Iowa, and Line D at Milan (tr. 1/52-53, 104-05).

12. Line 3A at Iowa is a state-of-the-art production line for large caliber artillery, considered by Army personnel to be the very best in the country (tr. 4/130, 6/109). Line 3A control cools M107 projectiles after they are loaded with molten explosive by means of circulating water and a heated panel that surrounds the top portion of the M107 projectiles (tr. 1/52-53).

13. For controlled cooling on Line 3 at Iowa, an air-cooled process was employed. In this air-cooled process, heated air is drawn from the base of the M107 projectile up past the nose. The neck and funnel of the high explosive on Line 3 is kept molten through the use of specialized funnels containing phase-changed materials. This was a system developed (and later patented) by AO. The phase-changed material once heated would stay heated for eight to ten hours. Inserts were placed over the rounds and kept the area hot for the time the rounds were cooling. (Tr. 1/104-05)

14. Line D at Milan accomplishes controlled cooling of the M107 projectiles through the use of heated air drawn across the base of the metal parts. To keep the explosive molten in the neck and funnel, Line D employed heated copper probes. The heated probes had circulating water or steam running through them and they were lowered into the funnels and down into the neck of the metal parts to keep the explosive in a molten state. (Tr. 1/104-05) Each individual controlled cooling station had duct work and a blower that would draw the air across the base of the shells in order to effect a bottom-up solidification in the M107 (tr. 2/154-55).

15. Once the explosive cast in the metal parts has cooled to a solid state, the M107 projectiles are then allowed to further cool to ambient air temperature. Each M107 projectile is then individually radiographically tested using x-rays to check for cast defects, such as cavitation, cracks, porosity, piping and base separation. (Tr. 1/53-54)

16. Post cycle conditioning was developed as the final step in the melt/pour production process (tr. 4/114). The purpose of post cycle conditioning is to allow the explosive cast to expand or "grow" inside the metal part and, thereby, reduce or eliminate base separation. Following the x-ray examination, all acceptable M107 projectiles are placed in post cycle conditioning ovens that heat and cool the rounds to promote irreversible growth of the explosive cast. (Tr. 1/54)

17. The 1993 M107 specification (and later the 2000 M107 specification) set forth the requirements for approving the contractor's post cycle conditioning capability (R4, tab 44 at 669). Additionally, Note 22 in the M107 Design Drawing gives the step-by-step process that AO was to follow when post cycle conditioning M107 projectiles. Note 22 provides:

> AFTER THE LOADING, PROBING AND COOL DOWN OPERATIONS HAVE BEEN COMPLETED, SUBJECT PROJECTILE TO THE FOLLOWING POST HEAT TREATMENT PROCEDURE:
>
> A. PLACE THE LOADED PROJECTILE(S) IN HEATING/COOLING CHAMBER.
>
> B. CIRCULATE HEATED AIR (68ºC (155ºF) MAXIMUM) AROUND THE PROJECTILE(S). AFTER THE AIR TEMPERATURE OF THE AIR EXITING THE CHAMBER REACHES 60ºC (140ºF) CONTINUE TO CIRCULATE HEATED AIR THROUGH THE CHAMBER TO MAINTAIN EXIT AIR TEMPERATURE BETWEEN 60ºC (140ºF) AND 65ºC (150ºF) FOR A MINIMUM OF 18 HOURS.
>
> C. CIRCULATE COOL AIR (13ºC (55ºF) MINIMUM) AROUND PROJECTILE(S). AFTER THE TEMPERATURE OF THE AIR EXITING THE CHAMBER IS REDUCED TO 21ºC (70ºF) CONTINUE TO CIRCULATE COOL AIR THROUGH THE CHAMBER TO MAINTAIN EXIT AIR TEMPERATURE BETWEEN 21ºC (70ºF) AND 16ºC (60ºF) FOR MINIMUM OF 18 HOURS.
>
> D. CIRCULATE HEATED AIR (68ºC (155ºF) MAXIMUM) AROUND THE PROJECTILE(S). AFTER THE TEMPERATURE OF THE AIR EXITING THE CHAMBER REACHES 60ºC (140ºF) CONTINUE TO CIRCULATE HEATED AIR THROUGH THE CHAMBER TO MAINTAIN EXIT AIR TEMPERATURE BETWEEN 60ºC (140ºF) AND 65ºC (150ºF) FOR A MINIMUM OF 18 HOURS.
>
> E. CIRCULATE COOL AIR (13ºC (55ºF) MINIMUM) AROUND THE PROJECTILE(S). AFTER THE

(R4, tab 47 at 767, tab 480 at 12627)

18. There are important differences between TNT and Comp B that impact the effectiveness of post cycle conditioning. Comp B is a mixture consisting of approximately 59.5% of a compound known as Royal Demolition Explosive (RDX), approximately 39.5% TNT, and approximately 1% of a desensitizing wax. (Tr. 6/98; app. br. at 15) The military specification for Comp B allows for some limited variation within the RDX, the TNT and the wax percentages (R4, tab 449 at 17992-93). The explosive cast in M107 projectiles poured with 100% TNT has two and one-half times more expansive growth potential than those poured with Comp B during post cycle conditioning. Conversely, Comp B loaded M107 projectiles have only 40% of the growth potential during post cycle conditioning. This is because the RDX in Comp B, which is approximately 60% of the mixture, does not grow or expand during post cycle conditioning due to the fact that RDX never melts. Comp B is not a very strong material, and has a tendency to crack or shatter when placed under tensile load. The metal parts temperature prior to pouring and post cycle conditioning are both factors that can impact cracking in Comp B. (Tr. 2/170-76, 6/167; R4, tab 449 at 17993)

19. Both the government and AO knew about the "wax wars," an expression used by the parties to describe the period in the 1970s and early 1980s when the munitions industry tried to solve cast quality problems because of the difficulties in successfully producing rounds with Comp B comprised of the various types of waxes. The challenge with any wax is to get it completely melted and to keep the wax in suspension so that it does not separate. If the wax separates, it can form balls or lumps which can cause pouring problems, and also can negatively impact cast quality and base separation. There was considerable variation in the properties of the waxes which could be made by different manufacturers using Grade A or Grade B wax, and there were various levels within the grades. Grade A wax: (1) had less impurities; (2) stayed in suspension without an elevated melt temperature; and (3) usually did not require an additive, thus making it easier and cheaper to use in production. The supply of Comp B made with the better quality wax had been used up, and the available government supply of Comp B that remained for this contract contained a lesser quality wax. The Comp B used in the production of M107 projectiles in this appeal is government-furnished material which contained Indramic wax. Indramic wax is a Grade B wax considered inferior in quality, the "worst of all waxes for [base] separation," and requires an increased melt temperature and an additive to keep it in suspension. (Tr. 1/49-50, 63-64, 67, 83, 123-24, 2/15, 17-18,

171-72; 5/21; R4, tab 80 at 1383) Indramic wax is cheaper than other waxes (tr. 1/63). As explained by the following testimony, because the only ready government supply of Comp B contained Indramic wax, the contractor encountered the same difficulties in successfully pouring M107 rounds with Comp B that had been recognized during the wax wars:

> A ...It varies—it can vary in physical nature. It can vary in color. It can vary in particle size. From some of its chemical characteristics it varies in viscosity when it's poured. It can vary in its chemical nature as far as impurities are concerned. It can vary in the way it control cools. It can vary in the way that it's machined.
>
> Q And how do those variations, if they in fact do, get taken into account during the processing of Comp B rounds?
>
> A Well, it's very difficult to take variation into account. It's like predicting the future. It's very difficult to do, because [we as a company], we don't necessarily know say [sic] the characteristics of the Composition B. It's furnished to us. It's given to us to use. And the B –
>
> Q Given to you by the government?
>
> A It's given to us by the government, that's correct.... It's very difficult to predict from lot to lot how the Composition B will change.

(Tr. 2/173-74) Because individual lots of Comp B vary, AO had to be flexible and be prepared to use variable parameters to handle this variation:

> Comp B acts differently with your loading parameters by different kettles. The kettle size can make a difference, whether it is steam heated or water heated makes a difference. The actual lots, individual lots of the Comp B will vary and you have to have variable parameters to handle those. So you can't set just one set of parameters and assume it will work on this production line and you can then transmit it to the second line[;] it will not work.

(Tr. 5/32-33)

20. On 2 December 1998, the parties entered into Delivery Order No. 0001 (DO 01). DO 01 incorporated the 1993 M107 specification and required AO to produce TNT loaded M107 projectiles for FAT certification. (JS ¶¶ 21-22) On 16 February 1999, the Army placed an order with AO for the production of 343,872 TNT loaded M107 projectiles through Modification No. 01 of DO 01 (R4, tab 46).

Army's Change from TNT-loaded to Comp B Loaded M107 Projectiles

21. From the late 1960s, the Army had certified the use of both TNT and Comp B as acceptable for 155mm M107 projectiles (JS ¶4). AO's predecessor corporation loaded Comp B M107 projectiles at Iowa until the mid to late 1970s, but not thereafter as the Army shut down production. These 1970s-era Comp B M107 projectiles were manufactured under a different TDP which did not include the notch and drop test. After DO 01 was executed, the Army anticipated a continuing need for M107 projectiles. Since the supply of TNT was running short, the Army planned to load only some rounds with Comp B during FY99-01, and then to fill all of the rounds with Comp B thereafter (FY02-07). (R4, tab 382 at 3; tr. 1/101)

22. As of 1 August 1999, Mr. Phillip Clem, AO's technical director at Iowa, was unofficially informed, through an impromptu conversation which took place in a lobby, that the Army would be changing from TNT to Comp B for M107 projectiles:

> IOC is insistent that the M107 will go to the Comp B load. Pete [Czachorowski][3] has tried to argue against the use of Comp B in a practice round, but to no avail, because the Army is setting [sic] on a huge inventory of Comp B. This is certainly not news, because IOC wanted to load Comp B when we first started matrix discussions. The only thing that prevented it, was that the old projectiles were not ultrasonic tested, and therefore did not have the necessary safety margin for a Comp B load.

(R4, tab 90; tr. 1/179) AO internally suggested that it should begin to develop a Comp B loading process for the M107 in anticipation of the government's switch to Comp B since: (1) Comp B M107 projectiles had not been produced at Iowa for over 20 years; (2) the criteria for producing M107s had changed; (3) the types of x-ray film over time had changed and the specification required 100 percent x-ray inspections; and (4) AO could acquire from IOC some spare Comp B and use reject M107s from current production (to build a prototype), thus saving time in the initial ramp-up phase of

[3] Mr. Peter Czachorowski is employed by ARDEC, and is responsible for writing the "notch and drop" requirement for the 2000 M107 specification discussed *supra* (tr. 6/159-60).

production, "putting us ahead of our competitors" (*id.*; tr. 1/180-82). However, in the end, AO never got permission or load authority to proceed with the proposed early Comp B loading process (tr. 1/182). AO had to have government approval "for the explosive material, the projectiles to use in the test and everything else" to develop a loading process (tr. 1/181).

23. On 24 August 1999, certain ARDEC personnel[4] met to discuss the available data related to safety issues for Comp B loaded M107 projectiles. The attendees concluded:

> We initially objected to the loading of a training round with Comp B because of Viet Nam era study data indicating that it is more likely to cause a [sic] inbore premature than TNT. A review was conducted of Viet Nam data together with malfunction and use data since that time.... The new Comp B M107s will have [ultrasonic tested] inspected bodies, 100% x-rayed charges, and new design supplementary charges which can't pop out if chambered without a fuze.... Based on the malfunction data and the afore mentioned improvements, the attendees concluded that it is safe to load the new M107s with Comp B.

(R4, tab 382 at 2)

24. On 25 October 1999, ARDEC submitted to IOC the Comp B engineering study proposal (Army Comp B Load Study) to request approval and funding from IOC to "establish a controlled cooling Composition B melt pour loading process for the M107 155mm HE projectile" (R4, tab 379). The study's Background/Guidance/Status section consisted of seven bullets which included the following:

- Over the past 10 years numerous loading problems and excessive defect rates have been experienced during the loading of various munitions with Comp-B having Indramic wax.
- *The current M107 Comp-B loading drawings/specification does not specify a loading process. Therefore, it is expected that without proper process controls critical defects will be generated and likely*

[4] The names of the ARDEC attendees listed in the e-mail at R4, tab 382 at 2, appear to have been redacted but the list appears again, unredacted, at R4, tab 386A at 1-2. The list of attendees did not include any contractor personnel.

increase over current levels when loading Comp-B having Indramic wax begins.

- *155mm Comp-B loaded munitions are 2-3 times more likely to experience an incident vs. TNT loaded projectiles.*

(*Id.* at 3) (emphasis added) The objective of the Army Comp B Load Study was to "establish a robust controlled cooling loading process for the M107 which will reliably produce zero base separation after nose drop testing (comparable to the M795 loading process)" (*id.*).

25. The Army Comp B Load Study proposal noted the alternatives to conducting the proposed load study. The Alternatives section provided the following:

- Option 1 – Maintain the status quo
  - Critical defects will be generated during the production of Comp-B loaded M107 projectiles.
  - Contractor has no incentive to develop a robust loading process.
  - *Contractor is likely to over/under bid LAP cost since required processing time is unknown.*
- *Option 2 – Increase inspection requirements in order to ensure that process control is maintained* (i.e. i and s value requirements, nose drop testing, automated base gap inspection, etc.)
  - *Increased LAP costs.*

(R4, tab 379 at 4) (emphasis added) The Army Comp B Load Study under the Issues/Concerns section emphasized again that *"[i]f the project is not approved the inspection requirements for the M107 will have to be increased to ensure that the required cast quality is achieved. This will result in an increase in LAP contract costs."* (R4, tab 379 at 8) (emphasis added)

26. The initial funding for the Army Comp B Load Study was $411,900.00, and completion was anticipated by the first quarter of fiscal year 2001, no later than 31 December 2000 (R4, tab 379 at 2, 6; tr. 4/154).

27. The Army Comp B Load Study proposal listed as the "Proposed/Approved Solution" to establish a controlled cooling loading process for the Comp B M107 projectile and to "*[i]ncorporate the established process into the M107 [TDP] for use on current and future production contracts*" (R4, tab 379 at 4) (emphasis added).

28. In early December 1999, e-mails between various Army organizations[5] revealed the Army was still soliciting and receiving input about safety concerns regarding the Army's decision to change from TNT to Comp B loaded M107 projectiles, as evidenced by the following:

> Currently the IOC plans to procure the M107 projectile at a rate of approximately 200 k per year for the next several years. The TDP for the M107 permits loading the projectile with either TNT or [Comp B]. Since the supply of TNT is running short, the current plan is to begin filling some M107 rounds with [Comp B] during the FY99-01 buys and then fill all of the rounds with [Comp B] thereafter (FY02-07).... There is a surplus of about 80 million pounds of [Comp B].
>
> ....
>
> *The question is: Is there a safety issue with loading the M107 projectile with [Comp B] such that restrictions/conditions need to be identified?*
>
> The Cannon Artillery Munitions IPT is planning to initiate a strategic look at HE rounds beginning this Wednesday, 8 Dec 99 in Washington. The IPT which is chaired by PM ARMS is comprised of *all key stakeholders* which include TACOM-ARDEC, IOC, DCS AMMO, the Field Artillery School, the USMC and many others. *The answer to this question can significantly impact future planning***.** Hence, a response prior to the meeting would be greatly appreciated, if possible.

(R4, tab 382 at 2-3) (emphasis added) There is no evidence in the record that this information was ever shared with AO. The Army Comp B Load Study proposal was disclosed to AO over two years later (findings 54, 55).

Engineering Change Proposal No. R9Q2049

[5] The e-mails show dissemination to various individuals at government organizations which included the United States Marine Corps, U.S. Army Research Development & Engineering Center, Tank Automotive and Armaments Command Cannon Artillery Mortar Munitions, Rock Island government personnel and others (*see* R4, tab 382 at 2-5). The contractor was not included in the e-mail list.

29. On 15 December 1999, during AO's performance of DO 01 and before the Army Comp B Load Study was funded or completed, ARDEC initiated Engineering Change Proposal (ECP) No. R9Q2049. ECP No. R9Q2049 proposed the substitution of the notch-only test requirement with the "notch and drop" requirement (alternatively referred to as "nose bump test," "drop test," or "notch and drop test") for use in FAT certification testing of base separation. The notch and drop requirement proposed by ECP No. R9Q2049 provided as follows:

> 4.5.3 Determination of base separation. After heat treatment the samples from each post cycle heat treatment lot shall be cooled to ambient temperature. The projectiles shall be conditioned for a minimum of eight (8) hours at 75 ± 10ºF and sectioned at 75 ± 10ºF. A notch shall be cut from the base in the following manner: cut parallel to the base approximately two (2) inches up from the base to the center of the projectile axis. Next cut through the base toward the nose perpendicular to aforementioned cut so as to remove a wedge of steel to expose explosive and metal parts interface. Gap measurement shall be made with one half (.5) inch wide feeler gage. Base separation shall be measured with the projectile in the nose down orientation. *Subject the projectile to an acceleration level of 200 to 250 G's in the nose down orientation and maintain the projectile in that orientation to measure for base separation with a one half (1/2) inch feeler gage.*

(JS ¶¶ 23-25; R4, tabs 71, 384) (emphasis added) The purpose of the notch and drop test is to simulate the ramming force of the howitzer gun as it positions an artillery shell for firing (tr. 4/144-45, 5/108). If the explosive cast is loose inside the metal part, the drop portion of the test will cause the cast to move forward, toward the nose, thereby exposing any base separation (tr. 5/107).

30. ECP No. R9Q2049 arose out of ARDEC's review of testing information developed during AO's prior production of TNT loaded M795 projectiles (JS ¶ 29). "*The Army's technical requirements for M795 projectiles only permit the use of TNT in production and prohibit use of alternative explosives, such as Comp B*" (JS ¶ 30) (emphasis added). ECP No. R9Q2049 added the notch and drop requirement to M107 projectiles loaded with either TNT or Comp B (JS ¶ 31). Mr. Peter Czachorowski, an ARDEC employee with over twenty-five years experience with high explosive field artillery ammunition, was responsible for writing ECP No. R9Q2049 (tr. 6/155, 159). In making the recommendation to add the test to M107 rounds, Mr. Czachorowski relied on the notch and drop testing done with M795 rounds (which are subjected to this test but are produced with TNT), production data from the 1980s at the Louisiana Army

Ammunition Plant, and his engineering judgment of the presumption that "we would get...about 40 percent of the growth out of the post-cycle process, which we had made a vast improvement to" compared to the post-cycle process used previously, to determine that ECP No. R9Q2049 could successfully be performed on Comp B M107 rounds (tr. 6/159-63, 203-04, 206). The Army initiated ECP No. R9Q2049 without technical data, independent research or testing to validate whether Comp B loaded M107 projectiles could reliably pass the notch and drop test (tr. 6/201-03). Government counsel never qualified Mr. Czachorowski as an expert. Mr. Lawrence E. Niebuhr, an engineer at Rock Island Arsenal, worked with several ammunition programs including the M107 projectiles (tr. 6/25-26). He was a member of the Configuration Control Board (CCB)[6] that added the notch and drop test. This was done because the test had been useful in detecting base separation in the M795 projectiles. (Tr. 6/61-63) Mr. Niebuhr testified that there was no independent testing to verify the assumption, or to investigate the impact of adding this test in a production environment (tr. 6/65-72).

31. A study[7] completed at the Louisiana Army Ammunition Plant in 1982 (the 1982 study) was part of the "production data" upon which Mr. Czachorowski and ARDEC relied to support the position that Comp B loaded M107 rounds could pass the notch and drop test ECP (gov't br. at 16; gov't reply br. at 27-28; R4, tab 79; tr. 6/206). In its briefs, the government posits that "[t]his data shows that during the 1982 study, 113 rounds were tested as to whether there was base separation of Comp B M107 rounds after the round was dropped" (gov't reply br. at 27-8) and that "[q]uite a few of the rounds passed the drop test and showed less than 0.015 [inches] of base separation" (gov't br. at 16). However, this testing did not incorporate the same notching requirement AO had to meet in the 2000 M107 specification.

32. The purpose of the 1982 study was to "conduct the third phase of an evaluation of wax candidates for use in Composition B" (R4, tab 79 at 1220). Two formulas of Comp B, one containing Fuller Wax and the other Emerwax, were evaluated in the 155mm, M107 projectile (*id.*). The 1982 study included data on base separation which seem to indicate that M107 rounds with Comp B could pass the notch and drop test with less than 0.015 inch base separation (R4, tab 70 at 1319-22). However, the M107 projectiles poured in the 1982 study were not part of a production run, and were not required to pass even the drop test administered in the study as official inspection was made after notch sectioning but before dropping. Even with this less rigorous testing, more than half of the projectiles tested in the 1982 study would be rejected under the

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[6] The Configuration Control Board controls the technical data package of ammunition items. An item cannot be changed or go into production unless the CCB has approved the change to the TDP. (Tr. 1/184-86)

[7] Thiokol Corp., *Composition B Wax Study--Evaluation in the 155mm, M107, HE Projectile of Composition B Containing Wax Candidates* (March 1982) (R4, tab 79).

2000 M107 specification as these rounds showed more than 0.015 inches of base separation. Finally, the Comp B utilized in the study contained different waxes than the government furnished Comp B containing Indramic wax used in the present appeal. (R4, tab 79 at 1222-30, 1319-22; app. br. at 8, 9; tr. 6/138-39, 146-51)

33. We conclude that the 1982 study is not evidence that Comp B loaded M107 projectiles could pass the notch and drop test in ECP No. R9Q2049. We find no other evidence in the record that supports the proposition that Comp B loaded M107 projectiles could reliably pass the notch and drop test at the time ARDEC initiated ECP No. R9Q2049.

34. Despite having the information from the 1982 study and without bringing the 1982 study to the attention of the contractor, the Army represented that the cost of the addition of ECP No. R9Q2049 would be $5,000, the equivalent of "paper work money," since "[the Army] had no way to estimate what the contractor's risk would be from accomplishing this task" (R4, tab 68; tr. 6/163-64, 212).

35. The Army provided AO with ECP No. R9Q2049 for review on 17 February 2000 and requested a formal cost estimate from AO of its implementation no later than 17 March 2000 (R4, tabs 49, 386).

36. By date of 8 March 2000, Modification No. 07 to DO 01 contractually incorporated the addition of the notch and drop testing requirement described in ECP No. R9Q2049 into the Army's order of TNT loaded M107 projectiles. On 20 March 2000, the Army added Amendment No. 2 to the 1993 M107 specification which incorporated the notch and drop requirement (hereafter the 2000 M107 specification). (JS ¶¶ 33, 34) Thus, we find that the Army chose first to implement Option 2 specified in the alternatives section of its Army Comp B Load Study to increase the inspection requirements before it conducted or completed its anticipated load study. Had the Army developed the "robust...loading process" the Army Comp B Load Study proposal indicated was needed, that effort would have been completed by 31 December 2000 (findings 24, 26), at least ten months before AO's first FAT attempt in October 2001 (findings 71-72).

37. AO accepted the notch and drop test ECP at no cost or schedule impact to DO 01 (R4, tab 70). AO relied on the Army's approval of ECP No. R9Q2049 as a representation that validation testing had been performed, that its addition to the M107 specification would not render the item non-producible and that the estimated cost for the change was insignificant (tr. 6/212, 7/60-61). Mr. Richard Zastrow, Chief of the Energetic Materials and Corrosion Control Branch for ARDEC, testified to the following:

> Q Mr. Zastrow, would you be surprised to know that the Army relied only on the data from the M-795

program in support of the ECP for adding the nose bump to the M-107 [specification]?

A I believe I said that in my deposition, yes.

Q And you'd be surprised, because in your view, the Army typically tests everything in advance, because they do not set contractors up for failure, is that right? In your experience, is that right?

A That's what I thought was done.

Q And I believe you're also of the view that a contractor has a right to rely on a technical data package as being accurate and producible?

A Yes, I made that statement.

(Tr. 6/113-14) We find that AO reasonably relied upon the government's assertion that the addition of the notch and drop test to the TDP was valued only as a minimal "paperwork" change.

38. On 19 September 2000, the parties entered into Delivery Order 0022 (DO 22). DO 22 required AO to provide the Army requirements and Foreign Military Sales (FMS) requirements of the 155mm, M107 LAP using TNT. The place of performance for DO 22 was Iowa. (R4, tab 14)

39. On 21 December 2000, ARDEC distributed for comment within the government[8] only, a revised Army Comp B Load Study proposal (R4, tab 382). Under the Background/Guidance/Status, one of the bullets was expanded as follows:

> The current M107 Comp-B loading drawings/specification does not specify a loading process. Recent loading of M107 projectiles has experienced reject rates above 9%. Therefore, it is expected that without proper process controls critical defects will be generated and likely increase over current

[8] The cover e-mail was sent from "Jack Hyer, Artillery & Mortar Team Leader" to various individuals at Rock Island and ARDEC (R4, tab 382 at 1). Besides the cover e-mail and the revised Army Comp B Load Study proposal, the e-mail contained a string of e-mails dating from the December, 1999 timeframe addressing government concerns over Comp B safety issues and is referenced at finding 28 (*id.* at 2-5).

> levels when loading Comp-B having Indramic wax begins. *In addition, without a specified loading process, start-up problems are more likely to occur that will increase cost and delay production deliveries.* [Emphasis added]

(*Id.* at 7)

40. Since the initial submission of the Army Comp B Load Study proposal on 25 October 1999, the schedule also had changed. ARDEC now estimated that the Army Comp B Load Study would not be completed until the second quarter of fiscal year 2002. (*Id.* at 10) However, as in the original submission of the Army Comp B Load Study, ARDEC concluded that "*a mandatory loading process is required in order to ensure that safe munitions are provided to the United States*" (R4, tab 379 at 11, tab 382 at 15) (emphasis added).

41. On 18 March 2001, the Army's CCB approved funding in the amount of $690,236 for ARDEC to complete the Army Comp B Load Study which included $152,223 for validation testing by AO (R4, tab 387 at 2, 6, 11; tr. 5/205). The final, revised Army Comp B Load Study acknowledged that AO "plans to transition M107 melt pour production from Line 3A to Line 3 in Jul 01" (R4, tab 387 at 7). (Line 3A at Iowa is a water-cooled process and Line 3 at Iowa is an air-cooled process.) The Army Comp B Load Study had been modified to require the prove-out of both a water-cooled and an air-cooled process for the M107 "which will *reliably produce zero base separation after nose drop testing* (comparable to the M795 loading process)" (*id.*) (emphasis added). Under the Conclusions section an additional bullet was added which read, "Advisory baseline parameters will ensure that the TDP is competitive and not fixed to a single facility/process" (R4, tab 387 at 15). This last statement is important as it demonstrates the government's understanding that a fully developed TDP had to address both multiple manufacturing processes and facilities.

Delivery Order 0043

42. On 22 March 2001, the Army issued Request for Proposal No. DAAA09-01-R-0023 (RFP 0023) to AO, which called for the production of both Comp B loaded and TNT loaded M107 projectiles at Iowa (JS ¶ 35; R4, tab 50). The Army did not disclose: (1) that the Army Comp B Load Study had been proposed and funded but not yet executed; or, (2) that it anticipated that the contractor would likely experience increased costs and problems, including significant critical defect problems, production line shutdowns, and difficulty passing the notch and drop test while producing and loading Comp B projectiles.

43. On 6 April 2001, AO accepted Delivery Order 0043 (DO 43) for a firm fixed-price of $28,116,492. DO 43 required AO to provide rounds for the Army and FMS requirements of the 155mm M107 as follows:

CLIN	Quantity	Type
0002AA	12,237	Comp B
0003AA	170,500	Comp B
0003AB	14,016	Comp B
0004AA	203,816	TNT

(R4, tab 15)

44. Pursuant to DO 43, the parties agreed that AO would produce the Comp B loaded M107 projectiles according to the 2000 M107 specification (JS ¶ 36). At the time AO signed DO 43, neither AO nor its predecessor had produced Comp B M107 rounds for over twenty years (tr. 1/101, 5/19).

45. DO 43 contained standard contract provisions including: FAR 52.242-17, GOVERNMENT DELAY OF WORK (APR 1984); FAR 52.233-1, DISPUTES (OCT 1995); and FAR 52.243-1, CHANGES—FIXED-PRICE (AUG 1987) (R4, tab 15 at 427-29).[9]

46. In addition to the standard contract provisions, DO 43 incorporated DFARS 252.243-7000, ENGINEERING CHANGE PROPOSALS (JUL 1997) which allowed AO to submit an engineering change proposal (R4, tab 15 at 428, tab 1 at 47).

47. Under DO 43, AO was required to pass all requirements for the FAT under the 2000 M107 specification consistent with clause E-5 (R4, tab 15 at 424, tab 1 at 9). Clause E-5 incorporates 52.209-4511, FIRST ARTICLE TEST (GOVERNMENT TESTING) (MAY 1994) which provides in relevant part:

> (a) The first article shall consist of [the assemblies, components, and test specimens listed in the quantities indicated per MIL-P-60377B with Amendment 2] which shall be examined and tested in accordance with contract requirements, the item specification(s), the Quality Assurance Provisions (QAPS) and drawings listed in the Technical Data Package.
>
> (b) *The first article shall be representative of items to be manufactured using the same processes and procedures as*

[9] FAR 52.233-1 and 52.243-1 are incorporated by reference from the BOA under Section I-46 (R4, tab 1 at 50-51).

> *contract production.* All parts and materials, including packaging and packing, shall be obtained from the same source of supply as will be used during regular production. All components, subassemblies, and assemblies in the first article sample shall have been produced by the Contractor (including subcontractors) using the technical data package provided by the Government. [Emphasis added]

(*Id.*)[10]

48. Together with FAR 52.209-4511, section 4.3 of the 2000 M107 specification sets forth additional requirements for acquiring FAT certification for the production of M107 projectiles (R4, tab 71 at 1055-56). In order to acquire FAT certification, AO had to pour Comp B loaded M107 projectiles that satisfied the 2000 M107 specification criteria in the Quality Conformance Inspection tables and Section 4.4.3 (*id.* at 1068). Section 4.4.3.1.1 set forth the following requirements for base separation testing:

> 4.4.3.1.1 Base Separation. (See 3.3.5) – Critical Defect-Eight (8) projectiles with base separations as determined by X-ray will be selected for test per post cycle heat treatment lot. If insufficient samples are available with base separation a sufficient number of samples shall be randomly selected from that portion of the lot that was not X-rayed to make up the required samples. The samples shall be placed in the coldest area of room. *Any projectile having base separation in excess of that permitted by the applicable requirement shall be classed defective and the post cycle treatment lot represented by that sample shall be rejected.* The test shall be performed as specified in 4.5.3 [*i.e.*, the notch and drop test] using equipment in accordance with 4.4.4. [Emphasis added]

(*Id.*) Thus in order to acquire FAT certification, the AO samples had to pass the notch and drop test 100%, with no failures.

49. Attachment 11 of DO 43 listed AO's obligations under the Critical Defect Program as follows:

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[10] Clause E-5 incorporates the IOC command unique clause 52.209-4511 which can be found at http://www.osc.army.mil/ac/aais/ioc/clauses/cmduniq/index.htm. FAR 52.209-4511 contained blanks in the BOA that were filled in by Attachment 001 to DO 43 (*see* app. br. at 8 n.5).

> 3.2.4 Critical Defect Program:
>
> 3.2.4.1. The contractor's processes shall be designed to prevent the creation or occurrence of Critical and Special (Critical Level I or Critical Level II) nonconformances. The contractor shall establish, document, and maintain specific procedures, work and handling instructions and process controls relating to any critical characteristics....
>
> 3.2.4.2 In the event a critical defect is found anywhere in the production process, the contractor, as a part of his quality system, shall have procedures in place to ensure:
>
> 3.2.4.2.1 The defect is positively identified and segregated to ensure that there is no possibility of the item inadvertently re-entering the production process. This control shall be accomplished without affecting or impairing subsequent defect analysis.
>
> 3.2.4.2.2 The operation that produced the defective component or assembly is immediately stopped, and product is suspended back to the last accepted lot.
>
> 3.2.4.2.3 Immediate notification of the occurrence of a critical defect is made to the government (DI-SAFT-80970A).
>
> ....
>
> 3.2.4.2.5 An investigation is conducted to determine the cause of the deficiency and required corrective actions....
>
> 3.2.4.2.6 A request to restart manufacturing or to use any suspect material associated with the critical defect is submitted to the government (DI-SAFT-80970A). Restart of manufacturing or use of any suspect material shall not occur without authorization from the Procuring Contracting Officer.

(R4, tab 15 at 449) Thus, if AO had a base separation greater than 0.015 of an inch in even a single projectile, then an entire oven load (up to 2,700 rounds) would be put into reject status and the production line would automatically be shutdown. The cost per day to AO for a production line shutdown was $35,000. (*Id.*; tr. 4/202-05, 226, 5/54-55; app. br. at 10)

50. Section 6.13 of the 2000 M107 specification contains the following requirement in regard to Comp B:

> 6.13 Processing aid material for high explosive charge. *Only qualified process aid materials are permitted with Composition B, MIL-C-401.* Before adding materials, the Comp B temperature shall be above 194 degrees Fahrenheit to provide satisfactory emulsion. The following materials have been found acceptable as wax dispersants when added to molten Comp B:
>
> Lecithin, MIL-L-3061, in quantity of 0.10% - 0.02% by weight added.
>
> Pegosperse 400 DS in quantity of 0.08% - 0.02% by weight added.

(R4, tab 71 at 1074) (emphasis added)

51. When AO executed DO 43, it was experiencing capacity issues at its production Line 3A at Iowa (tr. 4/74). The Army had greatly increased its requirements for M107 projectiles and AO could not satisfy the demands by solely using Line 3A. In addition, the Army had "several urgent foreign military sales orders" for countries which included Israel and Australia (tr. 4/210, 7/68-69). To meet the increased requirements for M107 projectiles, AO in consultation with the government decided to bring Line 3 at Iowa "out of mothballs" and upgrade Line D at Milan (tr. 4/212-14). On 12 April 2001, AO requested the Army's permission to change the place of performance on a portion of DO 43 to Line D at Milan (R4, tab 16). The Army responded to AO's request with the following conditions: (1) the contract quality must remain the same; (2) government costs will not be increased because of the change in place of performance; (3) materials or equipment that must be relocated will be at AO's expense; (4) delivery schedules must remain intact; and, (5) "[r]egarding the technical aspects and planning for the Milan effort, request a Load Plan and Pour Study" (R4, tab 18).

52. By letter dated 30 May 2001, AO accepted these conditions and forwarded a copy of the requested Load Plan and Pour Study entitled "Engineering Pour Study Plan Cast Loading of Projectile, 155mm, HE, M107 (Comp B)" (AO Load Plan) (R4, tab 19). The AO Load Plan proposed to perform engineering "Design of Experiments (DOE) in order to determine the best available loading parameters for the 155MM M107 (Comp B) projectiles using its [Milan] Line D facility." Specifically, AO proposed eight test runs using sixteen M107 projectile metal parts for each run, for a total of 128 projectiles. (R4, tab 100) The goal of AO's Load Plan was to identify the best parameters available on Line D based on testing, and the plan was provided for informational purposes at the

request of the Army. AO's Load Plan described its anticipated, but not yet completed, production line. (*Id.*; R4, tab 103 at 1657-61)

53. By letter dated 7 June 2001, the Army proposed a face-to-face meeting to resolve scheduling issues relating to the change in place of performance and emphasized the following:

> The underlying concept to the Government is that we need the increased M107 deliveries the recently awarded incentive will provide to support training, and that a change in the place of performance should not cost the Government any additional money. The incentivized, increased deliveries are US Army assets and are to be TNT loaded, while the Comp B loaded rounds are FMS quantities that are not contractually scheduled to begin until Sep 2002.

(R4, tab 21 at 488) The Army also provided comments on AO's Load Plan which included the following:

> 1. The plan references the SPCC [Single Pour Controlled Cool] melt-pour process *research and development program.* [11] Paragraph 4.1 [of AO's Load Plan] states that the facility (Line D) utilizes this traditional process, however upon review of the reference and the subject plan, it is not clear how the SPCC process will be applied. There are inconsistencies between the melt pour/controlled cooling process specified in the plan and the conclusions in the report. Additional details are being requested on what SPCC methods will be applied including the rationale for deviations.
>
> ....
>
> 6. Paragraph 5.2.2 It is assumed that this paragraph is related to the controlled cooling process, however, no details are provided as to what a fixed probe is, its purpose and how/when it is to be used. A separate section addressing the use of a fixed probe including the controlled cooling process should be included in the plan.

[11] This is a reference to the 1955 Study which was cited in AO's Load Plan and is discussed at finding 59 (*see* R4, tab 19 at 478).

> 7. Paragraph 8.1 It is recommended that thermocoupled projectiles be utilized during the post cycle heating to verify that the ovens are providing the required heating and cooling to the center of the projectiles.

(R4, tab 21 at 490) (emphasis added)

54. Before performance of DO 43, AO hosted an event on 13 June 2001 known as the Comp B Symposium, the purpose of which was to assemble and promote the exchange of information and ideas between government and contractor personnel with knowledge, information and experience relevant to the production of large caliber Comp B artillery shells, since it had been about twenty years since large artillery rounds had been loaded with Comp B (tr. 1/105-06). Representatives from ARDEC and IOC[12] attended the event (R4, tab 101).

55. Both AO and government personnel made presentations followed by an open forum discussion which covered several topics including the use of the additive NT-60, the different waxes used in Comp B, coatings for the projectile interior, radiographic criteria currently in use and whether it should be updated, and bottom-up loading in Comp B loaded projectiles. During the course of these open forum discussions, AO learned for the first time that the Army was planning to perform a load study (the Army Comp B Load Study Proposal) for Comp B M107 projectiles, although the government did not disclose the anticipated scope of the study at the Symposium. Thus, a number of the items discussed were proposed by AO as additions to the Army Comp B Load Study Proposal, including conducting a study on the use of NT-60 and other additives:

> Lengthy discussion continued on the use of additives; primarily HNS,[13] NT-60. This discussion eventually got into the realm of post cyclic heat, in that HNS and NT-60 both will produce a tight cast and [this potentially] could lead to the elimination of the post cyclic process. A couple of Taskers evolved from this discussion.
>
> Any discussion of Composition B will always get to the subject of waxes. Most everyone was familiar with Indramic 170C, Petrolite, Sunoco, and Witco, but another wax,

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[12] The IOC has gone through numerous name changes. At the time of the Comp B Symposium, it was known as the Operations Support Command (OSC) (*see* app. br. at 6 n.4).

[13] Hexanitrostilbene, a thermally-stable explosive which is especially useful as a crystal-modifying additive in melt-cast TNT (*see* http://www.wipo.int/pctdb/en/wo.jsp?IA=GB1988000420&DISPLAY=DESC).

> Indramic 800, was also mentioned. The 800 variety is suppose [sic] to be far superior to the Indramic 170C, which is the worst of all the waxes for separation. *It was evident that no one knew exactly what was in the inventory, so another Tasker evolved from this discussion.*

(R4, tab 72 at 1078) (emphasis added) Government employees viewed these requests or "taskers" by AO to the Army as something the government was not obligated to do and inappropriate assistance on a firm fixed-price contract (tr. 4/123).

56. The government's participation at the Comp B Symposium included a presentation on the basics of melt/pour loading with Comp B. At no time during the Comp B Symposium did anyone from the Army share with AO the concerns, set forth in the October 1999, December 2000 and 18 March 2001 versions of the Army Comp B Load Study proposal, that: (1) AO was going to experience problems producing Comp B loaded M107 projectiles; (2) AO was going to experience significant problems passing the notch and drop test with Comp B loaded M107 projectiles; (3) AO would likely experience increased critical defects and production line shut-downs once production of Comp B loaded rounds began; or, (4) AO was going to experience increased LAP costs in its efforts to pass the notch and drop test when loading with Comp B. (R4, tabs 72, 379, 382, 387; tr. 1/119-20, 2/197-98, 4/123, 135, 159-60)

57. The government contends that there was no reason to share these concerns of potential problems with AO at the Comp B Symposium because AO and its predecessors already knew that production of Comp B loaded munitions was problematic. As evidence, the government presents a series of studies and articles including: (1) "Typical Cast Loading Defects Encountered in Production of 105mm Comp B Loaded Shell," a study conducted at Lone Star Ordnance Plant in April, 1954[14] (1954 study); (2) "The SPCC Melt-Pour-Cool Process Research and Development Program (The Shell Loading Process of the Future)," a study conducted by Mason & Hanger-Silas Mason Co., Inc.,[15] at the Iowa Ordnance Plant in May, 1955[16] (1955 study); (3) "Casting of TNT, Part II: Crack-Preventing Additives," a study conducted in June, 1956[17] (1956 study); (4) the 1982 study (findings 31-33); and, (5) "Assessment of Production Loading Problems with

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[14] J. Stewart Petersen, *Typical Cast Loading Defects Encountered in the Production of 105 MM Comp. B Loaded Shell* (21 April 1954) (R4, tab 76).

[15] Mason & Hanger is a partner in the joint venture that owns AO (gov't br. at 12; R4, tab 81; tr. 5/7).

[16] Brig. Gen. Joel G. Holmes (Ret.), Dr. L.R. Rothstein, Mr. R.L. Holmberg, *The SPCC Melt-Pour-Cool Process Research and Development Program (The Shell Loading Process of the Future)* (10 May 1955) (R4, tab 77).

[17] Armour Research Foundation, *Casting of TNT, Part II: Crack-Preventing Additives* (20 June 1956) (R4, tab 78).

4.2 inch M329A2 Mortar and 155-mm HE Artillery Projectiles" at Louisiana Army Ammunition Plant, conducted by ARDEC in November, 1990[18] (1990 study). At hearing, key AO personnel were asked about these studies and generally acknowledged their awareness that these older studies had been conducted. (R4, tabs 19, 76-80; tr. 2/8-9, 3/47-8, 51, 60)

58. The 1954 study identified and analyzed "the various types of cast loading defects, which have occurred in production of 105 MM Comp. B Loaded Shells" and also "describe[d] the conditions which caused the defects and the measures which have been taken throughout the industry to control them." Seven types of cast defects were identified: (1) irregular pipes; (2) oval cavities; (3) cracks in any section of the cast; (4) low breaks; (5) foreign matter in the shell; (6) cavities caused by interrupted pours; and (7) porous areas caused by water in the shell. (R4, tab 76 at 1091) The analysis was performed on 105mm Comp B loaded shells and not 155mm shells at issue in this appeal. Base separation was not among the cast defects identified or analyzed in the 1954 study.

59. The 1955 study discusses the advent and development of the Single Pour Controlled Cool (SPCC) process. It provides an historical background on the shell loading process from World War II to 1955, discusses the melt, pour, and cooling phases of the process, summarizes the testing of different variables that affect the shell loading process, and explains the design, fabrication and operation of the prototype plant set up at the Iowa Ordnance Plant (R4, tab 77). In discussing the difference between TNT and Comp B in the manufacturing process, the 1955 study stated:

> [F]or TNT casts, temperatures below 65ºF. resulted in severe cracking due to thermal shocking. With Composition B such cracking occurs with temperatures below 120ºF. *In the future, it may become possible to lower these temperatures by the use of crack preventing additives such as ortho and para nitro toluene and anthracene. These are currently being studied.* [Emphasis added]

(*Id.* at 1117) Ortho and para nitrotoluene are the chemical names for NT-60 (gov't br. at 12; tr. 2/179). The 1955 study discussed the water bath process as a controlled cooling method and reported results of testing various types of funnels and other variables (R4, tab 77).

60. The objective of the 1956 study was "to find suitable additives which will prevent cracking of TNT casts, so that more rapid cooling may be used in the SPCC

[18] U.S. Army Armament Research, Development and Engineering Center, *Assessment of Production Loading Problems with 4.2 inch M329A2 Mortar and 155-mm HE Artillery Projectiles* (November 1990) (R4, tab 80).

process." The recommendation section in the 1956 study provided that "[t]he study of crack-preventive additives on commercial TNT and purified TNT should be continued and *extended to Composition B.*" (R4, tab 78 at 1199, 1215) (emphasis added)

61. The 1982 study[19] tested two wax candidates, other than Indramic wax, for use with Comp B. The facility conducting the study used passive air cooling in the production process. (R4, tab 79) Line D at Milan and Line 3 at Iowa both use active air cooling (tr. 1/104-05, 2/208-09).

62. The 1990 study conducted by ARDEC detailed the production problems at the Louisiana Army Ammunition Plant:

> During FY 88 and FY 89, Louisiana Army Ammunition Plant (AAP) experienced recurring difficulties in production loading 4.2-inch M329A2 high explosive (HE) mortar and 155-mm M107 HE artillery projectiles on Lines "D" and "S" respectively.... The loading problems, explosive cast defects such as voids, cracks and cavitation, persisted regardless of whether the Composition B explosive used in the loading operations was manufactured with Fuller...or Indramic 170C waxes....
>
> Wax separation during the loading of Composition B explosive is a common problem and will cause critical defects in the explosive casts if not controlled during the melt, pour, and cooling operations. Based upon a review of the production line data from Louisiana AAP and followup discussions at ARDEC, two interrelated contributing factors were identified as impacting the melt-pour operations [at Louisiana AAP]:
>
> - Composition B explosives manufactured with Fuller and Indramic type waxes exhibit a history of explosive cast problems that can be attributed in some measure to wax separation. In order to properly process Composition B explosive containing these waxes, accurate control is required of the metal parts temperatures and the explosive melting, pouring, and cooling parameters.
>
> - Lines D and S at Louisiana AAP have not been modernized and use passive convection (air) cooling, which

[19] The 1982 study is discussed at greater length at findings 31-33.

> results in extreme difficulty in controlling the process for Composition B loading with explosive manufactured with Fuller and Indramic type waxes. In addition, the equipment on these lines is outdated; the air cooling bays and melt-pour equipment lack the basic instrumentation systems needed to properly control and monitor the loading process.

(R4, tab 80 at 1383) The 1990 study further noted:

> At other GOCO LAP plants, specifically Milan AAP where Composition B explosive is loaded into 60/81-mm HE mortars and Iowa AAP where the explosive is loaded into 155-mm and 175-mm HE projectiles, *the wax separation problem has been overcome through the stringent control of the processing parameters and the use of active, instead of passive controlled cooling systems.* [Emphasis added]

(*Id.* at 1385) The 1990 study included an exudation test of potential process aids which did not include NT-60. The 1990 study concluded that passive air cooling and the outdated state of the production equipment were the primary causes of the problems encountered at Louisiana AAP.

63. In regard to the 1954, 1955, 1956, 1982, and 1990 studies, AO maintains that "the Army fails to establish that AO did not use [the principles espoused in the studies], where appropriate, in the course of its efforts to pass the [notch and] Drop Test," but that there was nothing in these studies germane to the specific points at issue in the appeal (app. reply br. at 4-10). We agree. All of the studies provide background information to both AO and the government about the SPCC process, research into variables that affect the SPCC process, indicate that production of Comp B loaded munitions was problematic, and point to NT-60 and other additives as possible solutions that needed further study. But we conclude that these studies were not informative in solving the base separation problems AO encountered producing Comp B loaded M107 projectiles that could pass the notch and drop test.

64. On 28 June 2001, following the Comp B Symposium, the proposed face-to-face meeting took place between AO and government representatives concerning the change of place of performance to Milan for DO 43. This was one of several meetings on changing the place of performance. The issues discussed included how the contractor would handle government-furnished material which included Comp B, how to get materials located at Iowa to Milan, as well as many other issues regarding the move to Milan. (R4, tab 103; tr. 7/22-23)

65. By letter dated 3 July 2001 letter AO responded to ARDEC's comments concerning AO's Load Plan, specifically addressing the government's concerns and detailed comments on various aspects of AO's Load Plan, including how Milan would apply the SPCC process outlined in the 1955 study:

> [We stated that the] facility uses the traditional method of Single Pour, Controlled Cooling for cast loading in general accordance with [the 1955 study]. We wish to stress the term "general accordance" and offer the following: The SPCC melt pour process establishes a temperature gradient on the HE-loaded shell body, with the highest temperature located at the shell body nose and pouring funnel. The heat radiated by the shell body from solidification of molten HE (in this case, Comp B) is transferred to a fluid via convection; therefore, the lowest temperature of the gradient (also referred to by some as a "cooling profile") is located at the base of the shell body. This effects what is referred to as "bottom-up" solidification of the molten HE (i.e. the HE solidifies in a direction from the base of the shell to the nose, as opposed to inward from the outer projectile walls). *The SPCC document details the use of a water bath; however, Milan proposes to deviate from the SPCC document by removing the heat from the solidifying shell bodies using air as the convection media.* AO has used this same process to successfully cast load 155MM HERA M549/M549A1 projectile to which the 155MM M107 is very similar. Milan has the ability to control the temperature and flow rate of the air used to remove the heat from the solidifying shell bodies in their Bldg. D-41 melt pour/controlled cooling system. The driver for using air instead of water for removing heat from solidifying projectiles is capital equipment cost associated with using a water bath.

(R4, tab 103 at 1657) (emphasis added) Also, AO expressly agreed in this letter that the move to Milan would result in "NO ADDITIONAL COST TO THE GOVERNMENT" for the projectiles (R4, tab 103 at 1656; tr. 7/38-39, 62-65) (emphasis in original). As an AO witness explained:

> When we submitted our request for change of Place of Performance for the Comp B rounds for the 54,000 rounds, there were a lot of issues that had to be addressed between the Government, the Contracting Officer and American Ordnance. Such as who, who is going to be delegated the

> Government Quality Assurance functions, where will the DD250 Document, which is the acceptance document by the Government of these rounds, [where will we] perform those, how will the projectile metal parts get to Milan, how will the sub-charges get to Milan.
>
> ....
>
> We had a lot, a lot, a lot and I underline a lot of meetings on all of these subjects and this was my way of going back of which we had repeated in several documents, we would do that. This is just my emphasis that all of that added cost would not be added to the cost of the product and our price back to the Government.

(Tr. 7/63-65) The statement that there would be "no additional cost to the government" referred to relocation associated with the move (R4, tab 103; tr. 7/82-83). The contracting officer for the M107 projectile was asked whether he understood AO's 3 July 2001 letter regarding the move to Milan at "no additional cost to the government" as being related to AO's defective specification claim and he responded, "I don't believe so. I don't know how it would be." (Tr. 7/38-40)

66. The government alleges that AO agreed to conduct its Comp B load study at no cost to the government, and thereby it "promised that it would complete the research and development necessary to setup the facility at Milan," and further "promised that this research and development would be completed at no cost to the Army" since AO "did not specifically carve out or exclude the 'research and development' referenced in the attachment to [the 3 July 2001 letter]" (gov't br. at 59, 133, 136; R4, tab 21 at 490, tab 103 at 1656-57; tr. 5/35-36, 7/83). AO maintains that by agreeing to submit its Load Plan for Line D at Milan and agreeing that there would be no additional costs for relocating metal parts and other materials relating to production, AO was not agreeing to perform open-ended research and development under its firm fixed-price contract (app. reply br. at 27-32). AO's Load Plan proposed eight test runs using sixteen M107 projectiles metal parts for each run, for a total of 128 projectiles. AO proposed to perform limited testing in order to identify the best parameters available on Line D through its Load Plan. We find that there is no evidence in AO's Load Plan or elsewhere in the record to support the conclusion that AO agreed to perform open-ended research and development for the Army beyond its Load Plan at no cost to the government when it requested a change in place of performance to Milan under DO 43 for the production of Comp B loaded M107 projectiles.

67. On 1 August 2001, Modification No. 2 to DO 43 approved a change in place of performance allowing AO to produce Comp B loaded M107 projectiles at Milan on

Line D (JS ¶ 37), and also required the FAT to be conducted by 12 October 2001 (R4, tab 476 at 28905).

68. Facilitization[20] of Line D at Milan began in late January or early February 2001, before DO 43 was executed and government permission was given to move production to Milan of the Comp B M107 projectiles (tr. 2/133). The initial work on Line D was prompted by a strategic business decision by AO to get Milan back into the melt-pour business (tr. 4/212-13). AO had to have approval from the government to change or to do anything to a particular building, "even a minor modification" as the government owned the plant (*id*.). The challenge AO faced in setting up Line D in a GOCO facility was explained as follows:

> The problem we have with facilitization at the GOCOs is we don't own the plant and if you do anything to a building on the GOCO, [FAR ¶ 45] comes into play. That's the property section of the Federal Acquisition Regulation.
>
> And basically what it says is, if I modify and attach something to a building, the Government will then own it. So if you put in new modernization, you can put in a piece of equipment and bolt it to the floor and we can own it, but then all the ancillary piping, plumbing, electrical, water treatment, disposal, all of that other stuff that's needed to hook up to run this particular piece of equipment, the government then owns.

(Tr. 4/215) The move to Milan for the production of Comp B loaded M107 rounds under DO 43 was temporary and the government "absolutely did not want to spend any facility money" on any of AO's production lines (*id.*; tr. 5/29). Therefore, capital costs factored into the decision by AO to use the active air cool process on Line D at Milan for controlled cooling (*id.*; tr. 2/156-57). This method of production was not new as AO had used it on both the production of TOW missiles (R4, tab 98) and the "155MM HERA M549/M549A1 projectile to which the 155MM M107 is very similar" (R4, tab 103 at 1657).

69. Facilitization on Line D continued through late spring and the summer of 2001. Production equipment was installed and tested. At this point, Line D at Milan was the first production line in over twenty years to attempt to produce Comp B loaded M107 projectiles and the first to ever attempt to satisfy the notch and drop test on a Comp B loaded artillery shell. Milan performed test pours and made certain adjustments to the

[20] Facilitization is defined in the record as the "refurbishment or reconfiguration of a process or production line in order to manufacture a given piece of ammunition" (tr. 2/132; *see also,* R4, tab 440).

production equipment. AO then successfully passed the FAT, produced and delivered Comp B loaded M74 grenades on Line D at Milan before obtaining government approval for Comp B loaded M107 projectiles. (Tr. 2/35-38, 133-37, 203-05; *see also* R4, tab 440)

70. Following the success with the M74 grenade, AO began the process of test pouring M107 projectiles with Comp B. These tests were performed in an effort to identify the optimum set of production parameters to meet the 2000 M107 specification. As part of this effort, the AO team at Milan verified they were getting a consistent temperature reading on its copper probes, performed tests using different temperatures in the controlled cooling bays, and analyzed the airflow in the controlled cooling bays. All of the data that AO collected was analyzed through the use of statistical principles to isolate and select the parameters the team believed were most likely to consistently produce an acceptable Comp B loaded M107 projectile. (Tr. 2/206-11)

First Article Testing

71. On 4 October 2001, AO scheduled the FAT for 16-17 October 2001 (R4, tab 114). Between 4-15 October 2001, the Army conditionally approved or commented on Milan's Acceptance Inspection Equipment (R4, tab 396); post cycle conditioning process (R4, tab 398); x-ray system (approved) (R4, tab 399); and Statistical Process Control plan (R4, tabs 115, 119). Approval of these aspects of AO's process was specifically set forth as applicable milestones in the Army's 7 June 2001 comments on AO's Load Plan (R4, tab 21 at 490-91).

72. On 15 October 2001, AO halted the scheduled FAT at Milan when cracks were found in the explosive casts during radiographic examination. AO identified an interpretation issue between Iowa and Milan in which, according to AO personnel in Iowa, x-ray readers in Milan were incorrectly applying the TDP in their interpretation of the x-rays by misinterpreting the method for counting cracks in the M107 projectile explosive casts during radiographic examination under the 2000 M107 specification. (R4, tab 126; tr. 2/39, 6/14) This internal x-ray interpretation issue was promptly resolved by AO and had no subsequent impact on later FAT failures due to base separation as determined using the notch and drop test (*see* findings 75, 84).

73. Besides the x-ray interpretation issue, AO also determined that it had insufficient control of the metal parts temperature. If a round is not adequately preheated to a high enough temperature, it can directly affect whether there is base separation in a round. But there is a problem in that higher temperatures increase the risk of cracking and cavitation. Following the failed October 2001 FAT attempt, AO effected improvements in the metal parts temperature conditioning bay air ducts through the utilization of multi-directional air ducts, lowering ducts from the drop ceiling to assure air flow to the floor of the bay, and adding air return ducts at the sides of the bay at floor

level to assure efficient cross ventilation. AO replaced existing wall-mounted thermocouples with imbedded thermocouples. Control improvements allowed the reduction of the metal parts preheat control tolerance to ± 1ºF. (R4, tab 193 at 2118 (Oct 01), tab 287 at 2583; tr. 5/169)

74. During its review of M107 projectiles poured for the October 2001 FAT, Milan also encountered an unusually high number of base separation rejects as compared to that experienced during its confirmation pours. AO determined that the Comp B furnished by the government used for the FAT was a "special lot" which contained twice the normal wax content above the specification limits, and that it contained a different type of wax than AO had been using during its confirmation pours. AO concluded that these differences in the Comp B might have been the cause of the change between the confirmation pours and the FAT. (R4, tabs 126, 400, 403 at 2, tab 404; tr. 3/129-30)

75. AO scheduled another FAT for mid-November, 2001 (tr. 3/131-32). The M107 projectiles poured for the 14 November 2001 FAT all passed x-ray inspection requirements (R4, tab 133). Under the 2000 M107 specification, the first batch of Comp B loaded M107 shells poured for the FAT at Milan failed the drop element of the "notch and drop" requirement (JS ¶ 38). It was discovered during sectioning of two of the post cycle heat samples that there were base separations of .025 inches and .024 inches. As a result, the Army halted the FAT and requested that AO perform a root cause analysis to determine the cause of the drop test failure (R4, tab 407; tr. 6/15-16).

76. By e-mail dated 15 November 2001 and sent to various AO personnel, John Crowley, a process engineer at Milan, recounted a discussion he had regarding the failed November 2001 FAT with John Cortum, an AO employee at Iowa:

> 1. John [Cortum] felt that the cool air in the post cycle heat process may be short-circuiting from the ducts in the ceiling to the return air vent in the east wall of the bay. This may cause the projectiles to remain warmer than necessary during the cool cycle and would lessen the expansion of the cast. He mentioned Iowa's F-Yard system where the air was drawing across the projectiles from left to right, not ceiling to floor as our D-42 system is arranged. He also mentioned that our "return air" thermocouples located above the heaters may be giving us a false reading as to what the internal temperature of the projectile is during the heating cycle. I agreed. He strongly suggested the fabrication of thermocouple rounds to determine how long it takes the center of the cast to reach 140F. I also agreed.

> 2. We then discussed the Louisiana [AAP] melt pour study pertaining to the wax used in Comp B. I asked him if our 200-gallon kettle would melt and disperse the wax when the vacuum was applied. He responded in the affirmative, but suggested that we increase the melt temperature in the 350-gallon units to 200F before drawing down, then cooling the HE in the 200-gallon kettle to 188F prior to pouring. This would assure the wax was melted. I feel our process as-is adequately melts the wax....
>
> In my opinion, thermocouple rounds are what is needed to assure that we are getting the temperature needed within the cast.

(R4, tab 130)

77. AO completed its root cause analysis and forwarded the Corrective Action Report (CAR) to the Army on 12 December 2001. The CAR concluded that post cycling conditioning of the rounds was done at the minimum cycle time per the specification. The post conditioning cycle time was increased, established and verified. (R4, tab 138 at 1767) The CAR also found that a contributing factor was the discovery that the "bay temperature controlled by the PLC [personal computer] was 6 degrees different than the actual air temperature in the bay (measured with a mercury thermometer) due to a programming error. The programming discripancy [sic] masked a 6 deg. F variation between PLC output and actual bay temp" which AO had corrected by 3 December 2001. (*Id.*)

78. Following the failed FAT attempt in November 2001, AO retained an expert in Six Sigma to help identify the cause of the drop test failures. Six Sigma is a problem-solving method that uses a defined process and statistical analysis to identify and isolate variables in a production process that could be causing problems, and then provides tools to help resolve those problems. (Tr. 2/49-50, 233-34) From 15 November 2001 through 16 January 2002, AO Milan used Design of Experiments (DOE) and Six Sigma principles in an effort to determine the cause of the drop test failures, resolve the problem and obtain FAT certification. AO's efforts were primarily directed toward correcting flaws in its production process at Milan. (R4, tabs 139, 449; tr. 2/232-33, 246-47, 4/62-64) For example, changes made in Building D-42 in November 2001 allowed the narrowing of the bay temperature range from ± 4ºF to ± 2ºF (R4, tab 193 at 2118 (Nov 01)).

79. During this November 2001 to January 2002 timeframe, AO was able to successfully pour "a very small group" of Comp B M107 rounds without NT-60, but AO could not repeatedly attain the same results (tr. 3/39). For the same reason as the

projectiles produced without NT-60 at Iowa Line 3A discussed below (findings 115 *et seq.*), the "very small group" at Milan would not have comported with all TDP requirements including first article testing criteria.

80. On 15 November 2001, following the FAT failure on 14 November 2001, AO submitted ECP No. AO-01-003 (NT-60 ECP) entitled "ADDITION OF NT-60 AS A PROCESS AID" to change the 2000 M107 specification to permit the use of NT-60 (JS ¶ 39; R4, tab 405).

81. The original submission on 15 November 2001 of the NT-60 ECP did not include supporting tests or compatibility data. Box 20, NEED FOR CHANGE, of the NT-60 ECP provided, "NT-60 is an approved process aid for Comp B explosive on 81mm and 120mm mortars and the 105mm M1 projectile to enhance quality of explosive cast by eliminating cracking and other defects and providing good wall adhesion." (R4, tab 405) Since the Army had approved NT-60 for use in three other Comp B loaded rounds, AO believed that demonstrating the acceptability of NT-60 again would not be necessary (tr. 1/134).

82. On 14 December 2001, the CCB at IOC recommended disapproval of AO's NT-60 ECP and required that the following tests be completed and the supporting data submitted with the ECP when resubmitted:

1. Compatibility test between NT-60 and the M107 projectile interior paint primers as identified in source control drawing 12991256.
2. Compatibility test between NT-60 and the supplementary charge liner adhesive sealant, RTV 3145 (gray), drawing 12913704.
3. Compatibility test between NT-60 and the process aid Lecithin, MIL-L-3061.
4. Compatibility test between NT-60 and the process aid Pegosperse 400DS.
5. Compatibility test between supplementary charge liner material, aluminum alloy impacts, 6061-T6, Spec Mil-A-12545.
6. Exudation test with M107 projectiles loaded with Comp B and NT-60 at 160 Degrees F for 30 days.
7. Melt pour compatibility study to show that Comp B and NT-60 mix will meet the cast quality requirements for the M107.

(R4, tab 52 at 881) Implementation instructions from the CCB directed the contracting officer to inform AO of the disapproval, and to have AO complete the tests as itemized and resubmit an ECP with the supporting data (*id.*).

83. By letter dated 4 January 2002, the Army sent AO the disapproval of the NT-60 ECP. The basis of the disapproval was given in the remarks section which provided:

> It is recommended that this ECP be disapproved for lack of supporting qualification test data. The NT-60 has to be qualified for use on the M107 projectile by conducting compatibility test between NT-60 and the interior paint primer, NT-60 and liner RTV sealant, NT-60 and lecithin, NT-60 and pegosperse 400DS. Also an exudation test has to be conducted with loaded M107 rounds with NT-60 at 160º F for 30 days. Contractor should resubmit ECP when all tests have been done and the test results are favorable.

(R4, tab 143 at 1817; JS ¶ 40) The notice given to AO included only limited pages of the CCB directive and did not include the full list of compatibility tests the CCB required (*compare* R4, tab 52 *with* R4, tab 143).

84. As recorded in the contractor's weekly report of 10 January 2002, AO Milan poured in early January 2002 Comp B loaded M107 projectiles for a third FAT attempt (R4, tab 149 at 1837-38). All of the rounds passed the x-ray inspection. Three of the eight rounds selected for the notch and drop test failed the test. (*Id.*; tr. 2/247-48)

85. As a result of the CAR and Six Sigma efforts, AO identified and made a number of changes to its production equipment, narrowed the variation of temperature in its control cooling bays and its post cycle conditioning bays, and performed additional thermal mapping and experimental pours (tr. 2/230-32). AO's weekly activity reports dated 10 and 17 January 2002 provided that "[t]he controlled cooling bay still experienced some air flow issues" and ductwork was modified "to improve airflow across poured M107 rounds during the post-pour cooling process" (R4, tab 145 at 1822, tab 149 at 1838). The Engineering section of the 10 January 2002 weekly activity report noted the following for the M107 round:

> Replacement of thermistor temperature sensing elements with Type J thermocouples and installation of additional thermocouples is being completed at the D-42 Building M107 post pour conditioning bays. This will allow temperature sensing inside a poured M107 projectile to be monitored, recorded, and used for bay temperature control [as well as] ambient air temperature.

(R4, tab 145 at 1824) AO installed additional ductwork to the controlled cooling bay in Building D-41 and also Building D-42 in order "to change the airflow and bring the post cycle heating bays' air down closer to the floor and the rounds" (R4, tab 145 at 1822).

86. Following the January 2002 FAT failure, AO reviewed all the data collected in connection with the FAT but found no parameter outside of specified tolerances (tr. 2/54-55, 248). AO and Army personnel from ARDEC and IOC met in an effort to resolve the notch and drop test separation issues. Government personnel on 16 January 2002 made suggestions to AO which included the following:

> During our visit, we made a number of observations and we were asked to provide our observations to American Ordnance....
>
> Paragraph five [of the trip report] in particular brings up a concern on keeping the upper part of the projectile warmer than the rest of the round, for lack of a better term.
>
> When you melt-pour a projectile, after the molten explosives are in there, you want to solidify the cast or solidify the explosive from the bottom up. You need to keep the neck area open, to provide for backfill of the explosive from the funnel into the cast.
>
> That does two things. It releases the air out of the projectile, which eliminates cavities and porosity, and it backfills the explosive cast, the head pressure which assists in providing a [tight] cast and prevent base separation.

(Tr. 6/31-32; R4, tab 412) Other government recommendations included using: (1) a larger or taller funnel "to provide added weight and make-up explosive as the cast cools and shrinks during cooling;" (2) additional heat to maintain a molten funnel and ogive[21] area; and, (3) a smaller diameter cooling probe "to allow a larger neck opening" (R4, tab 410 at 12635-36; tr. 6/35-36). Sometimes the government suggestions from Army engineers were conflicting (*compare* R4, tab 410 at 12635 ("It is recommended that if possible, a smaller diameter probe be designed and implemented to allow a larger neck opening.") *with* R4, tab 412 ("[The width of the probe] would not directly contribute to the cast looseness/base separation problem however"). An ARDEC representative concluded that "[t]he melt pour equipment and process in place at [Milan] is judged to be

[21] For the 155mm M107 round, the ogive is the piercement of the projectile "where it tapers up to the nose" (tr. 5/143; gov't br. at 93 n.24).

capable of providing for a repeatable process that is well in control and is monitored with the exception of the operation for filling the projectile/funnel assemblies." A second trip report filed by IOC representatives concluded that "[o]verall the M107 melt pour process at Milan has the potential for producing good Comp B M107 projectiles" but that the "system needs to be enhanced to produce good tight casts prior to post cycle heat." (R4, tabs 410, 412)

87. AO's weekly report dated 21 February 2002 provided the following:

> M107 Program – Our results from the 16 round pour were unacceptable. It looks like our cooling process is allowing the top part of the round (section D) [to] cool too quickly. This causes us to have loose casts that can not be "grown" enough in post cycle heating. We have worked with both [OSC and ARDEC] and feel we have a good [design of experiments] to change the parameters in the part of the cooling bay process that will stop the top section of the round from cooling too quickly.
>
> ....
>
> Controls contractor is completing M107 post-pour conditioning HVAC controls program modifications this week. The modifications will improve the process so that temperature changes during transition from heating to cooling cycles and vice versa can be closely controlled.

(R4, tab 161 at 1895, 1897)

88. Following the January 2002 FAT failure, AO again used extensive design of experiments and statistical analysis in an effort to isolate and resolve the cause of the drop test failures. The suggestions made by Army personnel ultimately were not implemented because the data AO compiled and analyzed demonstrated that these aspects of AO's equipment and manufacturing process were not adversely impacting AO's ability to pass the notch and drop test. (R4, tabs 449, 487; tr. 5/230) During February 2002, AO increased air conditioning capacity in Building D-41 "in order to better control the air temperature during controlled cooling" which reduced the temperature variation to ± 2ºF (R4, tab 193 at 2119 (Feb 02)).

89. On 18 February 2002, AO resubmitted the NT-60 ECP with the following successful compatibility tests: red oxide paint primer that was included in AO's TDP; Comp B; lecithin; and the RTV adhesive sealant (R4, tab 159).

90. On 21 February 2002, the Army again disapproved the NT-60 ECP "for lack of supporting qualification test data." It recommended AO complete the tests "as stated in the CCB Directive" and resubmit the ECP. (R4, tab 160)

91. On 22 February 2002, the Army informed AO that it had begun conducting its Comp B Load Study (R4, tab 414). On 4 March 2002, ARDEC hosted a presentation, entitled "155 mm M107 Projectile ARDEC Composition B Load Study Review," that examined its progress in performing the Army Comp B Load Study. The presentation outlined the plan for the Army Comp B Load Study with an expected completion date of July 2002. (R4, tab 418) AO personnel attended the Army's 4 March 2002 presentation on its Comp B Load Study and toured ARDEC's melt-pour facilities but received presentation materials of the study which did not include ten pages, and were not given a slide with the subheading "Recommendations" under which the addition of NT-60 is listed (*compare* R4, tab 163 *with* R4, tab 418 at 21; tr. 2/63-77). The government made no mention of NT-60 at the presentation and did not discuss NT-60 as a possible recommendation to be considered in loading the Comp B M107 (tr. 2/77) even though ARDEC then contemplated the use of NT-60 as part of the Army Comp B Load Study (tr. 5/214). The presentation materials referenced an "ESP" which government personnel confirmed was a reference to the Army Comp B Load Study and its revisions that ARDEC had initially prepared in October 1999 (R4, tab 163 at 28,026; tr. 5/211-12). However, no other information relating to the Army Comp B Load Study proposal was given to or discussed with AO beyond this acknowledgment (tr. 2/65-6). The government provided no justification for its refusal to disclose to AO for roughly 2½ years that the Army was conducting a Comp B Load Study; its unreasonable conduct continued even then with the deliberate redaction of pages noting the government's independent consideration of NT-60 to rectify TDP process shortcomings.

92. As part of the Army Comp B Load Study, ARDEC conducted six tests using eight M107 rounds for each test run. The first test round was poured on 28 November 2001, the last on 26 February 2002. (R4, tab 418 at 22; tr. 5/110-15) ARDEC tested controlled cooling using both the air-cooled and the water-cooled processes. Four of the six test rounds were water-cooled and two test rounds were air-cooled. Two out of the four water-cooled tests had "acceptable rounds" while one out of the two air-cooled tests had "acceptable rounds," ***based on the use here of a drop test only that did not include notching and an x-ray inspection.*** (R4, tab 418 at 22; tr. 5/216) Two of the six test rounds had rejects for excess piping and porosity while in one test all rounds were rejected for base separation in excess of 0.015 inch (R4, tab 418 at 22). According to one government witness, one-half of the test rounds ARDEC produced for the Army Comp B Load Study were acceptable as measured in accordance with the 2000 M107 specification (tr. 5/112). However, ARDEC did not have a saw available to notch M107 projectiles and did not send M107 projectiles to Milan to complete the notch and drop test as originally planned (tr. 5/112, 116; R4, tab 414). Instead, ARDEC substituted the procedure of omitting the notching requirement, then just dropped the projectiles and

subjected them to a nose down x-ray examination to check for base separation (tr. 5/112, 212-13). In its post-hearing brief, the government maintains that this substituted procedure is a more reliable measure to show base separation than the notch and drop test required by the 2000 M107 specification (gov't br. at 79-80). Three government witnesses did not confirm this assertion but rather testified that notching the M107 projectile (so that a measurement could be taken) was better and "more reliable than x-raying for determining base separation" (tr. 4/173, 6/72, 114-15). Further, another government witness, Mr. Paul Betts, supervisor of the munitions load assemble and pack branch at Picatinny Arsenal in Picatinny, New Jersey, conceded that the Army Comp B Load Study never produced any Comp B loaded M107 projectiles that passed the notch and drop test, and that "before American Ordinance was going to produce M107 Comp B loaded shells pursuant to the notch and drop [test] that no other contractor had been asked to do that by the Army" (tr. 5/212-14, 224-25). We find that ARDEC did not produce any M107 Comp B rounds compliant with the 2000 M107 specification.

93. The Army only partially executed the Army Comp B Load Study. The team effort with AO to develop detailed technical plans, establish test designs and procedures, and establish key melt pour process parameters as called for by the final version of the Army Comp B Load Study proposal was never accomplished. Although the final version of the Army Comp B Load Study Proposal was funded, neither full-scale verification nor validation of notch and drop testing was ever performed. Baseline loading procedures for the M107 Comp B projectiles were not inserted into the TDP. Part of the reason the Army Comp B Load Study was only partially finished was because a substantial amount of the data generated by the study was destroyed by a disgruntled government employee. Therefore, the various test results could not be correlated and the final report could not be completed. (R4, tabs 293, 418, 458[22]; tr. 5/110-16, 207-226)

94. AO continued its efforts to pass the FAT. AO identified seven variables within the Milan production process that it believed had the most impact on base separation detected using the notch and drop test, based upon data analysis and experience. These variables were: (1) the temperature of the high explosive; (2) the metal parts temperature; (3) funnel type; (4) the probe bay temperature; (5) the probe station air flow; (6) the presence or absence of post cycle conditioning; and, (7) the type of probe station. AO performed a number of tests over a two month period. All of AO's efforts to isolate key variables that had the most significant impact on notch and drop test base separation since the January 2002 FAT failure were recorded in the Quick Look Report dated on or about 17 March 2002 (R4, tab 487; tr. 2/56-61, 3/88-9). AO found that the metal parts temperature had the potential to be a significant contributor to base

[22] Rule 4, tab 458 contains the uncompleted final report Mr. Betts tried to write based on the Army Comp B Load Study. Itemized but not included are a list of figures and a table with references to "120mm M934 HE projectiles" which are not explained in the record. (*See* R4, tab 458 at 3)

separation, and the metal parts temperature of 170° F. achieved the lowest base separation measurements (R4, tab 487 at 16016). Using the extensive data collected from the DOEs conducted from 24 January 2002 through 12 March 2002, AO concluded that no process variable under AO's control could be manipulated or changed in such a way so as to pour Comp B loaded M107 projectiles that would pass the notch and drop test. The key recommendation that the AO Milan team made was to "[e]valuate the availability of testing with NT60 and determine the test and sampling plan." (R4, tab 487 at 16031-32; tr. 2/264-67) We find that the Quick Look Report is creditable and persuasive evidence that AO systematically tested and evaluated variables most likely to have a determinative effect on base separation detected by the notch and drop test under the 2000 M107 specification. We also find that AO was conscientious in correcting process problems once these were identified.

95. Beginning 12 March 2002, AO began several days of testing, with ARDEC personnel in attendance to observe and assist, as part of its ongoing efforts to develop a successful melt-pour loading process. One test was designed to delineate differences between various methods of introducing heat to the neck of the projectile during the controlled cooling cycle. On 14 March 2002, a brainstorming meeting between AO and the government was held at which an ARDEC employee, Mr. Kris Keeton, reported that the following suggestions were proffered and conclusions drawn:

> a. *Everyone agreed that the single most important immediate course of action would be to procure and test the additive NT-60.* Unfortunately, acquiring NT-60 to date has presented a number of challenges.
> b. Once NT-60 is introduced to the mix, previously determined parameters may change.
> c. It was believed that the external heat sources were not only located too low on the body of the projectile, but did not provide enough heat in general.
>
> ....
>
> e. Notch/drop testing of Comp B loaded rounds was added to the M107 LAP specification; therefore, past production data for this requirement does not exist.
>
> ....
>
> C. Conclusions:

> 1. *The equipment and controls on Line D of [Milan] are more than capable of producing repeatable results. The statistic process control (SPC) and data monitoring equipment are exceptional.* What is lacking is a set of parameters by which consistently good rounds can be produced. Finding these parameters will require additional testing, both at production and pilot facilities.
>
> 2. *Though it has not been done before, this office believes that it is certainly possible to load comp B artillery rounds that can pass a notch/drop test.* [Emphasis added]

(R4, tab 420 at 4) Paragraph "c" refers to testing of an experimental heat source meant to supply heat to the neck of the projectile and did not pertain to an overall metal parts preheating problem (R4, tab 420 at 2). Although the government agreed that pursuing NT-60 as a possible remedy was the "single most important immediate course of action," it did not inform AO that it independently was considering use of the additive as part of the Army Comp B Load Study (finding 91).

96. Pursuant to the recommendations of the Quick Look Report and the 14 March 2002 meeting, AO acquired a pilot quantity of NT-60 from Iowa (tr. 3/136). On 21 March 2002 AO poured the first Comp B loaded M107 projectiles using NT-60, at its own risk and cost (R4, tab 449). The results were "overwhelming," "exceptional" and "dramatic" (tr. 2/81, 3/136-7). In an e-mail dated 21 March 2002, LTC Jonathan Markol, the Army commander at Milan, sent an update on the status of the M107 projectile to Army officials which stated:

> AO continues the DOE process to "tighten" the cast during the melt pour process. Various pour and cooling parameters are being refined this week, as well as the use of an additive NT-60 to the composition. *This effort is groundbreaking in that AO is the [sic] basically performing the experimental work for ARDEC to determine the precise comp B melt-pour parameters for 155 [projectiles] which will pass modern inspection criteria*. [Emphasis added]

(R4, tab 422 at 2)

97. On 4 April 2002, the Army provided AO with a test plan describing how it was to perform the exudation test regarding NT-60. The test plan required AO to conduct the exudation test with M107 projectiles loaded with Comp B and NT-60 at 160° F. for 30 days. (R4, tab 170) On 22 April 2002, AO submitted the exudation test plan which proposed to conduct the test at 159° F. for 30 days (R4, tab 427 at 12563). The

Army recommended changes including requiring the test to be conducted at 160° F. and also that the rounds used for the test "be selected from the melt pour NT-60 process that AO will utilize for FAT and/or production" (R4, tab 178). AO resubmitted the exudation test plan on 7 May 2002 with the recommended changes. The Army approved the test plan on 15 May 2002. (R4, tabs 180, 183)

98. During April 2002, AO implemented the following at Milan:

- Added additional in-duct cooling coils to better control temperature variations in Bldg. D-41 controlled cooling bays.

- Made major modifications to controlled cooling bay duct work in order to balance temperature throughout controlled cooling bays. Added insulation to common wall between metal parts conditioning bay and controlled cooling Bay 8 to mitigate heat transfer between bays. Added roof vents to Bay 8 in order to better balance air flow and to dissipate heat during summer months.

- Relocated thermocouples within controlled cooling bays to strategic locations more representative of temperature experienced by projectiles in order to better monitor and control the controlled cooling bays. Enhancements allowed narrowing of temperature variation within controlled cooling bays to ± 1ºF.

(R4, tab 193 at 2119 (Apr 02))

99. During the week of 20 May 2002, AO conducted a FAT for Comp B loaded M107 projectiles on Line D using NT-60. AO conducted this FAT at its own risk and prior to receiving the Army's approval to use NT-60 in its production. (R4, tab 181) LTC Markol in reporting on the FAT results wrote the following:

> M107 FAT – *Great news!* The M107 FAT started yesterday with representatives from OSC and ARDEC on-site. A total of 160 rounds were poured for the FAT and 20 were selected at random by the team for test and examination. We've completed the review of X-ray film of the FAT samples and all were acceptable. In the entire 160 rounds, we had none with base separation of any degree. Other films were then reviewed to help establish standards for porosity and

> cavitation. *All eight of the FAT samples for notch and drop testing were completed with absolutely no base separation for cast looseness.* FAT for the fuze cavity drilling and expulsion charge cup swaging was completed with no failures or nonconformance. The weighing, marking, and packing portions of the assembly process are being reviewed today. Once this portion of FAT is completed, fifteen rounds will be sent to Yuma for ballistic testing. The [Army] FAT team was also given a tour of the new melt-pour facility at [Milan's Line D] and they were very impressed with the amount of control we have over all process inputs. *The team members had numerous positive comments about our process controls, cast quality, and adhesion of the cast in the projectile.* A successful ballistic test will complete all FAT requirements.

(R4, tab 435) (emphasis added)

100. By letter dated 30 May 2002, the Army informed AO that the Comp B loaded M107 projectiles with NT-60 had satisfied all criteria for the FAT with the exception of the exudation test and ballistic testing, which had not yet been performed (R4, tab 189 at 2097). Nevertheless, the Army refused to provide FAT certification for the batch tendered by AO because the 2000 M107 specification did not allow the use of NT-60 at that time (JS ¶ 44). Mr. Niebuhr, the government's M107 program leader, explained the reasoning behind the decision to not provide FAT certification:

> Q Why did you direct Mr. Almeida not to approve the FAT until AO accepted the ECP for the NT-60?
>
> A Well, First Article was supposed to prove that you can meet the requirements of the technical data package. At that time, NT-60 was not in the technical data package. So if they produced a First Article with NT-60, it would not be to the tech data package; therefore, it would fail.
>
> We had been through this type of thing before, where you try to cut corners and then you go through it. Then after the fact, something happens and a mistake was made, and then you need to undo everything. That's what I was trying to avoid. I was trying to do things by the book.

(Tr. 6/86)

101. AO successfully completed the exudation test on 17 June 2002 (R4, tab 438). On 19 June 2002, AO submitted the revised 15 November 2001 NT-60 ECP with all of the test data that the Army had required with the exception of the compatibility test with Pegosperse 400DS. AO did not intend to use this additive for lack of availability and requested the compatibility test for it be waived. AO also requested expedited approval. (R4, tab 199 at 2159) The Army responded to the revised NT-60 ECP by requiring AO to: (1) submit compatibility testing with a Sherwin Williams interior paint primer; (2) perform the compatibility tests again (with the exception of the Pegosperse 400DS test which was waived) and resubmit the NT-60 ECP referencing the correct MIL-STD even though the test procedures and results should be the same; and, (3) conduct further tests with the red oxide primer (R4, tabs 206, 446). AO had tested the interior primer paint that was in its TDP for DO 43. The Army had added additional approved interior primer paint sources pursuant to ECP No. R9A2015 but had failed to update AO's TDP to provide the drawing with this change. (R4, tabs 208, 381; tr. 6/74-5)

102. On 12 July 2002, a Final Report created by AO's Six Sigma team was distributed. The Final Report documented the results of the DOEs conducted on Line D and the conclusions that the AO Milan team reached as a result of their efforts over the prior eight months. (R4, tab 449) One of the conclusions in the Final Report was that, "[a]ll potential melt-pour input treatments have been evaluated within acceptable parameters. None of these treatments or their combinations can produce a tight cast that passes the minimum ≤015 inch standard for base separation after Notch-and-Drop test" (*id*. at 17902). The Final Report ultimately concluded that from all of AO's research, NT-60 was necessary to obtain FAT certification and successfully produce Comp B loaded M107 projectiles under the 2000 M107 specification. (R4, tab 449; tr. 3/14, 19)

103. The Final Report documented the degree to which AO had tight control of its production equipment, and analyzed Line D's "process capability." The term "process capability" is expressed as a number which states to what degree one is compliant with a specification as explained by the following:

> A Process capability, is what CPK stands for, okay? Now, say you take the same range, that same allowable range, and your data set goes from, say 203, to 207, and your mean is still 205.
>
> If you calculate your CPK, it will be much higher. It will be in the range of, say, 1.6. *So as the variation of the data gets smaller, the CPK gets larger.*

> And what it is, is it's an indication of how little or how great your process is varying, with respect to an upper and lower specification limit.
>
> A CPK of one is acceptable. A CPK of, say, 1.67, is very good. *A CPK of two is absolutely fantastic. That is a process that is very, very tightly controlled.*

(Tr. 3/21) (emphasis added) In the Final Report, the process capability (Cpk) for Line D's various production processes are listed. With the exception of the heating phase on the post-cycle conditional bay which had a Cpk of 1.67, all of AO's process on Line D had a Cpk above 2 (R4, tab 449 at 17958; tr. 3/21).

104. In July 2002, AO experienced difficulties with cast quality issues, but not base separation, in part of its M107 production at Milan. The cast quality issues included "cavitation, porosity, or annular rings in Segment B, C, & D [of the M107 projectile]." The Critical Safety Item, Characteristic and Critical Defect Report (31 July 2002 Critical Defect Report) provided:

> All projectiles produced in Bay 8 conditional bay and projectiles produced in Bay 9 on pour dates 7/8, 7/9, and 7/10/02 are being held pending acceptance of this corrective action plan. *All of the projectiles have been X-rayed, segregated and accepted based upon 1/10 inspection. All of the projectiles found to be acceptable by X-ray have also passed notch and drop testing after post cycle conditioning.*

(R4, tab 211 at 2337) (emphasis added) Thus the cast quality problems AO experienced were unrelated to base separation as all of the projectiles poured passed the notch and drop test. The 31 July 2002 Critical Defect Report found that there were two root causes which led to the defective casts in the M107 rounds. The first root cause was the "[v]ariation in staging location of projectile metal parts preheat/pour buggies during preheating of the projectiles. This resulted in the airflow being disrupted, which in turn caused some of the projectiles to be hotter than required for an acceptable cast." (*Id.* at 2338) The 31 July 2002 Critical Defect Report explained:

> The restriction of air flow to the thermocouple rounds resulted in low temperature readings from the thermocouple rounds which in turn called on the system to add more heat to the bay thus raising the temperature of the projectiles but not affecting the thermocouple round to the same level because of the obstruction of the air flow to the thermocouple rounds. This obstruction also created hot spots within the heat bay,

> which could have resulted in some projectiles having higher temperatures than others did. This explains why some projectiles on a buggy were found to have acceptable casts while others were unacceptable.

(*Id.*) The second root cause for the cast quality problem was human error. As the 31 July 2002 Critical Defect Report explained, "[d]uring this period a new Melt Pour System Technician was operating the system. This was the first time in which this Technician operated the system without oversight from the Lead Technician.... Technician experience is believed to be the other potential root cause although this could not be quantified." (*Id.* at 2238-39) We find that the 31 July 2002 Critical Defect Report documents an isolated incident of that same month that was promptly identified and resolved by AO, and that this had no impact on the notch and drop test base separation issues that are central to the dispute before the Board.

105. In an e-mail dated 1 August 2002, Mr. Larry Gulledge, the top ranking Army civilian official at Rock Island, expressed concern to other Army officials following an IOC meeting on the status of the M107 program (R4, tab 452). Specifically, Mr. Gulledge stated:

> I didn't see any reference to the issue of AO losing $100K a month while they are in park. Or the fact the company(s) have a couple of million tied up in this at this time. Or how long the test samples have been at Yuma, when they will be done, or who to call. Or estimated date for quality plan resolution. *Or the fact this smacks a lot like an R&D effort.*

(R4, tab 452 at 45430) (emphasis added) Mr. Gulledge further stated, "*Heresy of all heresies, we may even have to start renegotiating some contracts that have just proven impossible to execute"* (*id.*) (emphasis added).

106. On 7 August 2002, the IOC's CCB approved ECP R1A3007-R1 (the NT-60 ECP), which included the information relating to compatibility testing and exudation testing that the Army had demanded (JS ¶ 45; R4, tab 453).

107. On 21 August 2002, the parties reached agreement on an Alternate Critical Non-Conformance Control Plan (ACNCP) for Milan. The ACNCP modifies the Critical Defect clause in DO 43 as it relates to Line D and permits the contractor to continue production even in the event of a critical defect within a specified threshold. Under the ACNCP, AO was permitted up to 1% confirmed base separation rejects at x-ray in excess of .015 inches provided the base separation did not exceed .030 inches. If a base separation at x-ray exceeded .030 inches or if a single M107 projectile selected for notch and drop exhibited base separation in excess of .015 inches after the drop test, AO was

required to shut down the production line. With government approval, AO could repeat post cycle conditioning for the oven load represented by the failed notch and drop sample up to two times. (R4, tab 454A at 10499, 10508, 10510, tab 454B; tr. 4/56)

108. By 26 August 2002, AO began full rate production at Milan of Comp B M107 projectiles with NT-60 (R4, tab 495). Production was at AO's risk and cost, pending FAT certification and incorporation of the NT-60 ECP into DO 43. The Army continued to withhold FAT certification from AO until AO accepted the revised NT-60 ECP as optional (R4, tab 230; tr. 6/82, 86). When AO expressed concerns to the Army about accepting the NT-60 ECP as optional rather than mandatory, AO was told that it "could accept this at no cost or they [the Army] would take the item and go elsewhere with it" (tr. 4/228-29).

109. By letter dated 12 September 2002, AO notified the Army: (1) that it accepted the NT-60 ECP as optional with no cost or schedule impact; and (2) of its intent to submit a claim to recover costs incurred "due to the nonproducibility of the Government's 155MM, M107 Comp B TDP." AO intended to separate any cost impact discussions from timely implementation of the NT-60 ECP. (R4, tab 231) The Army's CO for the M107 contract understood this letter as putting the Army on notice that AO intended to submit a claim which he would "be willing to entertain [the claim], resolve it, do whatever we had to do to fix it" (tr. 7/44-45).

110. By letter dated 19 September 2002, the Army advised AO of the following:

> Engineering Change Proposal R1A3007R1, allowing use of NT-60 as a process aid, is hereby incorporated and approved for use in M107 Delivery Orders under DAAA09-98-G-0011 at no cost and no schedule impact with implementation as "optional." Formal incorporation will be memorialized by the next modification to the Delivery Order. Incorporation of this ECP does not constitute an admission on the part of the Government that the current TDP is defective nor is it an admission that any basis for a claim exists.

(R4, tabs 59, 244)

111. On 23 September 2002, AO's production Line D at Milan received FAT certification and was permitted to begin full-scale production (JS ¶ 47).

112. On 24 September 2002, representatives of OSC[23] and ARDEC performed at Milan a two-day process review of x-ray film and AO's interpretation of the film. The following findings were made during the audit:

> 1) Three film[s] were judged by the customer and concurred by AO to be as bad as or in [excess] of the standard for gas porosity. The serial numbers were 4368, 4400 and 880. Serial number 880 was a ballistic sample in ammunition lot MA-02G001-001.
>
> 2) Some of the penetrameter shots which were reviewed showed the penetrameter not [to] be in the proper location. Film quality was judged to be very good, but all test shots should be in accordance with requirements.

(R4, tab 253 at 2416) The following action items were noted and agreed to by AO as recorded in an e-mail dated 26 September 2002:

> 1) 100% screen (re-read) all film previously accepted for porosity prior to implementation of training and use of the acceptance standard. This will be all projectiles accepted prior to 9/26/02....
>
> ....
>
> 6) Review the penetrameter test round for proper location of penetrameter. Review process set-up for penetrameter shot to insure rounds are properly orientated in fixture.
>
> 7) Review X-ray process to include fixturing of the projectiles to insure that projectiles are properly aligned with source beam to reduce variation in base separation as seen [in] the film.

(*Id.* at 2416-17) Mr. Czachorowski testified that a parallax problem occurs if the round is not always placed in the same position within the fixture used to hold the round during x-ray. If there is a parallax problem with x-rays, base separation on the x-ray film is not clearly displayed, causing an x-ray reader to believe that a base separation was smaller than it actually was. (Tr. 6/187-89) In its brief, the government maintains that with a parallax problem, "AO would believe that the first part of their process was controlled, but it really was not. They would then be unable to isolate where in the manufacturing

[23] Operations Support Command, later known as the IOC (*see* n.12).

process the problems occurred." (Gov't br. at 99) The Army did not present the 26 September 2002 e-mail to Mr. Czachorowski during the hearing to inquire whether what is described in paragraph seven is in fact a parallax problem (*see* tr. 6/153-205; app. reply br. at 35-36), nor did it offer other proof that there was a continuing parallax problem.

113. On 8 October 2002, Modification No. 12 to DO 43 was formally executed as a bilateral modification incorporating the NT-60 ECP into the TDP which permitted use of NT-60 in the production of M107 Comp B projectiles at no additional cost to the government (R4, tab 457).

114. AO's Line 3 production line at Iowa received FAT certification and was permitted to begin full-scale production on 15 October 2002. Later, on 4 March 2003, Line 3A at Iowa was FAT certified and approved for full-scale production. (JS ¶¶ 47, 48)

115. As part of AO's initial Comp B test pours on Line 3A at Iowa, AO ran three test rounds without NT-60 at three different sets of parameters that had acceptable results and passed the notch and drop test. The total number of projectiles produced without NT-60 in these test rounds was 180 out of 2128 rounds. The reason AO decided to try to produce Comp B loaded M107 projectiles without NT-60 was financial, as explained by the following:

> Q Did American Ordnance have any incentive to your understanding of trying to produce M107 Comp B rounds without NT-60?
>
> A Absolutely.
>
> Q And what was that?
>
> A Financial. It's a fixed-price round. If you add [NT-60] you're wrapping a dollar around every [round], so it's to our advantage not to do that.

(Tr. 1/155; *see also* tr. 2/84-85 (with the NT-60 ECP approved as optional, AO had the responsibility to pay for the NT-60 and therefore had incentive to avoid its use if at all possible)) AO requested permission to combine all of the acceptable test rounds from these initial pours on Line 3A at Iowa and present them as a hybrid lot (R4, tab 279; tr. 1/158-59, 6/59). A hybrid lot is not a normal production ammunition lot (tr. 6/64). A government witness explained a hybrid lot as follows:

> Sometimes you're at the end of production and you've got some odds and ends metal parts sitting around from different lots, but you don't really want to throw them out.

> You can load those up and put them together and come in – well first, you come into the government and request – you state the position. You say "We've got these leftover parts; we don't want to throw them out. We'd like to form what's called a hybrid lot," meaning that you're putting together – it's not a homogenous lot.
>
> You're putting together different components to make a lot for economy.
>
> So it can either be, you know, a change in metal parts, Comp B interfaces or even change in processes if the processes are basically the same.

(Tr. 6/51-52) By letter dated 7 July 2003, the Army authorized and directed AO to form two hybrid lots from the test rounds, one with projectiles made without NT-60 and the other with projectiles made with NT-60. Both hybrid lots were ballistically tested (the final test performed before the government accepts the rounds) to check if there was "any evidence of projectile break-up or separation of metal parts in the gun bore or in flight when fired at a chamber pressure range of 41,000 to 44,000 pounds per square inch." Both hybrid lots passed the ballistic test. As a result, approximately 100[24] rounds poured without NT-60 were included in the hybrid lot which the government accepted, even though they were not made in accordance with contract specifications. According to government engineer Mr. Niebuhr, when testifying about the limited number of projectiles without NT-60 made at Iowa Line 3A, the government would not accept as FAT those batches of projectiles that were smaller than AO's process production lots which were numbered in the 1000s. (R4, tabs 286, 290; tr. 6/55-59, 64-65)

116. The government alleges that by producing these acceptable test rounds in a hybrid lot "AO was able to produce M107 Comp B loaded rounds that met the nose bump test without using NT-60" (gov't br. at 106). The government further alleges that "AO opted not to submit a ninety round pour for FAT" of the rounds without NT-60 as "[s]ubmitting a ninety round pour from Line 3A which used Comp B without NT-60 for FAT would have undermined [AO's contemplated] claim" (gov't br. at 108). AO maintains that: (1) these initial test rounds were not part of a normal production lot; (2) AO was "able to do it on one test but we couldn't replicate the results;" and, (3) the Comp B rounds without NT-60 included in the hybrid lot would not have been acceptable as FAT by either AO or the government under Clause E-5, FIRST ARTICLE

[24] The end lot number of projectiles was 100, down from the initial 180 projectiles produced without NT-60 because when AO poured the test round projectiles "they were cutting a lot of them up" (tr. 6/59).

TEST (GOVERNMENT TESTING) of the 2000 M107 specification (finding 47). (App. br. at 63-64; tr. 1/154-55, 158-59, 6/63-65) We agree with appellant. We find that the 180 M107 projectiles poured on Line 3A at Iowa without NT-60 as part of its initial test runs and the indeterminate "very small group" made without NT-60 at Milan were not part of a normal production lot, would not have been acceptable as FAT, and do not evidence that AO was able to produce M107 Comp B loaded rounds that fully met the 2000 M107 specification requirement contract.

117. Since acquiring FAT certification on its three production lines, AO produced and delivered over 600,000 Comp B loaded M107 projectiles. With the exception of the 180 nonstandard rounds poured without NT-60 on Line 3A at Iowa, every other Comp B loaded M107 projectile delivered under the 2000 M107 specification has been successfully produced using NT-60. (Tr. 6/65)

118. On 2 December 2003, AO submitted a request for an equitable adjustment which was denied on 14 June 2004 (R4, tabs 41, 42). On 23 June 2004 AO submitted a certified claim in the amount of $3,346,045 (R4, tab 43). Following a deemed denial, AO filed its notice of appeal on 2 September 2004.

119. American Ordnance claimed that it incurred additional costs and performance delays on the basis of the government's defective specifications and other unreasonable conduct (R4, tab 43). Among other arguments, it contended that the government had withheld superior knowledge regarding the specifications (*id*. at 593, 610-11), including the necessity of using NT-60 as an aid to successfully produce M107 projectiles under the TDP; improperly withheld approval of AO's request for permission to incorporate the additive (*id*. at 605-07); incorrectly added the "incompatible Notch and Drop requirements" (*id*. at 599-601, 603-04); and breached the warranty of accuracy of contract specifications (*id*. at 608-10).

120. American Ordnance contended that it suffered 199 days of delay resulting from these wrongful government acts, which it calculated as follows. Although it believed that the delay actually began on 14 November 2001, the date of the second FAT attempt (finding 75), as explained at the hearing, American Ordnance only sought compensation from 6 February 2002, the date it was required to begin full scale projectile production to meet the schedule under the contract as awarded, until 26 August 2002, when it did begin full rate production. AO also subtracted two days for holidays during that 201-day period, thereby reducing the number of days claimed to 199. (Tr. 3/144, 187-88; R4, tab 43 at 614-15) Appellant did not assert government-caused delay for those periods of time during which it was obligated by contract to perform such requirements as ballistic lot testing (R4, tab 43 at 614-15, 628, 634-36; tr. 3/139-49). We find that by calculating the delay from 6 February 2002 rather than 14 November 2001, AO effectively took into account any concurrent delay which it was responsible for. We find AO's determination of 199 days to be reasonable.

DECISION

A. Positions of the Parties

American Ordnance asserts that the 2000 M107 specification, under which AO was originally required to produce Comp B loaded projectiles pursuant to DO 43, was defective and that the government unreasonably withheld superior knowledge. AO was required to achieve a 100% passage rate for all sample projectiles under the notch and drop test in order to obtain FAT certification under the 2000 M107 specification. Appellant maintains that the government: (1) failed to share vital information from the Army Comp B Load Study and the Proposal for that study; (2) imposed the notch and drop test to assess base separation within the M107 shell without first validating the efficacy of the test and without disclosing the Army's prior knowledge that AO was going to incur significantly increased costs due to the switch to Comp B from TNT; (3) executed a firm fixed-price delivery order knowing the work was going to be problematic and more akin to research and development with associated additional costs; and, (4) failed to cooperate with AO's efforts to remedy the defect in the 2000 M107 specification. American Ordnance argues that the government's collective improper conduct in supplying a defective specification, failing to share its superior knowledge, and its unreasonable delay in approving AO's NT-60 ECP constitutes a compensable breach of the implied duty of good faith and fair dealing, which we regard as a breach of the implied duties of cooperation and noninterference. As a result of these actions, AO incurred increased costs of production, including the expense of attempting to perform the defective specification in its extensive efforts to produce compliant Comp B loaded M107 rounds, as well as those associated with the delay caused by the government's alleged failures. (App. br. at 81-83)

The government contends that Comp B loaded projectiles that meet the notch and drop test can be made without NT-60, and that it was American Ordnance's chosen manufacturing methods and inability to control process variables that caused difficulties in producing projectiles compliant with the 2000 M107 specification. The government not only denies that it bears any responsibility for appellant's failure to successfully produce projectiles under the TDP, but affirmatively asserts that, under this fixed-price contract, American Ordnance assumed the risk of increased costs of performance and associated delays. The government argues that the contractor failed to effectively measure production variables by its Six Sigma analysis due to bad data generated by an out of control manufacturing process. The government denies that it had superior knowledge, and maintains that it shared all information not already available to AO. It reasons that, since American Ordnance knew at the time it executed DO 43 that: Comp B was a more problematic explosive to work with than TNT; a pour study would be needed for the Comp B loaded M107 projectiles; and some of the difficulties encountered in producing rounds with Comp B could be limited by adding NT-60 to the Comp B; AO

knowingly assumed the risk of successfully producing projectiles under the TDP. The government further asserts that AO, by entering into Modification No. 2 to DO 43, had agreed to conduct a Comp B load study at no cost to the government. The government avows that it acted reasonably and cooperated with appellant. Finally, the government contends that AO is not entitled to damages for delay because the contractor failed to reasonably calculate delay, and because AO concurrently delayed production by its poor manufacturing processes. (Gov't br. at 116-36)

B. Defective Specifications

American Ordnance argues that the government's 2000 M107 specification is defective, and not suitable for producing the required result of Comp B loaded projectiles within acceptable base separation tolerances as measured by the notch and drop test. The government denies this assertion, and attributes any failures to the contractor's allegedly poorly-controlled manufacturing procedures.

The requirements for a contractor's recovery for defective government specifications are well settled:

> Where the Government has specified the manner in which work is to be done, it warrants the outcome. Once the contractor has established it substantially complied with Government plans and specifications, but that unsatisfactory performance resulted, the burden shifts to the Government to prove that the contractor performed improperly, or that there were other causes absolving the Government of liability. *SPS Mechanical Co., Inc.*, ASBCA No. 48643, 01-1 BCA ¶ 31,318 at 154,692 citing *C.L. Fairley Constr. Co. Inc.*, ASBCA No. 32581, 90-2 BCA ¶ 22,665, *aff'd on recon.*, 90-3 BCA ¶ 23,005 and *R.C. Hedreen Co.*, ASBCA No. 20599, 77-1 BCA ¶ 12,328.

M.A. Mortenson Co., ASBCA No. 53062 *et al.*, 01-2 BCA ¶ 31,573 at 155,906. To obtain an equitable adjustment from the government as a consequence of defective specifications, "a contractor must show three necessary elements – liability, causation, and resultant injury." *Servidone Construction Corp. v. United States*, 931 F.2d 860, 861 (Fed. Cir. 1991) *citing Wunderlich Contracting Co. v. United States*, 351 F.2d 956, 968, 173 Ct. Cl. 180 (1965).

1. Design versus Performance Specifications

Design specifications and drawings describe in precise detail the materials to be incorporated and the manner in which the work is to be performed, from which the

contractor is not permitted to deviate. *J. L. Simmons Co. v. United States,* 412 F.2d 1360, 1362 (Ct. Cl. 1969); *Cable and Computer Technology, Inc.*, ASBCA Nos. 47420, 48846, 03-1 BCA ¶ 32,237 at 159,408. Performance specifications, in contrast, set forth an objective or standard to be achieved, and the contractor may use its ingenuity to select the means to achieve that objective or standard of performance while assuming responsibility for meeting contract requirements. *J. L. Simmons Co.,* 412 F.2d at 1362. The distinction between design and performance specifications is not absolute; it is the obligation imposed by the specification which determines the extent to which a contract contains performance or design specifications. *Blake Construction Co. v. United States,* 987 F.2d 743, 746 (Fed. Cir. 1993). Contracts may have both design and performance characteristics; the former limit the contractor's flexibility, while the latter grant some leeway in how the work is to be accomplished. There is an implied warranty that government design specifications detailing the actual method of performance are free of errors and the contractor can successfully perform based upon the specifications with a resulting satisfactory product. *United States v. Spearin*, 248 U.S. 132, 136 (1918); *White v. Edsall Construction Co.,* 296 F.3d 1081, 1085-86 (Fed. Cir. 2002).

In addition to denying that the specifications were defective, the government focuses upon American Ordnance's alleged performance problems as the cause of Comp B projectile failures. The government asserts that, even if the Board determines that the 2000 M107 specification is principally a design specification for which the government is responsible, American Ordnance had to decide how it would manufacture the M107 rounds and it was AO's failure to control that process through its chosen methods of production and not the government's specifications that caused base separation failures. To the extent that the government can prove the fault lay with AO's poor performance, or that the contractor unwisely chose and/or executed production processes, AO must suffer the loss.

We conclude that the 2000 M107 TDP is primarily a design specification. To the extent the contractor complies, the government retains responsibility for the suitability of the contract for its intended purpose; this contract did not shift that risk to American Ordnance. The government imposed exacting requirements, as it mandated the manner in which AO was to prepare the metal parts, detailed the precise materials AO was to use in the production of Comp B loaded M107 projectiles, furnished the Comp B high explosive that contained varying amounts of lesser quality Indramic wax, directed the temperature to which AO was to melt the Comp B, meticulously controlled the amount and types of additives allowed for the Comp B mixture, and imposed other specific parameters which AO had to follow. The 2000 M107 specification also required AO to perform post cycle conditioning of the filled rounds and outlined in a step-by-step process the precise temperatures and times AO was required to achieve. To the extent that AO conformed to the TDP yet incurred additional costs and delays as a result of the government's defective specifications, the government is liable for those damages.

The 2000 M107 specification is also, in part, a performance specification in that it allowed AO to exercise some judgment in choosing the means of production in manufacturing the M107 rounds. An example of production parameters within the contractor's control is the type of cooling process used for filled rounds. With the government's permission, AO accomplished controlled cooling in different ways, depending upon where the projectiles were produced. On Line D at Milan, it used an air-cooled process using probes, on Line 3A at Iowa, it employed a water bath process, and on Iowa Line 3 it again used an air-cooled process. The mix of design and performance specifications in the instant contract requires AO to show it was unable to produce compliant M107 projectiles despite adhering to the specifications, and that AO's manufacturing process was not the cause of Comp B munitions failures.

Although the same warranty does not attach to performance specifications as design specifications, *Stuyvesant Dredging Co. v. United States*, 834 F.2d 1576, 1582 (Fed. Cir. 1987), we find that the government's restrictive oversight of AO's manufacturing process and its retained right to accept, reject, or modify the contractor's proposed production methods reflect design characteristics for which the government remains responsible. *Collazo Contractors, Inc*., ASBCA No. 53925, 05-2 BCA ¶ 33,035 at 163,743 citing *Jacksonville Shipyards, Inc*., ASBCA No. 45789, 95-1 BCA ¶ 27,332 at 136,226. American Ordnance can recover under the theory of defective specifications to the extent it proves that it followed the TDP and worked within the government's stringent allowances yet still could not produce the desired result.

2. Were Appellant's Difficulties in Producing Comp B Loaded M107 Projectiles Caused by Defective Government Specifications or the Contractor's Uncontrolled Processes?

We next determine whether American Ordnance complied with the 2000 M107 specification in making the controversial Comp B rounds. Under DO 43, the 2000 specification required AO to manufacture M107 projectiles with Comp B with a base separation of equal to or less than 0.015 of an inch that could pass the notch and drop test with no failures. The Comp B high explosive was government-furnished material that contained the inferior grade Indramic wax which required continual monitoring by AO due to its variable quality by lot and propensity to cause base separation (finding 19).

The government maintains that Comp B M107 rounds can be manufactured under the contract's TDP without NT-60, and blames AO's chosen means of production and lack of control of production variables for contract failures and not the 2000 M107 specification. According to the government, American Ordnance demonstrated a lack of control over the following production variables as evidenced from AO's own records: x-rays, preheat temperature for metal parts, ductwork, airflow, and thermocouples. The government maintains that because AO's production variables were out of control and AO could never isolate the human variable, bad data was generated thus rendering the

contractor's Six Sigma results unreliable. We examine each of these variables below, as well as the government's affirmative assertion that Comp B loaded rounds were successfully produced under the 2000 M107 specification without the NT-60 additive by both AO and the government, thus establishing that it was the contractor's performance and not the government's specification that was at fault.

a. *X-Rays*

The government makes two allegations impugning American Ordnance's use of x-rays to demonstrate acceptability of the rounds. First, the government alleges that the x-ray technicians at Milan were inexperienced and did not know how to read x-rays; second, it contends that AO had a parallax problem which impacted x-ray accuracy. The government offers as proof of the first assertion that AO's attempted FAT in October 2001 was halted because x-ray technicians in Milan erroneously applied the TDP by incorrectly using x-rays to count cracks in the M107 projectile explosive casts. We have examined this allegation, and found that this was an isolated incident that was promptly resolved by the contractor and was not an issue by the time of the November 2001 or January 2002 FAT attempts (finding 72). The government has not shown that, beyond this limited event, the inexperience of AO's x-ray technicians adversely affected the contractor's production capability.

The government's second contention regarding the contractor's alleged x-ray parallax problem rests upon an occurrence in September 2002 during a two-day government process review of x-ray film and AO's interpretation of the film. Some of the shots reviewed indicated that the penetrameter had been improperly located. Although the government posits that this x-ray parallax problem "*may have* existed during the October 2001 timeframe" and "this problem would account for AO being unable to understand why some of the rounds would seem good at x-ray and then subsequently fail the notch and drop" test (gov't br. at 122-23 citing ¶¶ 230-33 at 98-99) (emphasis added), the government offers no evidence to support this broad assertion or proof of a pervasive problem.

The government never proved that x-rays were a continuing problem, only that there were two different and separate instances where a correction was necessary with respect to x-rays. We observe that prior to October 2001, the government had approved AO's x-ray procedures (finding 71) and that AO agreed to correct the possible parallax problem within two days after it occurred (finding 112). In the November 2001 and January 2002 FAT attempts, all rounds passed FAT requirements, including x-ray examination, except for base separation as determined by the notch and drop test (findings 75, 84), indicating that AO had corrected the problem by November 2001. As to the alleged parallax issue, the government did not contemporaneously regard the problem as sufficiently serious to warrant revocation of the FAT certification it granted to AO on 23 September 2002 (finding 111).

We conclude that the contractor's October 2001 and 24 September 2002 problems with x-rays were isolated, unrelated and quickly corrected incidents that have not been proven to have an overarching, adverse impact on base separation issues.

b. Preheat Temperature for Metal Parts

Following the October 2001 FAT attempt, American Ordnance determined that part of the reason for the failure was because it had insufficient control of the metal parts preheat temperature (finding 73). The government maintains that AO continued to have problems controlling its manufacturing process, in particular finding the optimal metal parts temperature, as evidenced by the observation in a 15 March 2002 trip report of ARDEC employee Mr. Kris Keeton. The report noted that: "It was believed that the external heat sources were not only located too low on the body of the projectile, but did not provide enough heat in general" (gov't br. at 80, ¶ 189). We have found that this observation referenced the testing of an experimental heat source to the neck of the projectile (finding 95). This had nothing to do with the metal parts preheat temperature issue.

American Ordnance had trouble controlling the metal parts preheat temperature early in its attempt to pass the October 2001 FAT but thereafter effected improvements (finding 73). The contractor's Quick Look Report, which evaluated testing conducted from 24 January 2002 through 12 March 2002, found that the metal parts preheat temperature variable had the potential to significantly affect on-base separation. However, the contractor's report, unlike the contractor's initial evaluation, does not attribute the October 2001 FAT failure to that variable and the government points to nothing in the record to prove that this was an ongoing failure. The Quick Look Report considered but rejected the metal parts preheat as the cause of base separations, and concluded that no process variable under AO's control could be manipulated or changed in such a way so as to successfully pour Comp B loaded M107 projectiles that would pass the notch and drop test (finding 94).

We find American Ordnance's evidence more credible and persuasive than that of the government. The record does not support the conclusion that the contractor's metal parts preheat temperature effort denoted a generally out of control process, and the government has not demonstrated that this issue caused appellant's failure to produce M107 rounds under the TDP that met the notch and drop test.

c. Ductwork

The government maintains that the numerous additions and corrections American Ordnance made to its ductwork prior to passing the FAT are indicative of yet another manufacturing process out of the contractor's control. Specifically, the government

alleges that AO could not pass the November 2001 FAT because the ductwork was inadequate (gov't br. at 122), and directs the Board's attention to difficulties AO experienced "a few years ago" at Milan in manufacturing a different mortar under a prior government contract (*id*. at 50-51, ¶ 122). As evidence of the contractor's allegedly continuing deficiencies, the government cites an internal e-mail by John Crowley referencing the opinion of another AO employee that the "post cycle heat process *may* be short-circuiting from the ducts in the ceiling to the return air vent in the east wall of the bay" (finding 76) (emphasis added).

We find the government's generalized allegations about difficulties under a prior contract and regarding ductwork in performing this contract, fail for want of proof to substantiate that AO engaged in an uncontrolled manufacturing process for the rounds in question. Although AO made improvements to its ductwork following both the aborted October and November 2001 FATs (findings 73, 80), the Corrective Action Report submitted to the government following the November 2001 FAT concluded that the failure was attributable to post cycling conditioning of the rounds done at the minimum cycle time per the TDP. A programming error masked a six degree F. variation between the personal computer output and the actual bay temperature that was corrected by 3 December 2001 (finding 77) and did not prove there was inadequate ductwork. [25] The government cited nothing in the record that shows ductwork or the lack of it to be the cause of base separation failures.

d. Airflow

The government asserts that AO had numerous problems controlling airflow which adversely impacted the contractor's ability to pass the notch and drop test and FAT (gov't br. at 122-23, 74-76, 81, ¶¶ 176, 177, 179, 180, 191). According to the government, AO's 10 January 2002 and 21 February 2002 weekly activity reports show that airflow was a problem in the contractor's manufacturing process. The 10 January 2002 weekly activity report mentioned that the "controlled cooling bay still experienced some air flow issues" (finding 86). The 21 February 2002 weekly activity report provided the following: "M107 Program – Our results from the 16 round pour were unacceptable. *It looks like our cooling process is allowing the top part of the round (Section D)* [to] *cool too quickly.* This causes us to have loose casts that cannot be 'grown' enough in post cycle heating" (finding 87) (emphasis added). The 21 February 2002 weekly activity report also stated that AO was completing modifications to its "post-pour conditioning HVAC controls" so that temperature changes could be closely controlled (*id.*). In April 2002, AO installed additional in-duct cooling coils at Milan to better regulate temperature variations in Building D-41 controlled cooling bays, made

[25] The government does not assert, nor do we decide, that this programming error caused base separation failures.

major modifications to controlled cooling bay duct work, and added roof vents to Bay 8 to balance airflow (finding 98). In July 2002, AO experienced defective casts due to the staging location of a projectile buggy which blocked airflow (finding 104). The government argues that these various problems taken from AO's own records show that the contractor's manufacturing process was uncontrolled.

We disagree that these references to airflow evidence a pervasive problem. The contractor's 12 December 2001 Corrective Action Report, prepared following the November 2001 FAT failure, concluded that part of the reason for the failure was a temperature discrepancy in the post cycle conditioning bay caused by a programming error in the computer which caused a six degree F. variation in the actual air temperature in the bay. AO identified and promptly corrected this problem by 3 December 2001 (finding 77). The CAR attributes the overriding problem to the programming error and not airflow, and there is no evidence that a computer programming error recurred or affected base separation thereafter.[26]

The statement in American Ordnance's 21 February 2002 weekly activity report is tentative as it states: "[i]t *looks* like our cooling process is allowing" (finding 87), but does not conclude that "our cooling process" *caused* the problem (emphasis added). The fact that from January through April 2002 AO made improvements to its airflow processes to better manage temperature, without more, does not prove that the airflow process was uncontrolled to the extent that it caused base separation failures. The Final Report found that Milan's Line D had production processes which were very tightly controlled (finding 103). The July 2002 incident with a buggy obstructing airflow and contributing to poor cast quality (but not base separation) was an isolated incident (*see* finding 104). We conclude that the government has not shown that airflow was an overall uncontrolled process which caused base separation failures.

e. Thermocouples

The government alleges that poor contractor performance is shown by American Ordnance's placement of thermocouples in the wrong position so that the contractor was unable to accurately monitor the M107 manufacturing process; return air thermocouples were giving false readings; and American Ordnance erroneously used thermocouples in a static location rather than installing thermocouple rounds. As evidence that AO was using thermocouples that gave false readings, the government cites to an internal e-mail from AO employee John Crowley, sent following the November 2001 FAT failure. The e-mail discussed the possible causes of the failure and contained the following observation: "[John Cortum] also mentioned that our 'return air' thermocouples located above the heaters *may be giving us a false reading* as to what the internal temperature of

[26] *Id*.

the projectile is during the heating cycle. I agreed. He strongly suggested the fabrication of thermocouple rounds" (finding 76) (emphasis added).

The government's argument is unpersuasive; it fails to show that AO's inadequate handling of thermocouples prevented AO from being able to produce Comp B rounds. The cited evidence provides an insufficient basis for the government's broad assertion of an uncontrolled manufacturing process. Placed in context, AO employees were theorizing in tentative terms the possible causes of the FAT failure and potential solutions. Although AO made improvements to the number and placement of thermocouples following the October 2001 FAT failure (*see* finding 73), AO did not attribute either the number or the placement of thermocouples as a cause or contributing factor to the October 2001 FAT failure (*see* findings 72-74). The government has presented no evidence to support a contrary conclusion. We find nothing in the record to support that AO was using thermocouples which gave false readings, or that AO's improper use of thermocouples hampered the contractor's ability to successfully manufacture loaded rounds. In January 2002, AO effected further improvements in the type of thermocouple it used and relocated thermocouples to better monitor and control temperature. Static thermocouples were replaced with thermocouple rounds, and the number of thermocouples was increased. (Finding 85) The government suggests that, because AO was continually trying to improve the M107 manufacturing process on Line D, this shows a manufacturing process out of control. However, the record is clear that AO was trying many possible solutions in its effort to pass the FAT and that its processes were tightly monitored and controlled.

f. The Contractor's Six Sigma Analysis

Although the purpose of American Ordnance's Six Sigma analysis was to demonstrate the degree to which the contractor correctly manufactured the Comp B rounds, the government argues that American Ordnance cannot use that analysis to demonstrate that it adhered to contract requirements and thus shift liability from contractor performance to defective government specifications. The government contends that, because the study was predicated upon bad data, the results are untrustworthy and do not demonstrate AO's manufacturing competence or compliance with the TDP. It reasons that, because AO was unable to make an accurate assessment, the contractor used incorrect information to make decisions about its assembly line process and in establishing parameters. Therefore, according to the government, AO's Six Sigma analysis is unreliable proof of the adequacy of appellant's manufacturing process. The government contends that AO's data was flawed by the following alleged process irregularities: (1) thermocouples were the wrong kind, in the wrong locations, inadequate in number, did not reflect the conditions on the assembly line and did not effectively monitor exterior temperature; (2) x-rays were read by inexperienced readers, AO had an x-ray parallax problem and x-rays were subject to human error; and (3) uncontrolled manufacturing processes as evidenced by AO's failing to control airflow,

being unable to isolate the human variable, inconsistently preheating metal parts, needing additional ductwork, having to install insulation between the bays, and having to provide greater air conditioning capacity, roof vents, cooling coils, and better HVAC controls.

We have evaluated the substance of the alleged process errors listed above, and find that these, considered singly or as a whole, do not constitute proof of a systemically uncontrolled manufacturing process. Rather, following the two aborted October and November 2001 attempts to pass the FAT due to poor interim results, AO employed Six Sigma, a rigorous problem solving technique which leveraged designed experiments and methodologies of statistical analysis to isolate and resolve the cause of the notch and drop test failures. As a result, American Ordnance further tightened control over its manufacturing processes, making improvements in production equipment and in other areas (findings 78, 85, 98).

After the January 2002 FAT failure, American Ordnance again performed extensive design of experiments and statistical analyses in an effort to resolve the cause of the drop test failures but ultimately found no parameter outside of contract-specified tolerances (findings 85, 94). Prior to receiving approval from the government to use NT-60 in its production and at its own risk and cost, AO during the week of 20 May 2002 conducted a FAT for Comp B loaded M107 projectiles using the additive. The results of this FAT were dramatic in their unprecedented success (finding 99), as were AO's pilot efforts prior to the FAT. The Army commander at Milan, LTC Markol, was so impressed that he called appellant's efforts "*groundbreaking*," and stated that AO was "*basically performing the experimental work for ARDEC to determine the precise Comp B*" parameters to pass the notch and drop test (finding 96) (emphasis added). This contemporaneous accolade from a high-ranking government official acknowledges that AO went to considerable lengths to devise a successful method of producing Comp B loaded rounds, despite the lack of government initiative or support in resolving problems with the TDP.

We have found that American Ordnance was careful and methodical in its efforts to pass the notch and drop test under the 2000 M107 specification (finding 94). The Final Report created by AO's Six Sigma team found one production process with a Cpk of 1.67, which is considered "very good," while the remaining production processes had Cpks above 2, which is considered "very, very tightly controlled" (finding 103). The Final Report is persuasive evidence that AO had tight control of its production equipment and processes and performed in compliance with the TDP. AO reasonably concluded through its careful efforts that Comp B loaded projectiles could not be manufactured to the 2000 M107 specification without the additive NT-60.

The government has attempted to extrapolate isolated events to undermine the overall credibility of American Ordnance's data, but the record, reviewed as a whole, does not prove that AO relied upon bad data in its Six Sigma analysis to evaluate its

manufacturing process. We find that the evidence supports the conclusions that AO's production process was capable of producing compliant Comp B loaded M107 projectiles once the explosive was stabilized with NT-60, that its process was tightly controlled, and that the defect lay with the government's design specification for Comp B loaded rounds that required verification of base separation by the notch and drop test but did not also provide for the use of NT-60 as an additive. These conclusions are buttressed by the dramatic results after the contractor, required to do so at its own expense, began using NT-60 in its production of M107 rounds, and American Ordnance has since successfully produced over 600,000 acceptable projectiles (finding 117). Even government officials overseeing the contract contemporaneously recognized that American Ordnance had found a way to achieve the production of Comp B M107 munitions despite (and not because of) the government's specifications. In addition to Milan's LTC Markol, Mr. Larry Gulledge, the top ranking civilian at Rock Island, captured AO's determined efforts and the company's significant investment in the additional work it was forced to do to make the required projectiles. Mr. Gulledge acknowledged to other Army officials that American Ordnance's endeavors "*smack*[ed] *a lot like an R&D effort*." We agree with Mr. Gulledge's assessment of the government's responsibility for additional costs, in that "*Heresy of all heresies, we may even have to start renegotiating some contracts that have just proven impossible to execute*." (Finding 105) (emphasis added)

3. The Government's Assertion that Comp B M107 Rounds Could be Successfully Produced without NT-60

The government insists that the 2000 M107 specification is "not defective," and that satisfactory "Comp B M107 rounds can be produced which meet the [notch and drop] test without using NT-60 as a process aid" (gov't br. at 119). It bases this assertion upon internal opinions, earlier reports, and three instances in which TDP-compliant rounds were supposedly made.

The government points to: 24 rounds it poured in the Army Comp B Load Study (finding 92), the 180 rounds poured by American Ordnance on Line 3A at Iowa, which were ultimately included in a hybrid lot (finding 115), and a small group of rounds which AO poured at Milan prior to the January 2002 FAT attempt (finding 78) as evidence that Comp B loaded M107 rounds that meet the notch and drop test can be successfully manufactured without NT-60. In addition to the government's practical assertions that both it and the contractor were able to produce a limited number of Comp B rounds without using NT-60 and that prior studies show Comp B to be troublesome, the government relies upon the theoretical evidence of internal "technical data" and the "professional opinions" of experienced government engineers to support its conclusion that acceptable rounds can be produced under the TDP. The government specifically cites the "1982 Comp B Wax Study conducted at the Louisiana Army Ammunition Plant" to support the integrity of the contract's specifications. (Gov't br. at 119)

We find that the government failed to prove that any of this small number of rounds were produced and/or tested in accordance with contract requirements, that the 1982 Comp B Wax Study ever produced rounds compliant with this TDP, or that the opinions and government data relied upon established that the specification was sound. At its best result, only one-half of the rounds the government produced in the Army Comp B Load Study passed the less stringent drop (without notching) and x-ray tests. More importantly though, is that *none* of the rounds made in the government study ever passed the contract's notch and drop test (finding 92). These government produced projectiles were not made in accordance with the specification imposed on American Ordnance, and do not suffice as proof that following the contract could or would result in successful Comp B loaded M107 projectiles.

As to the 180 rounds manufactured by AO without NT-60 on Line 3A at Iowa (using a water cooled production line) that passed the notch and drop test, these were poured as initial test rounds and would not have been accepted as FAT by the government. These projectiles were not made in compliance with the contract and do not evidence that AO was able to produce Comp B loaded rounds that met the 2000 M107 specification (finding 116), even though Line 3A at Iowa is considered the premier production line for munitions (finding 12). We view the "very small group" of Comp B M107 rounds AO poured on Line D at Milan without NT-60 that passed the drop test as similar to the rounds produced on Line 3A at Iowa that were included in a hybrid lot. These Comp B M107 projectiles were poured as test rounds that would not have been accepted as FAT by the government because they did not conform to the TDP. (Finding 79) There is no other evidence to support the government's contention that Comp B loaded projectiles without NT-60 can be or ever were produced pursuant to the 2000 M107 specification, or that "professional opinions" of government employees demonstrated the efficacy of the TDP.

Conclusion

We conclude that American Ordnance tightly controlled the manufacturing and testing procedures for producing M107 rounds, responded quickly to occasional difficulties and complied with the TDP; it has demonstrated that Comp B loaded M107 projectiles that met the 2000 M107 specification could not reliably be produced without adding NT-60, either at Milan with an air cooled process or at Iowa with either air or water bath processes. When a contractor proves that the intended result cannot be produced despite its adherence to the TDP, the burden shifts to the government to establish "additional causes of the contractor's difficulties which absolve the Government of responsibility." *Woerner Engineering, Inc.*, ASBCA No. 52248, 03-1 BCA ¶ 32,196 at 159,141, *citing R.C. Hedreen Co.*, ASBCA No. 20599, 77-1 BCA ¶ 12,328 at 59,554. American Ordnance has shown by a preponderance of evidence that the 2000 M107 specification was defective and that acceptable rounds could not be produced despite following the TDP. The burden thus shifted from American Ordnance to the government

to show the specifications were not defective or that AO was responsible for the failures, costs and delays.

We have carefully reviewed the government's allegations and the evidence relied upon, and find that the government has not shown AO's manufacturing process to be out of control or that its choices of process caused the difficulties. The government cited inadequate proof that the specifications are suitable for the intended purpose of producing Comp B M107 rounds without adding NT-60, or that American Ordnance's failures were the result of its poor performance. More is required to meet the government's burden of proof than its unsubstantiated assertions that TDP-compliant rounds were produced, and opinion testimony unsupported by specific proof and probative evidence that this specification *should* produce the intended result. *Woerner Engineering*, 03-1 BCA ¶ 32,196 at 159,142*, citing AGH Industries, Inc.*, ASBCA Nos. 27960, 31150, 89-2 BCA ¶ 21,637 at 108,864. Although the government attributes the munitions failures to American Ordnance's choices of process (gov't br. at 117-19), it does not make its case.

The government adduced no testimony at hearing nor has it produced documentary evidence or analysis that competently calls into question the credibility of AO's data, which demonstrated through the Six Sigma analysis that AO did a good job of complying with the TDP. Moreover, the Army's contemporaneous actions establish that the government believed during contract performance AO's data collection was more than adequate (*see* findings 71, 95), and there is no proof that unacceptable base separation of Comp B loaded M107 rounds was the result of an out of control manufacturing process that violated the specification. To the contrary: appellant has demonstrated that its manufacturing processes were tightly controlled, that it readily remedied the limited instances of problems cited by the government, and that these difficulties are not indicative of pervasive malfunctions as alleged by the government.

As heralded by the government at the time, the contractor's "at risk" addition of NT-60 resulted in dramatic and overwhelmingly successful results, and there is no evidence that AO made process changes beyond this additive which resulted in this significantly changed outcome. The contract did not permit American Ordnance to use NT-60 without specific permission from the government, even though the government understood the power of that additive (findings 91, 95). There is no proof that the government, AO, or anyone else ever produced compliant rounds in production quantities without the addition of NT-60. The government has not proven that American Ordnance's performance, and not the defective specifications, caused the increased costs and delay. The government has failed to establish any causal connection between the contractor's process issues, considered individually or cumulatively, and the critical defect of base separation as assessed by using the notch and drop test. American Ordnance is entitled to recover all of the costs proximately flowing from the defective specification, as all resulting delays are "*per se* unreasonable and hence compensable." *Essex Electro Engineers, Inc. v. Danzig*, 224 F.3d 1283, 1289 (Fed. Cir. 2000), *citing*

Chaney & James Constr. Co. v. United States, 421 F.2d 729, 732 (Ct. Cl. 1970) and *Daly Constr., Inc. v. Garrett*, 5 F.3d 520, 522 (Fed. Cir. 1993).

C. Superior Knowledge

We consider next American Ordnance's assertion that, at the time the parties entered into DO 43, the government withheld superior knowledge essential to the contractor's ability to successfully produce M107 rounds. The doctrine of superior knowledge is based upon the premise that, where the government has knowledge of vital information that will affect a contractor's performance, the government is obligated to share that information. *Helene Curtis Industries, Inc. v. United States,* 312 F.2d 774 (Ct. Cl. 1963). In order to recover on a claim based on superior knowledge, the contractor must show: (1) the contractor undertook performance without vital knowledge of a fact that affects performance costs or duration; (2) the government was aware the contractor had no knowledge of the vital information and no reason to obtain such information; (3) the contract specification supplied misled the contractor or did not put it on notice to inquire; and (4) the government failed to provide the relevant information. *Hercules, Inc. v. United States,* 24 F.3d 188, 196-197 (Fed. Cir. 1994), *aff'd on other grounds,* 516 U.S. 417 (1996).

Delivery Order 43, signed 6 April 2001, called for the production of Comp B loaded M107 projectiles (finding 43; R4, tab 15), but the contract did not call for appellant to conduct additional research to better develop the TDP. American Ordnance asserts that, at the time it "undertook to pass [the] FAT and produce Comp B loaded M107 projectiles under the 2000 M107 specification, it did so without" the vital knowledge that the Army: (1) "had approved an extensive Comp B Loaded Study to develop pouring parameters for Comp B loaded M107 projectiles"; (2) "had never validated the [notch and drop test] on Comp B load[ed] M107 projectiles" before making it part of the TDP; and, (3) " knew satisfying the Drop Test would be problematic for AO and would substantially increase AO's cost of meeting the specification" unless the TDP was modified to allow an additive such as NT-60. (App. br. at 81-82) Appellant alleges that it was unaware at the time it entered into DO 43 that "pre-developed [melt/pour] parameters were essential to avoiding production problems, production line shutdowns, and delayed deliveries of Comp B Loaded M107 projectiles that were slated for production by AO" (app. br. at 100) (emphasis in original). American Ordnance further denies that its Load Plan constituted agreement to conduct the same research and development envisioned by the Army Comp B Load Study (app. reply br. at 81).

The government does not deny that it did not for many months inform American Ordnance of the existence of the Army Comp B Load Study that was proposed in October 1999 but originated with ARDEC's 24 August 1999 meeting that focused upon problems with loading Comp B projectiles, and raised the importance of eliminating unsafe rounds from distribution if not production (findings 23-24). However, the

government does dispute that the knowledge it possessed was superior to that available to the contractor. The government contends that the parties were on a more equal footing at the time of DO 43 regarding relevant information, and that "the balance of knowledge was not so clearly on the Government's favor so as to shift the normal assumption of risk from the contractor to the Government" (gov't br. at 133). We understand the government, in addition to its general denial of superior knowledge, to assert that the contractor should have been able to deduce the same (but unshared) conclusion that additional research and development was needed for a sufficient TDP. In particular, the government argues that American Ordnance knew at the time it agreed in DO 43 to the change from TNT that: making Comp B rounds required a controlled manufacturing process; the Comp B furnished by the government could contain varying levels of wax; and that NT-60 had been shown to be a useful additive in producing other types of Comp B loaded munitions. (*Id*.) According to the government, this should have been enough information for appellant to avoid the difficulties it encountered. The government denies failing to share any specialized knowledge, contending to the contrary that it affirmatively "provided the information that it had in its possession" (*id*. at 134).

The government argues that, armed with the understanding that Comp B was difficult and that adding NT-60 was useful, American Ordnance disregarded information within its reach and voluntarily assumed the risk that performing the contract would cost more than it bargained for. The government contends that AO was so eager to obtain the work that it failed to consider all that was necessary to successfully produce Comp B projectiles. The government reasons that it was the contractor's lack of preparedness, not the government's reluctance to make known potential concerns, which resulted in the increased costs and delays now claimed by AO. The government also asserts Modification No. 2 to DO 43, approved on 1 August 2001, as proof that American Ordnance agreed to perform the necessary research and development to successfully make Comp B M107 munitions in return for permission to move production from Iowa to Milan. (Finding 67; gov't br. at 131-33)

We examine the parties' contentions below.

1. The Army Comp B Load Study

Government documents establish that ARDEC officials acknowledged among themselves, months before issuing DO 43, that the contractor would face specific problems in loading M107 projectiles with Comp B under the TDP. The government was sufficiently troubled over the necessity of developing a better process for use in both "current and future productions contracts" to make Comp B loaded projectiles that the government commenced a costly internal Army Comp B Load Study (findings 27-28). ARDEC justified the proprietary study to IOC as necessary to "establish a controlled cooling Composition B melt pour loading process for the M107 155mm HE projectile." The proposal stated that: (1) for over 10 years, "*numerous loading problems and*

excessive defect rates have been experienced during the loading of various munitions with *Comp-B having Indramic wax*"; (2) the "*current M107 Comp-B loading drawings/specification does not specify a loading process* [and] *it is expected that without proper process controls critical defects will . . .likely increase*" over those encountered with TNT-filled rounds; and (3) "155mm Comp-B loaded munitions are *2-3 times more likely to experience an incident* vs. TNT loaded projectiles" (finding 24) (emphasis added).

The government allowed American Ordnance to enter into DO 43 and undertake performance without disclosing exclusive vital knowledge that affected both contract cost and duration. This information was neither contained in the contract nor timely made available to AO, nor did its absence put American Ordnance on notice of a duty to inquire regarding the deficiency. The government was aware American Ordnance did not have knowledge of the internal study or reason to obtain it (*see, e.g.*, finding 23, 28). Because the government did not disclose its preaward knowledge that the TDP required refinement and that the contractor would experience problems in producing and evaluating the projectiles, AO was misled into believing that the contract could be readily performed as written when the government knew otherwise. At the time of award, AO reasonably believed that the government's TDP was capable of producing the intended result. American Ordnance was not obliged to inquire whether the government had information to the contrary or had already embarked upon a remedial scheme directed at this and future contracts, but the government did have the duty to provide this highly relevant knowledge and repeatedly refused to do so.

From the outset, American Ordnance was not informed when it executed firm fixed-price DO 43 on 6 April 2001 that the government had approved an internal study to research and develop process parameters. This information was not included in the instant TDP, nor was AO advised that these efforts were necessary to successfully produce Comp B rounds. Appellant was unaware that ARDEC had already concluded that pre-developed parameters were essential for the contractor to avoid problems under the TDP that would result in production line shutdowns and delayed deliveries of Comp B loaded M107 projectiles. Nor was American Ordnance told that the Army specifically anticipated before it issued DO 43 that AO would encounter significant obstacles very unlike those experienced in producing the contract's earlier TNT rounds.

2. Use of the Notch and Drop Test to Evaluate Comp B Loaded M107 Rounds

The Army decided, when it made the change to the Comp B explosive due to dwindling TNT supplies and increased customer demands, to increase inspection requirements in order to detect and eliminate from circulation those rounds with unacceptable base separation. The government elected to achieve this goal by imposing the unproven notch and drop test to eliminate unsatisfactory rounds rather than basing DO 43 upon a fully developed TDP capable of reliably producing the intended result.

The government did not share with American Ordnance its prior knowledge that DO 43 lacked a fully developed TDP, which would complicate production of rounds of acceptable quality. For example, the contractor was unaware, and was not on notice of a duty to inquire, that ARDEC previously had explicitly concluded in the Army Comp B Load Study proposal that, by increasing the inspection requirements through introducing the notch and drop test, the Army would increase AO's cost of production (finding 25), nor did the contractor know that the government had not verified the use of this test with respect to the M107 projectile (finding 30).

When American Ordnance began its efforts to satisfy the requirements for FAT certification under the 2000 M107 specification for Comp B projectiles, it was only producing TNT loaded projectiles and knew that validation testing had been done on other munitions containing that explosive. AO executed firm fixed-price DO 43 relying upon the assumption that the Army had performed validation tests to insure the notch and drop test was suitable for evaluating Comp B explosives for base separation. We find this assumption reasonable (*see* finding 37), as the government warrants the suitability of its specification; without more, a contractor is not required to inquire whether the government has concealed private knowledge that the TDP is fraught with inadequacies.

The information in the Army Comp B Load Study was vital to performing this contract, but was not timely disclosed to AO. We have found that the government relied on references to the 1954, 1955, 1956, 1982 and 1990 studies to advise AO of problems loading M107 projectiles with Comp B (finding 63). But, nothing in these studies informed AO of the specific problems with base separation under the notch and drop test incorporated in the 2000 M107 specification that were foreseen by the government (finding 63) and later encountered by appellant (findings, *passim*). The government failed to justify its decision to refrain from contemporaneous, open and frank discussions with the contractor about acknowledged obstacles.

The government's failure to disclose superior knowledge regarding this test is exacerbated by its affirmative representation, at the time rounds were made using TNT, that adding the notch and drop test warranted only a "paperwork change" valued at "$5,000" (finding 34). While this could have been true when rounds were loaded with TNT, the government knew differently before the change to Comp B was made, but did not advise American Ordnance that this inspection requirement would have a significantly greater effect on production under DO 43. This foreknowledge is evidenced by the specific objective of the government's 25 October 1999 study proposal to "establish a robust controlled cooling loading process for the M107 which will reliably produce zero base separation after nose drop testing (comparable to the M795 loading process)." (Finding 24) The government did not tell American Ordnance that it had allocated $152,223, a significant portion of the Army Comp B Load Study's $690,236 budget, to validation testing by AO. Even though AO never received the benefit of that planned effort, the government clearly understood that the impact of imposing the notch

and drop test far exceeded the few thousand dollars earlier represented (finding 41). The government by its silence misled the contractor with respect to the impact of the notch and drop test to evaluate Comp B projectiles.

There are parallels between the instant appeal and the historic case of *Helene Curtis Industries*. That specification was found to be misleading, and the government actionably to have withheld information it possessed regarding problematic contract-regulated procedures and required ingredients. In both *Helene Curtis* and here, the government knew but did not disclose that: the government privately had sponsored research; manufacturing the product would be more difficult than the contract revealed; the TDP procedures were not adequate for working with a very difficult component that was uncertain in reaction and required extreme care in handling; and, the contractor in its ignorance would believe the specification to be adequate. *Id*. at 777-78. The balance of knowledge of the infirmities of this TDP squarely places upon the government the duty to divulge this insight, especially as Comp B rounds were not off-the-shelf commodities. Comp B loaded M107 projectiles were a specialized, nonstandard product in which the "ratio of actual and potential knowledge" places an affirmative duty on the government to impart information to the contractor. *Helene Curtis Industries,* 312 F.2d at 778. The government is "not excuse[d]...from liability if it breaches an independent duty to reveal data or if the end-product specification embodies a material misrepresentation misleading the contractor." The Court's holding remains instructive over 40 years later:

> In this situation, the Government, possessing vital information which it was aware the bidders needed but would not have, could not properly let them flounder on their own. Although it is not a fiduciary toward its contractors, the Government—where the balance of knowledge is so clearly on its side—can no more betray a contractor into a ruinous course of action by silence than by the written or spoken word. Cf. Cardozo, J. in Globe Woolen Co. v. Utica Gas & Elec. Co., 224 N.Y. 483, 489, 121 N.E. 378, 380 (1918)

Id. at 778.

3. The American Ordnance Load Plan

The government responds to American Ordnance's claim of superior knowledge by contending that the contractor knew, before entering into DO 43, that "it would need to conduct [an] applied research and development study" to "refine its manufacturing process" and "would need to eliminate production problems within" its chosen production methods" (gov't reply br. at 131-32). The government does not assert any contract language to support the contention that American Ordnance specifically agreed to conduct extensive research and development to compensate for issues with the TDP.

Rather, the government couples internal contractor documents including e-mails suggesting an internal study to show that American Ordnance had prior knowledge that it had to conduct research and development as part of the change to Comp B required by DO 43. The e-mail exchange among AO employees began with Mr. Philip Clem's 1 August 1999 message relating an impromptu conversation he had just had with Mr. Czachorowski about the government's anticipated procurement of Comp B rounds. Mr. Clem suggested that AO obtain some rejected M107 shells and some spare Comp B before submitting its proposal. (*See* finding 22) The government urges that this writing proves that AO knew that a load study was needed before going into production.

The government also relies upon AO correspondence dated 3 July 2001, in which the contractor offered to move production from Iowa to Milan at no cost to the government, as proof that American Ordnance understood that it was obliged to also conduct additional research and development as part of DO 43. The contractor's letter references AO's 30 May 2001 "Engineering Pour Study Plan Cast Loading of Projectile" (finding 52), but did not specifically object to the government's 7 June 2001 description of that plan as a "melt-pour research and development program." The government reads these documents together to support its position that "AO proposed to complete the load study at no cost to the Government." (Gov't br. at 132; *see also* findings 52-53, 65)

The government's argument that American Ordnance cannot show superior knowledge where appellant knew in advance that a load study encompassing research and development was needed, and agreed to perform that work at no cost to the government in return for being allowed to produce Comp B projectiles at Milan, fails for want of proof of both elements. We are convinced by the record, supported by the credible and persuasive testimony of appellant's witnesses, that the American Ordnance Load Plan was focused upon refining the contractor's production efforts to comport with the TDP and obtain the delivery order. American Ordnance did not agree to undertake the considerable research and development that the government knew was needed, and there is no proof that the contractor's Load Plan was as extensive or encompassing as the Army Comp B Load Study. The government was aware prior to awarding DO 43 that the TDP should be revised, as evidenced by the objectives of the Army Comp B Load Study. As the government did not timely share this information, there is no basis for charging AO with this understanding. Mr. Clem's e-mail evidences that AO knew it would have to convince the government that it could produce Comp B rounds to win the procurement (finding 22). Neither the e-mail nor correspondence concerning the AO Load Plan or move to Milan show that American Ordnance was aware of the same level of work as anticipated by the government. The government provides insufficient evidence that the contractor's desire to be prepared to compete equates to the degree of knowledge the government had but did not share.

Unlike the facts presented in *Robins Maintenance, Inc. v. United States*, 265 F.3d 1254, 1257 (Fed. Cir. 2001), in which the contractor "knew about the defects in the

specifications [yet] nonetheless chose to submit a bid and agreed to the contract," the government offers no proof and we find no support in the record for the proposition that American Ordnance knew before it accepted DO 43 that the TDP was defective. The government has offered insufficient evidence that the Load Plan envisioned by American Ordnance was consonant with the Army Comp B Load Study undertaken by the government, or that the contractor understood that substantial research and development remained to be done before gaps in the TDP known by the government but not disclosed to the contractor could be remedied.

D. Cooperation and Noninterference

In addition, American Ordnance charges the government with breach of the duty of good faith and fair dealing as the government continued to withhold vital knowledge and obstruct its performance well into the contract. Placed in context, we understand appellant to argue that the government breached its implied duties of cooperation and noninterference (app. reply br. at 84-86). The government disputes this.

American Ordnance contends that the government's unwillingness to share information concerning both specification limitations and its understanding of the efficacy of NT-60 contributed to AO's inability to successfully pass a First Article Test, which the TDP required before regular projectile production could begin. The contractor in October 2001, November 2001 and January 2002 attempted but failed to pass a FAT. American Ordnance contended that the government breached its "implied duty of good faith and fair dealing" when it did not meet AO's reasonable expectation that the government "would not unreasonably hinder AO's efforts to obtain approval of the use of NT-60 in the production of Comp B loaded M107 projectiles." American Ordnance also contends that it "had a reasonable expectation that the Army would share" vital information from the Army Comp B Load Study. (App. br. at 112)

The government here bears the affirmative duty to cooperate with the contractor, which is "'to do what is reasonably necessary to enable the contractor to perform.' *SEB Engineering, Inc.*, ASBCA 39728, 94-2 BCA ¶ 26,810 at 133,352." *Coastal Government Services, Inc.*, ASBCA No. 50283, 01-1 BCA ¶ 31,353 at 154,833, *aff'd*, 32 Fed. Appx. 584 (Fed. Cir. 2002) quoting prior decision in ASBCA No. 50283, 99-1 BCA ¶ 30,348 at 150,088. The government also has the negative obligation of refraining from interfering with the contractor's performance:

> By contrast to the affirmative duty to cooperate, the implied duty of noninterference is a negative obligation that "'neither party to the contract will do anything to prevent performance thereof by the other party or that will hinder or delay him in its performance.'" *Lewis-Nicholson, Inc. v. United States*, 550 F.2d 26, 32 (Ct. Cl. 1977) quoting *George A. Fuller, Co. v.*

> *United States*, 69 F. Supp. 409, 411 (Ct. Cl. 1947); *Nanofast, Inc.*, ASBCA No. 12545, 69-1 BCA ¶ 7566 at 35,049.

Id.

We examine the reasonableness of the government's actions in assessing whether it breached the duties of cooperation and noninterference:

> Determination of a breach of the duty requires a reasonableness inquiry. "The nature and scope of that responsibility is to be gathered from the particular contract, its context, and its surrounding circumstances." *Commerce International Company, Inc. v. United States*, 338 F.2d 81, 86 (Ct. Cl. 1964).

Id.

1. The Army Comp B Load Study

American Ordnance has established that it was harmed because the government wrongly withheld superior knowledge about anticipated difficulties with the contract TDP that led to the government's Army Comp B Load Study. This pre-award failure on the part of the government impairs the overall procurement process, as prospective contractors may be misled in forming reasonable judgments about contract requirements and pricing. But the government's refusal here continued beyond contract formation into contract administration, as the government for an extended period persisted in withholding that vital information, or did not adequately or timely divulge what it knew. American Ordnance is entitled to recover for this continuing injury, and for costs and delay incurred during this extended period, as the government's misconduct progressed to breach of its implied duty to cooperate and of noninterference.

Not only did the government know well in advance of the problems that American Ordnance could and did encounter, and of AO's repeated requests for information, the government refused for nearly 30 months to divulge that it was conducting an expensive, internal study intended to improve the melt/pour process imposed by the contract's TDP. Even then, the government removed 10 important pages from the contractor's copy of a government presentation entitled "155mm M107 Projectile ARDEC Composition B Load Study Review" that showed NT-60 as a recommended solution to compensate for the instability of Comp B, particularly when this explosive was combined with the inferior Indramic wax (finding 91). The government's 4 March 2002 redaction took place after six load tests conducted by the government failed to produce Comp B projectiles in accordance with the TDP, and the government on 4 January 2002 had rejected AO's 15 November 2001 request to use NT-60, which was predicated upon prior successful applications that had been approved by the government (findings 81, 83, 92).

We note that, during the brainstorming session involving both government and contractor representatives the week following the 4 March 2002 redaction, the government agreed that NT-60 was useful (but still did not disclose its private consideration of the additive as a process solution) (finding 91). According to an internal ARDEC memorandum by Ms. Kris Keeton, dated 12 March 2002, "Everyone agreed that the single most important immediate course of action would be to procure and test the additional NT-60." (Finding 95)

The government's refusal to acknowledge, much less share, its insight into the improvements necessary for a successful TDP continued during a particularly difficult period of contract performance. For 2½ crucial years, during which the contractor struggled to make Comp B rounds and sought assistance, the government inexplicably did not reveal what it knew. Certain events stand out during that period, as American Ordnance made contracting decisions without the benefit of vital government information, and raised problems that might have been averted or ameliorated had the government admitted knowing that: (1) the TDP required revision; (2) considerable research and development on the TDP remained necessary but was not stated in the contract; and, (3) NT-60 was under independent government scrutiny as a useful additive for this particular government-furnished high explosive.

American Ordnance went to considerable lengths to remedy the situation after it was unable to successfully produce Comp B rounds using the specification. The contractor spent additional time and money to ensure it properly handled the materiel, scrutinized its manufacturing process variables, and evaluated its performance through a series of Six Sigma studies. Despite the contractor's best efforts, which were shown to be tightly controlled, it still could not successfully produce Comp B rounds unless it also added NT-60. Noting that the government never showed it was possible to produce reasonable quantities of the desired projectiles under the TDP, we hold that AO's concerted efforts to find the root cause of the failures were hampered by the government's unreasonable refusal to share particular knowledge of TDP deficiencies. The government's failure to admit what it knew, especially as evidenced by documents surrounding the Army Comp B Load Study, misled the contractor during performance into erroneously assuming responsibility for the failure to produce Comp B rounds under the TDP, and caused AO to incur considerable additional cost and delay.

The government was well aware of the contractor's need for help. On 13 June 2001, American Ordnance convened a "Comp B Symposium," in which it sought government assistance in and information about producing the Comp B rounds (finding 54). Despite the government's contention that, at the time "the Comp B Symposium [was held] and shortly thereafter, the Army provided the information that it had readily available to AO" (gov't br. at 134), the record does not support this level of cooperation. The government simply did not timely communicate the specialized information it had at

hand. The symposium took place in June 2001, two months after DO 43 was awarded and 22 months after the 24 August 1999 memorandum showing that the government knew internally that its Comp B specifications were lacking (findings 23, 24, 43, 54). The government would have been tardy had it disclosed information from the Army Comp B Load Study at the time it executed the delivery order, much less had it advised of the study's purpose at the time of the contractor's Comp B Symposium. Still, at no time before or during that meeting did the government share the specific concerns voiced in its October 1999, December 2000 and 18 March 2001 versions of the Army Comp B Load Study and proposal that: (1) AO was going to experience problems producing Comp B loaded M107 projectiles; (2) AO was going to experience significant problems producing projectiles that could satisfy the notch and drop test; (3) AO would likely experience increased critical defects and production line shut-downs once production of Comp B loaded rounds began; or, (4) AO was going to experience increased LAP costs in its efforts to pass the notch and drop test when loading with Comp B (*see* findings 24-27, 39, 41). The government knew that the contractor needed this information and was actively seeking help; inexplicably yet consistently, the government did not provide necessary and appropriate assistance to AO.

2. NT-60

American Ordnance undertook to devise solutions to the Comp B loading problem, and in its 15 November 2001 ECP recommended the use of NT-60. Its proposal was rejected by the CCB on 14 December 2001, even though the government was privately considering the additive in its independent study. Instead of admitting that it had planned to assume responsibility for similar tests, the government insisted that American Ordnance conduct a series of tests at the contractor's expense to verify compatibility with the munitions before allowing NT-60. The government does not adequately explain why it told AO about only a few of the CCB-required tests on 4 January 2002, and took until 21 February 2002 to tell AO of all the requirements that CCB had called for on 14 December 2001. (Findings 82-83, 90) Although the contractor eventually satisfied these tests, the government nonetheless continued in its refusal to change the TDP to permit the additive. Even after the government gave limited acknowledgment of the existence of the Army Comp B Load Study on 4 March 2002, it refused to accept AO's successful FAT attempt using NT-60 on 30 May 2002 because the TDP had not been amended to allow the additive (finding 100). Eventually, the government only allowed American Ordnance to produce Comp B rounds using NT-60 at the contractor's risk and expense, even though the government had doubts about the specifications and could not prove that the TDP was valid without that addition. The government went so far as to insist that the contractor accept this change at no cost, or else the government would cause American Ordnance to shut down production by taking its business elsewhere (finding 108).

We conclude that American Ordnance struggled with production of Comp B loaded M107 projectiles without the benefit of vital information pertaining to the use of the additive, known but withheld by the government, that adversely affected the cost, duration and method of AO's performance. Further injury to appellant resulted in that it was not until after the government's September 2002 approval of the NT-60 ECP (albeit at AO's risk and cost), that the Milan and Iowa facilities were granted FAT certification by the government, even though the government was already aware that its TDP required changes and that the additive would have a salutary effect.

Conclusion

Our "reasonableness inquiry" into the events of the appeal yields multiple instances in which the government did not cooperate with the contractor. Among other things, the record viewed as a whole shows that the government: did not disclose as AO proceeded with DO 43 that it knew the TDP contained inadequacies and required further research and development; refused to acknowledge its independent understanding that NT-60 was a possible solution to difficulties in producing Comp B loaded rounds under the TDP; did not share available, vital information even when specifically asked for assistance; foisted upon AO on a piecemeal basis the cost and responsibility for the same confirmation tests to verify use of the additive that the government internally had planned to assume responsibility for; and compelled American Ordnance to produce projectiles with NT-60 at the contractor's risk and expense. The government refrained from taking appropriate and readily available steps to facilitate American Ordnance's performance. Placing these events in the context of this "particular contract" and the "surrounding circumstances" of the parties' interactions, we hold that the government repeatedly breached its affirmative duty to cooperate with American Ordnance by failing "to do what is reasonably necessary to enable the contractor to perform," as well as its duty of noninterference by the government's repetitious acts that both hindered and delayed the contractor. *Coastal Government Services, Inc*., *supra*, 01-1 BCA at 154,833. We hold that the government's unreasonable actions breached the government's duties of cooperation and noninterference; appellant is entitled to recover for harm thus suffered.

E. The Firm Fixed-Price Nature of the Contract

In addition to examining the appellant's assertions of defective specifications, superior knowledge, and breach of the duty of cooperation and noninterference, we also assess the parties' relative risks and responsibilities under the contract, as this is reflected in the government's position that, by accepting firm fixed-price DO 43, AO willingly assumed the impacts now complained of. The government generally is correct that this type of contract usually allocates the risk of increased costs and time to the contractor, as "Absent unusual circumstances 'a fixed priced contractor...shoulders the responsibility for unexpected losses, as well as for his failure to appreciate the problems of the undertaking.'" *Gulf and Western Industries, Inc*., ASBCA No. 21090, 87-2 BCA

¶ 19,881 at 100,570, *citing Sperry Rand Corp. v. United States*, 201 Ct. Cl. 169, 181, 475 F.2d 1168, 1175 (1973) and *Utility Contractors, Inc. v. United States*, 8 Cl. Ct. 42, 48, *aff'd*, 790 F.2d 90 (Fed. Cir. 1986), *cert. denied*, 479 U.S. 827 (1986). The circumstances alleged by American Ordnance are of this unusual nature, and include defective specifications, wrongly-withheld superior knowledge and breach of the duty of cooperation and noninterference that would fix liability upon the government and not the contractor for the difficulties encountered, despite the firm fixed-price nature of the contract.

We do not agree that American Ordnance, by entering into either firm fixed-price DO 43 or Modification No. 2 thereto, assumed the risk of successfully performing or reforming the defective TDP. Certainly the contractor was responsible for carrying out a carefully controlled manufacturing process, and the record establishes that it fulfilled this duty in trying to make the specification work. It is not the fault of appellant that, until NT-60 was added, it could not pass the FAT. We have held that the TDP was defective, and that the costs and delays associated with making changes necessary to produce the Comp B rounds are the responsibility of the government.

Nor has the government asserted any contract language obligating American Ordnance to perform the work contemplated by the Army Comp B Load Study, and we are not convinced by other sources relied upon by the government to prove that AO agreed (or tacitly agreed by failing to object) to a significant research and development effort. American Ordnance's agreement to shoulder the cost of moving Comp B production from Iowa to Milan did not commit the contractor to take on the cost or duty of rectifying the contract's defective specifications, or to conduct a load study of the same undisclosed magnitude as envisioned by the government.

We hold that American Ordnance did not assume the risk of these defective specifications under the firm fixed-price contract. The government, not the contractor, is responsible for additional costs and delays resulting from AO's inability to successfully produce Comp B loaded M107 rounds without adding NT-60.

Although the government argues that American Ordnance had known of the utility of NT-60 since May 1998, well before entering into DO 43 (gov't br. at 134), this does not defeat appellant's claim. We do not fault AO for entering into a contract under the belief that the government specification would produce the intended result, even if the contractor knew NT-60 could be useful. If merely adding NT-60 was so obvious and inescapable a solution, why did the government fail to include it in the first place, and then wait so long to allow its use and only then at AO's expense? The government acts unreasonably where it conceals from the contractor the knowledge that the TDP is defective. It cannot oblige a contractor in a firm fixed-price contract to conduct research and development that was not mentioned, or impose without compensation inspection

requirements that the government knows to be more challenging than depicted. This approach has been firmly rejected:

> Here, the Government, in its eagerness, represented a procurement as ready for large-scale production when the technology had not been adequately developed. The Government wanted a fixed-price production contract when what it was really offering was, in part, a research and development project. It was misleading to hold out [the problematic ingredient] as fully suitable when the Government had reason to know success would be highly elusive. It was, at a minimum, unimaginative, and in fact unintentionally deceptive, not to inform bidders that the performance requirements were difficult to meet and were based on the peculiarities of the [testing requirement imposed].… [A] critical flaw in the design portions of the TDP was the implied warranty that, whatever reasonable manufacturing processes were used, [the problematic ingredient] would be suitable.

Transtechnology Corp., Space Ordnance Systems Div. v. United States, 22 Cl. Ct. 349, 380 (1990).

The government repeatedly placed, or at least did not timely remove, significant obstacles in American Ordnance's path, making the contractor's performance more difficult and costly. This is unacceptable, as the government in every contract bears the implied duty "not to willfully or negligently interfere with contractor's performance." *Malone v. United States*, 849 F.2d 1441, 1445 (Fed. Cir. 1988), *citing Peter Kiewit Sons' Co. v. United States,* 151 F. Supp. 726, 731, 138 Ct. Cl. 668 (1957).

Conclusion

The government failed to show that American Ordnance willingly assumed the risk of those costs associated with remedying the defective TDP for the Comp B loaded M107 projectiles, which were a specialized and sophisticated product. The government did not divest itself of responsibility for the consequences it foresaw but concealed from American Ordnance, a lesson the government should have learned from prior experience:

> The lesson to be drawn from *Helene Curtis* is that the Government cannot launch a technical data package into the procurement process if it has reason to know that the results called for are problematic, unless it discloses the knowledge available to it concerning problems and possible solutions, or unless that information is already generally known by contractors in the field.

Transtechnology Corp., 22 Cl. Ct. at 379.

F. Government Assertions of Concurrent Contractor Delay

The government argues that, even if entitlement is found for the contractor, American Ordnance is not entitled to damages for delay because it both concurrently delayed production by delaying submission of its ECP to use NT-60, and failed to reasonably calculate its delay (gov't br. at 139-46). As discussed in *Fox Construction Inc.,* ASBCA No. 55265 *et al*., 08-1 BCA ¶ 33,810, a "delay connotes a time period [that] completion of a project must be extended to account for slow-down or unanticipated events" (*id*. at 157,379). The burden of proof is upon the contractor to establish both government fault and the length of that delay:

> To recover delay damages, a contractor has the burden of demonstrating that the specific delays were due to government-responsible causes, that the overall completion was delayed as a result, and that any government-caused delays were not concurrent with delays within the contractor's control. The mere fact that a contractor took more time than it thought it should take is in itself meaningless. "The length of time is meaningful only in relation to the effect it had on the project operations." *Law v. United States*, 195 Ct. Cl. 370, 384 (1971); *Jefferson Construction Co. v. United States*, 368 F.2d 247, 256 (Ct. Cl. 1966) (noting it is the contractor's burden to show "where the work was delayed because of the lack of approval").

Id.

We have held that the delays and associated additional costs were due to the government's wrongful withholding of superior knowledge, defective specifications, and breach of its implied duties of cooperation and noninterference.

We have carefully analyzed and rejected the government's assertions that AO delayed the contract by uncontrolled manufacturing processes, and hold that the government's defective specifications, not AO's production efforts, prevented successful contract performance. Although American Ordnance accepted responsibility for certain production hitches before it fully understood the inadequacies of the TDP known to the government prior to DO 43, the responsibility was ultimately the government's. The government breached its warranty of specifications, thereby entitling American Ordnance "to recover all of the costs proximately flowing from the breach." *AEI Pacific, Inc*.,

ASBCA No. 53806, 08-1 BCA ¶ 33,792 at 167,282, *citing La Crosse Garment Manufacturing Co. v. United States*, 432 F.2d 1377, 1385 (Ct. Cl. 1970).

The government has also criticized the amount of time taken by American Ordnance to conduct all the tests required by the government in support of the NT-60 ECP. We reject this contention as proof of concurrent contractor delay, because the very need for this ECP was the government's failure to issue an acceptable TDP that could produce the Comp B loaded projectiles that were the intended result of the contract. This failure was compounded by the government's breach of implied duties of cooperation and noninterference, and its repeated refusal to timely share superior knowledge regarding problems it anticipated and accurately foretold. We affirm the substance of the Board's holding elsewhere that the government bears responsibility for the consequences of issuing defective specifications:

> Unlike some situations in which the government has a reasonable time to make changes before it becomes liable for delay, "all delay due to defective or erroneous Government specifications are [sic] *per se* unreasonable and hence compensable." *Essex,* 224 F.3d at 1289 *quoting Chaney & James Construction Co. v. United States*, 190 Ct. Cl. 699, 421 F.2d 728, 732 (Ct. Cl. 1970).

AEI Pacific, 08-1 BCA ¶ 33,792 at 167,282.

Finally, we reject the government's allegation that American Ordnance should have used a more sophisticated approach to calculating the number of days of delay alleged. While appellant could have measured the impact in a different way, we found its showing of 199 days of delay to be reasonable and to account for any concurrent delays (finding 120).

CONCLUSION

We sustain appellant's claim that the government was responsible for increased costs and delays resulting from the government's defective specifications, the superior knowledge regarding the production of Comp B loaded M107 projectiles that it unreasonably withheld from American Ordnance, and breach of the implied duties of cooperation and noninterference. American Ordnance has demonstrated entitlement to 199 days of delay. We remand the appeal to the parties for resolution of quantum.

Dated: 17 February 2010

REBA PAGE

Administrative Judge
Armed Services Board
of Contract Appeals

(Signatures continued)

I concur

MARK N. STEMPLER
Administrative Judge
Acting Chairman
Armed Services Board
of Contract Appeals

I concur

EUNICE W. THOMAS
Administrative Judge
Vice Chairman
Armed Services Board
of Contract Appeals

I certify that the foregoing is a true copy of the Opinion and Decision of the Armed Services Board of Contract Appeals in ASBCA No. 54718, Appeal of American Ordnance LLC, rendered in conformance with the Board's Charter.

Dated:

CATHERINE A. STANTON
Recorder, Armed Services
Board of Contract Appeals