A SHIPBUILDER'S FIELD TRIP

AN ALL-EXPENSE-PAID ***BLAST*** ON COMPANY TIME

~ Introduction ~

Thousands of Newport News shipbuilders have participated in or witnessed some form of testing during the course of their work. Some of this testing was relatively mundane and included examinations such as Non-Destructive Testing, hydrostatic tests and system continuity checks. Others were much more dynamic and included dock trials, catapult dead load testing and the ultimate experience for any shipbuilder: sea trials.

In addition, a few shipbuilders were once engaged in another kind of testing. At a remote, water-filled rock quarry near Arvonia, Virginia, located roughly halfway between Richmond and Charlottesville, they were paid to perform and witness some pretty unusual and dramatic testing.

In the early 1970s, I made a trip to that shock test facility to observe a test involving a large, vital piece of machinery that had been designed for use in the NIMITZ. As a former nuclear propulsion plant test engineer in the 1960s, I had a fair amount of testing experience, but nothing like this! Best of all, there was no admission price. In fact, I got my expenses reimbursed, and enjoyed an expensive free meal courtesy of equipment vendors who were present at the test site when I was there. Such a deal!

~ Background ~

One of the many lessons learned during World War II was that near misses could be as damaging to naval vessels as direct hits, and in some cases even worse. Bombs, shells, mines or torpedoes exploding in close proximity to a ship often induced underwater, severe shock waves that caused machinery, piping, electrical/electronic gear to malfunction or to even be torn free of their respective foundations. In addition, under such conditions anything unrestrained could-and did-fly around, killing or injuring any hapless sailor in the wrong place at the wrong time.

Utilizing battle damage reports and survivors' interviews, the Navy embarked on a program to make their future ship designs less susceptible to such damage. The end result was a design and test regimen cast in military specification language – which was almost always referred to simply as MIL-S-901. One interesting element of this program was the conduct of a series of tests in the 1950s that involved controlled explosions in close proximity to surplus warships.

One of the early tests involved a small minesweeper. Later tests were 'scaled up' and one test, conducted in Hawaii, involved setting off 500 tons of TNT fairly close to a surplus light cruiser. The ship's hull resisted serious damage, but extensive damage was suffered by the vessel's superstructure and vital equipment located internally.

To help educate us about the damage that underwater explosions could cause, members of the NIMITZ design team were shown a navy film made during the shock test experiment involving the minesweeper. The entire sequence of events filmed took place in the vessel's machinery space. A high-speed camera, positioned on a flexible mount, captured grainy scenes of what happened when an underwater explosion was deliberately set off just feet from the vessel's hull.

The resultant shock wave completely wrecked the space. The main engines broke free of their foundations, which distorted and cracked, in places. A large electrical generator came completely free and rolled on its side. Piping systems ruptured and, according to an accompanying report, almost all the electrical breakers opened. Many smaller items also flew around the space, and clouds of dust and dirt rose from their hiding places.

The items that stayed in place swayed alarmingly from the effects of the shock. What appeared to be sturdy equipment attachments were badly distorted in milliseconds. Some returned to their original configuration; most did not.

To say that we were both impressed and amazed would be a gross understatement.

~ Making NIMITZ Shock-Resistant ~

The specifications for the NIMITZ propulsion plant (and other parts of the ship, I presume) required that everything installed be shock qualified, using one of the methods spelled out in MIL-S-901C. Revision C of that specification was in effect at that time. The current specification, Revision D, is 83 pages long, and reflects extensive experience gained during years of Revision C usage.

A number of large machinery components were designed especially for use in the NIMITZ-class propulsion plant. Older, navy-standard equipment designs that were to be installed had to first be modified in order to meet the acceptance criteria of MIL-S-901. To ensure that all these designs could continue to function following a near-miss, a series of rigorous shock tests were specified. The severity of the four separate tests required for heavyweight shock testing can be appreciated by reviewing the details of the following table, extracted from MIL-S-901.

TABLE II. Test schedule for heavyweight shock testing.

Test conditions	Standard floating shock platform	Large floating shock platform
Depth of explosive charge below water surface (for all shots)	24 feet	20 feet
Explosive charge weight/ composition	60 lbs/HBX-1	300 lbs/HBX-1
Shot direction[1]:		
Shot 1	Fore-and-aft	Fore-and-aft
Shots 2, 3, and 4	Athwartship	Athwartship
Standoff[2]:		
Shot 1	40 feet	110 feet
Shot 2	30 feet	80 feet
Shot 3	25 feet	65 feet
Shot 4	20 feet	50 feet

[1] For the fore-and-aft direction shot, the explosive charge shall be located relative to the floating shock platform so as to represent an underwater explosion occurring off the bow or stern of the ship in which the equipment is to be installed (see 6.2). Athwartship shots shall be oriented to represent explosions abeam of the ship.

[2] Refers to the horizontal distance between the explosive charge centerline and the near side of the floating shock platform.

For its own needs, and to assist equipment vendors for NIMITZ and other naval vessels under design in the 1960s, Newport News Shipbuilding created a shock test facility in central Virginia that could accommodate the so-called ‘standard floating shock platform’.

~ NNS' Arvonia Shock Test Facility ~

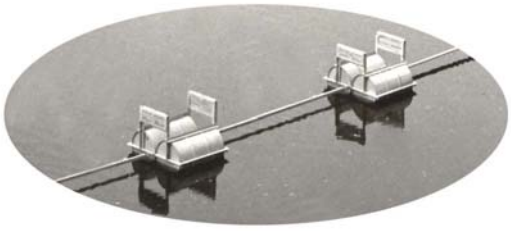
The site was acquired and equipped by the shipyard in order to test its own equipment designs and to provide heavyweight shock testing 'services' to equipment vendors. Each vendor had to pay a substantial fee to the shipyard in order for his equipment to be tested. Each vendor also had to arrange to transport items to and from the test site, not an easy thing to do whenever a large component had to travel hundreds of miles from a manufacturing facility to Arvonia. The last few miles of access road were narrow, steep in places and largely unpaved on the final stretch.

It was an activity far removed from normal shipbuilding.

The test basin was a water-filled rock quarry. Shipyard-built barges were transported there that had been fitted with metal frame/heavy canvas superstructures to prevent equipment components from flying off and being lost in the deep depths of the quarry during testing. There was also a stiff-leg crane on site, utilized to lift components on and off the barges. On at least one reported occasion, this crane was also put to hasty use to lift a sinking barge and its contents out of the quarry!

A couple of metal 'pre-fab' buildings were located in a fairly level spot at the quarry's edge. One of the buildings was outfitted as a test control center and maintenance shop. It contained several large and bulky multi-channel Offner high-speed strip chart recorders and mounts for cameras. The other building sheltered an electrical transformer and a high-pressure air compressor. Explosives were secured in a small but extremely sturdy building located in a remote part of the site.

Cables, instrumentation lines and hoses connected the buildings to one of the barges, after it was positioned roughly in the center of the quarry. Supports for these service lines were provided atop a series of improvised floats, which were simply 55 gallon drums lashed together in pairs and kept positioned in line by relatively inflexible tethers.



Test procedures required electrical equipment to be energized and running, and steam-driven equipment had to be operable, using high-pressure air as a practical substitute for steam as the motive power. Accelerometers, strain gages and high-speed cameras were located inside the barge, along with illumination sources. Some of the accelerometers and strain gages were attached directly to components under test. The rest, and the cameras and lighting were positioned on either fixed or flexible mounts.

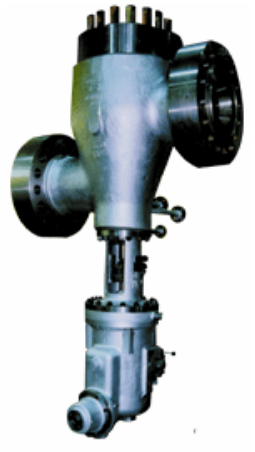
Explosive charges were placed at the prescribed distances and depths from the barge and also positioned on the side or end away from the test center. Each charge was set off remotely, following the traditional 10-9-8-7-6-5-4-3-2-1-FIRE! count-down as everybody present tensed up. In spite of that sequential warning we all jumped, anyway, when each muffled blast threw a plume of water high in the air and rattled the test center building. Small waves soon lapped the edges of the quarry as the plume of water subsided.

After each explosion, a skiff was used by the people assigned to the site to go out to the barge, inspect and report, and to also replace light bulbs, that in spite of being flexibly mounted, often didn't survive.

I assume they also positioned and connected the next explosive charge, but I had no interest in getting close to that part of the test preparations. My role there was simply as an interested observer.

The personnel stationed there told us 'sea stories' about parts of equipment coming off during testing, which is why the barges looked like covered wagons. In one case, a reciprocating air compressor's vertically mounted piston apparently was at or rapidly approaching top-dead-center in its cycle when an explosion was initiated. At least that was the best guess of the forensic engineers who studied the parts of the compressor that were recovered. The entire top of that piece of machinery, including a severed piston head, tore through the barge's canvas canopy and went to the bottom of the quarry.

Even equipment that survived such tests often exhibited startling results, when motion picture film was reviewed. One, in particular, that I saw in the offices of the vendor sticks in my memory. An important valve, several feet tall and weighing a ton or more had to be positioned in its shipboard configuration. This odd-looking piece of gear had an air operator, for remote opening and closing, mounted in the up-side-down position shown here.



An important part of the test was to determine if the air operator, actuated during the test, would keep the valve in proper position and operable throughout the series of shock tests. To make a long story short: it did.

When I viewed the film, I saw that the lower portions of the assembly deflected far beyond my expectations. It looked like a stalk of corn waving in the wind, with connected air hoses gyrating even more wildly. Even the massive upper body of the assembly appeared to momentarily become alarmingly distorted.

Some of the massive G forces generated and recorded during the valve's tests would have killed anyone onboard the barge. Such forces reflected the conservative approach that was an integral part of making sure that such equipment would survive under 'worst case' conditions.

~ My One and Only Firsthand Shock Test Experience ~

One of the pieces of NIMITZ equipment tested at Arvonia was a steam-driven, multi-stage high-pressure pump. Without getting into what may still be sensitive information, let me just say that anyone familiar with modern ships' steam cycles knows that such machinery is big, complex and has many interacting parts. The failure of any part would have resulted in an unsatisfactory test. This machine, of course, had to operational before, during and after the test.

To add drama to the event, any failure would have likely required a time-consuming redesign, retest and costly modification of the units already installed in NIMITZ. Such a sequence might have jeopardized the ship's delivery schedule. Problems previously experienced on the pump's operational test stand made this seem likely. So, understandably, the manufacturer's representatives present for the test were very nervous. So was I.

Shipyard cognizance for that vital piece of propulsion plant equipment belonged to the NIMITZ design project's Mechanical Components Section. Just a few weeks before the test, I had been named permanent Section Manager of that technical group by Don Kane, Chief Engineer of the shipyard's Nuclear New Design Department. I had been serving as Acting Section Manager because the group's previous manager was on extended sick leave. When it became apparent that he was not going to return to work…tag, I was 'it'.

While not responsible for the success of the test, I was the person sandwiched between the vendor and the Navy. A ditty I learned in STE School aptly describes my situation:

I am not allowed to run the train
The whistle I cannot blow –

I am not allowed to say how far
The railroad cars can go –

I am not allowed to shoot off steam
Or even clang the bell –

But just let it jump off the track
And then see who catches hell!

Normally, one of my group's engineers, or a supervisor would go to Arvonia for a day, to witness such testing and inspect any resultant damage. However, for this important series of tests, I decided to attend as well, accompanied by two engineers and a supervisor. In part, I made this decision because of the senior people we were told would be present representing the pump manufacturer and in part because I had never seen one of those tests firsthand. Oh, and also because my boss, Don Kane, had invited himself along, too! In retrospect, I am still a little surprised that the Navy didn't send someone as well.

We had assumed that setting the proper conditions for the tests and conducting the several explosions required would take two days, so we arranged beforehand to stay overnight as close to the site as possible. The best place we could find turned out to be a very modest roadside motel a few miles east of Charlottesville; a place no cost-conscious navy auditor could possibly question.

The manufacturer's reps had a grander place in mind, but changed their plans to stay in the same place with us, in case discussions became necessary after the first day onsite.

It was a nice spring day when we congregated at the site. A good day for an all-expense-paid field trip. The vendor's field engineer had been there for a couple of days, working with the site personnel, and together they had already satisfied the test set-up conditions. After a series of rowboat excursions by the several witnesses to the barge to inspect the test set-up, we gathered in the test center, some of us elbowing our way closer to a huge window, and some more timid souls elbowing their way to the back of the group.

~ The Test ~

After all systems were energized and verified to be operating properly, a protective cover was removed from the final switch in the explosives' firing circuit. The Offner recorders were started up, spitting out reams of paper.

Then, the first countdown commenced: 10-9-8-7-6-5-4-3-2-1-FIRE! BOOM!!

The equipment on test continued to operate normally-no problems!!!

The gages and strip charts were checked while a crew positioned another, closer charge and made sure all the test equipment under the barge's canopy was still fully functional.

This cycle was completed the requisite number of times and the pump performed beautifully, to the great relief of all present, even those who had wagered on failure. With reams of data in hand, we all went to the motel to make absolutely sure that no further testing would be required the next day.

Once everyone was satisfied, gleeful telephone calls were made to interested parties. Then, swept up in the euphoria of it all, the senior vendor rep present suggested dinner at Charlottesville's posh Boar's Head Inn (where he had wanted to stay, in the first place). He offered to buy. We accepted faster than it had taken for each blast to take place.

~ The Aftermath ~

Our celebration over dinner was extensive and expensive, and probably disrupted some of the better-dressed, regular and reserved patrons of the inn's exquisite dining room. At least that's what we were quietly told by a waiter anticipating a large tip from our large party. We didn't care.

The total bill for that evening probably 'disrupted' the bottom line for the pump company. We didn't care about that, either…except for our host, of course, who had to later explain it to his superiors. But no navy auditor ever saw that bill.

There were additional tests, of course, conducted with other equipment, some of which did not fair as well. But eventually, all tests and retests were completed in time for NIMITZ to go to sea and to be delivered without any 'shock test strings' attached.

I never attended another shock test session at Arvonia. I didn't think my sole near-perfect experience there, nor the celebration afterwards could ever be topped.

In 1979, a few years after NIMITZ had departed the shipyard, the shock test facility's workload dropped to the point where the yard's management decided to sell it off. A small low-overhead firm, HI-Test Laboratories, Inc., whose primary business was (and still is) to conduct MIL-S-901 tests, purchased the site. They have since added more testing platforms of various sizes and are still in business in Arvonia, serving the Navy, its prime contractors and numerous vendors.

The Boar's Head Inn is still a Charlottesville Mecca of fine dining, and even more expensive, I'm told. But I'd hazard a guess that successful shock tests are no longer celebrated there. Pity.

Bill Lee
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