The First Arctic Tanker

By Joe Evangelista

In one of history's biggest privately funded experiments, the tanker Manhattan won immortality as the first commercial ship to break through the Northwest Passage.

In 1969, four shipyards, an international team of maritime experts, and three major oil companies pitted their considerable technical, creative and financial resources against the monolithic might of nature. Their goal: to take a tanker through the daunting, deadly Northwest Passage.

For 500 years, the Northwest Passage had tempted merchant adventurers with its promise of a seaway connecting the Atlantic and Pacific oceans across the ice-choked top of North America. The first explorer to make it through did so in a three-year voyage in 1906. Though followed in succeeding decades by Coast Guard icebreakers and nuclear submarines, turning the Passage into a commercial route remained a dream – until oil was discovered on Alaska's North Slope in 1968.

The question of whether to export oil from Prudhoe Bay via pipeline or ship sparked a nationwide debate and inspired the project leader, Humble Oil and Refining (a subsidiary of Esso), to develop a new kind of ship: the icebreaking oil tanker. Although no one could say what, exactly, an icebreaking tanker would look like, the oil men did know where to turn to find out: the designers at Esso International in New York City, Esso's brain trust for difficult projects.

"When management asked us about icebreaking tankers, we answered that we can, presumably, build one and run an experiment," says Bill Gray, who was manager of Esso's Arctic Project. "Three of us who had worked together at Bethlehem Steel knew the perfect vessel for the job: the SS Manhattan." Built in 1962 at Bethlehem for the Niarchos organization and classed by ABS, the Manhattan possessed a unique, transitional structure that bridged an evolutionary moment in ship design. Developed during the change from empirical, experienced-based design to first-principals engineering aided by computers, the ship combined the daring size of the future with the conservative robustness of the past. For example, regulations in effect at the time of build stated that tank length between transverse bulkheads could not exceed 40 feet. As a result, the Manhattan had 45 cargo tanks in the 600-plus ft between the forepeak and engine room bulkheads.

Today a ship of similar length would have perhaps 15 tanks. For an idea of how design and production technology changed in just a few years, consider that the Manhattan was 105,000 dwt when built with a lightship weight of 30,000 tons. By January 1967, Esso was building 190,000 dwt tankers with a lightship weight of about 30,000 tons. Two years later, the company was building 250,000 dwt ships with a lightship weight of 34-38,000 tons.

Bill Gray

"The Manhattan was the only twin-screw tanker over 100,000 dwt in the world at the time. With 43,000 shaft hp it had considerably more horsepower per ton displacement than any other major merchant ship," says Gray. "Her short tank length gave a substantially more rigid structure than found in more modern designs, and her scantlings were so heavy – much more than one finds in tankers of similar size today – that the bottom plating, deck, and upper hull structures were of normalized, or heat-treated, steel, which by nature has very favourable low-temperature characteristics."

The Conversion

In December 1968, a team from Wärtsilä approached Esso and offered to share everything they knew about icebreaking. It was an unusual offer since Wärtsilä was the world leader in icebreaking technology and had built 60 percent of the of the world icebreaking fleet. "When we asked why, they answered, 'Icebreaking is one of our main business lines. You don't know anything about it, and it'll give icebreaking a bad name if you mess it up," Gray recalls. "They joined the project and were with us all the way." The experiment lasted 20 months from start to finish. Wärtsilä advised the project every step of the way, from vessel conversion to testing and finally to the modelling and design of future ships for Northwest Passage service. The Manhattan took everyone into the unknown, shipyard, scientist and expert alike. When the project got the green light, very little was actually known about the extent of the work needed to ready the ship for arctic service.

Only one yard, Sun Shipbuilding in Chester, Pennsylvania was willing to take on the task, which had been tendered only as "extensive modification" requiring "strengthening the hull and installing an icebreaking bow and propellers and rudder protection." In fact, over 9,000 tons of steel would be added to the ship. The Manhattan arrived at Sun Ship in January 1969, leaving in August as the most heavily armoured merchant ship in history. At its height, the project occupied over 90 percent of Sun's 5,500-man workforce and 100 percent of its production capacity. At one point, in fact, Esso paid Sun to suspend work on two new buildings while it finished the Manhattan. Still, the job was so big that no single shipyard could finish it within the required time frame and, at Sun's suggestion, the project was divided among four.

The 493-ft aft section stayed at Sun for modification. Newport News took the 122-ft forward section and Number One cargo tank. The 264-ft midbody went to Alabama Dry Dock at Mobile. The new icebreaking bow was to be built in two sections, the 56-ft after section at Sun and the 69-ft forward section at Bath Iron Works in Maine. In each yard, work was done under the watchful eyes of ABS surveyors.

Transverse bulkheads were strengthened by the addition of doublers, installed in way of the welded connections of horizontal girders, while heavy I-beams were placed at every web frame across the width of the ship. In the forward section, handled by Newport News, additional strengthening was provided by transversely-framed plated sponsons of high-strength steel placed over the existing side shell. A nine-ft-wide, sloping steel belt, like a great, triangular blister, was added to the ship's sides to increase strength and deflect the deadly pressure ice typical to the region. At the meeting point where two floes crash together, pressure ice forms rubble that has been known to climb up a ship's side, tumble onto the deck, and force the ship under. The ice belt did in fact help save the vessel on the second voyage, when the sloping sides caused the ice boulders to tumble back and away onto the floe.

Other modifications included: adding a helideck; renewing the shafting with higher strength materials; attaching a shearing coupling in the shafting to protect the low-pressure turbine rotor against the shock of ice loads; installing underwater rudder guards and higher-strength propellers; building a double hull for the machinery and steering gear rooms; reinforcing all machinery for stability; and installing a special 'liquid-phase' heating system that circulated heated oil to warm the deck machinery. Experience proved every modification to have been necessary.

The most distinctive aspect of the Manhattan was

the new bow. A design never before seen, it still influences icebreaker design. Previously, all icebreaker bows had a straight slope of about 30 to 40 degrees off the horizontal. The new bow, designed by Commander Rod White of the US Coast Guard, was completely different. Its fore part was sloped at 18 degrees, curving gently down to the bottom, where it was plumb. "I think Rod's design was one reason the ship's performance was so good," says Gray. Another lasting innovation of the Manhattan was the forward shoulder, the place where the bow section met the parallel body of the ship. It was made several meters wider than the hull, to cut a wide swath through the ice and reduce friction on the vessel. (When adopted for later-generation icebreakers, the feature was called a reamer.) This wraparound reinforcement to the bow, though only 123 feet in length, took nearly 3,000 tons of steel.

Despite 9,200 tons of added steel, an increase in length from 940 to 1,005 ft, added deadweight of 10,000 tons, a widening of 23 feet, and the angular belt on it sides changing the midbody cross-section, the Manhattan lost only about a quarter-knot in service speed. "Either hydrodynamics is not as important as we like to think, or perhaps it takes a lot to mess up a really good design," quips Gray.

The price of the experiment underscores Esso's commitment to the concept. The shipyard bill was $28 million, at a time when a standard 250,000-dwt tanker built in Europe cost about $20 million. A further $28 million went to the rest of the experiment costs, including about $10 million paid to the owners so that the ship didn't have to be unconverted.

Arco and BP kicked in a token $2 million each, meaning the stunning price that Esso paid to buy the future was $54 million (equivalent to nearly $300 million today). Until the premature end of her days in 1987, Manhattan sported her distinctive icebreaking bow – like a monument to what can be achieved when one has the will.

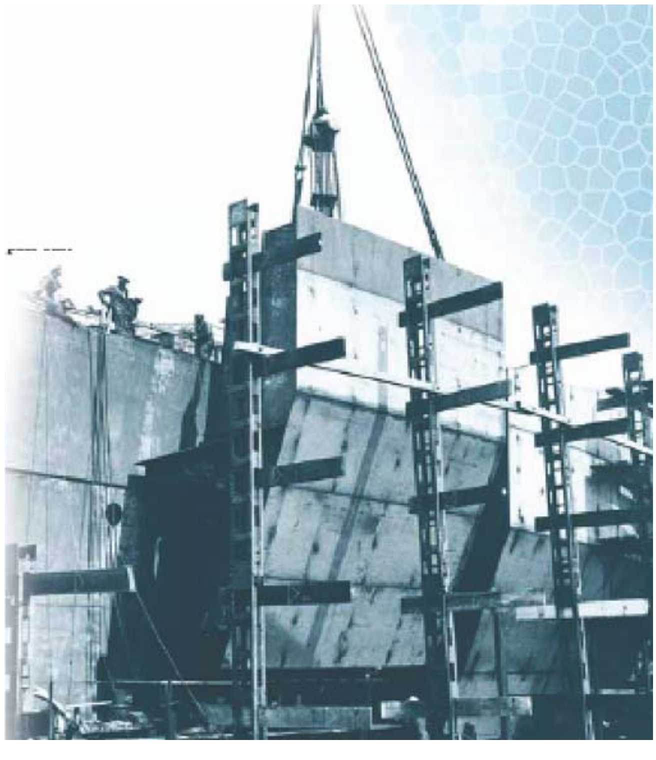
The Trip

Manhattan's first trip gave her a place in exploration history. As much publicity event as discovery mission, the late summer voyage took 126 people – 45 crew, the rest mostly scientists, journalists and politicians – on a thrilling 4,400-mile journey into one of the last frontiers. The adventure was closely followed on the front pages of every major newspaper, riveting readers with images of ambitious man against inscrutable nature.

It even made for a best-selling book, as a gasping world learned the particulars of Arctic ice. First-year ice contains salt, is white in colour and somewhat flexible. If it survives summer, it re-freezes in winter, losing salt and becoming more like freshwater ice, thicker and stronger and with a greenish tinge. Multiyear has a bluish hue and a vicious hardness. Polar pack ice can exceed 3 meters thick and roams about in vast floating plains miles across. Crashing into each other, the floes form huge rubble hills and undersea ridges that can reach 30 meters deep. To pass through such ice, an icebreaker rams,
rides up, and breaks through as the ship presses down. Especially ornery ice can stop a ship entirely, giving it two choices: heel and rock until working free, then back up, build up speed and try again; or, like its wooden-hulled ancestors, wait until the wind changes and opens a space in the pack.

"We couldn't have made the passage without the help of our icebreaker escorts, the US Coast Guard's "Wind" class vessels and particularly the Canadian John A. MacDonald," says Gray. "At times, when the ship was stuck in pressure ice, the only way to get out was to have them cut a path around her."

A National Geographic reporter described what one might call Manhattan's first big break" We bore down on a massive sheet of ice sixty feet thick and a mile across. The captain called for ten knots. The armoured bow struck, and a plume of salt spray shot sixty feet into the air. Chunks of ice as big as bulls' heads soared in wide arcs like mortar shells. There was a deafening explosion as the great floe shattered; blocks the size of bungalows turned over and scraped along the ship with agonizing shrieks. Incredibly, the Manhattan trembled less than a city sidewalk when a loaded truck passes."



Martii Saarakangas, the brilliant Wärtsilä design engineer who would later run the Helsinki shipyard and name it Masa Yards for himself, turned at that moment to his companions and said, "This ship just broke thicker ice than any ship in history. But before you start planning parties in Alaska, remember that an isolated floe – even a huge one like this – is child's play compared to pack ice under heavy wind pressure." Manhattan would find out soon enough.

Though half the first voyage was through open water, and most of the other half was spent breaking what Bill Gray calls "rotten summer ice," there were enough moments of real difficulty for the ship to gather useful data, and put a secretly desired scare into the guests. Attempting to be the first vessel to pass east to west through the M'Clure Strait, the ship got wedged so tightly into pack ice so tough that, according to one observer, steam had to be diverted from the cabin heating system to squeeze 7,000 additional horsepower out of the turbines to extricate the ship – after which, the vessel took the more common southerly route past the caribou and mountains into Prudhoe Bay. Manhattan carried no cargo on this voyage; her tanks were filled with water to simulate loading. In Alaska, the ship picked up a symbolic barrel of oil, returning to New York a merchant hero.

At Gray's urging, Esso sent the ship on a second voyage the following April, to test itself against the truly nasty Arctic winter ice.

There, it encountered the severe ice that Saarakangas talked of. In fact, the multi-year pack was ice so tough the ship couldn't even enter the Northwest Passage. Instead, it went to Pond Inlet near the top of Baffin Island, where the investigators conducted their icebreaking tests and, says Gray, gathered their best data. The ship was heavily instrumented, with strain gauges throughout the hull and the most modern electronics available housed in a 50-ft container on deck. Afterwards, a model of the Manhattan was built and tested in Wärtsilä's new Ice Model Basin. Built specifically to support the Manhattan Experiment, the basin opened the door for ice technology know how exchange between Soviet and Finnish scientists – a lesser-known part of the Manhattan's legacy. Voyage data were compared with model tests and calculations to calibrate the basin and its test results, with the information serving as the basis for Wärtsilä and Esso to design the ice-class tankers of the future. The reason their Arctic tankers were never built was not experimental failure, but that the project's sponsors always saw the Manhattan Experiment as a backup plan only, to be activated should the Trans-Alaska Pipeline not be approved. "As things worked out, the pipeline has proven to be a better solution economically, but not by much," says Gray. "Tankers would require such high power that they would have burned two to three percent of their cargo as fuel on the voyage; the pipeline consumes virtually none of its cargo, which becomes a big difference as the price of oil rises."

The Manhattan Experiment was a once-in-a-lifetime experience for all concerned. For Bill Gray, the data gathered were as thrilling as the voyage. "The best thing about the experiment was that we showed conclusively that it would be technically and economically feasible to do year-round marine transportation in tankers through the Northwest Passage," he says.

Most disappointing, however, was the public's understanding of it all. "Commentators at the time, and even today, consider the experiment a failure," says Gray. "But it wasn't a failure at all. The Manhattan was not intended to transport oil from the North Slope, nor to serve as a prototype tanker for that service. The whole experiment was one great, big model test. We needed to study the behaviour of a ship that was perhaps 15 times bigger than any icebreaker ever built. And, as a big model test, it was a success. She "did exactly what she was supposed to do."

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