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TEST OF RATED 15 TON PONTOON

24 OCTOBER 1947

24 October 1947

U.S. NAVY EXPERIMENTAL DIVING UNIT
NAVAL GUN FACTORY
WASHINGTON, D.C.

PROJECT NO.	-	SRD 789-47
REPORT NO.	-	One
TITLE	-	Test of Rated 15 Ton Pontoon

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COMMANDER USN
OFFICER IN CHARGE

OBJECT OF TEST

The object of this experiment is to test a rated 15 ton nylon rubber lifting pontoon with regard to its strength, durability, ease of handling, hook up time, maximum load and its characteristics under various loads and conditions. The tests are to be conducted in the Naval Ordnance Tank and in the open sea under various conditions with respect to depth of water, seas, etc., so that they approach actual operations as close as possible.

METHOD

The pontoon tested was a 15 ton rated, pontoon manufactured by the Goodyear Tire and Rubber Co., Akron, Ohio, blueprint number 6019-289. It is made of nylon rubber salvage bag fabric. It is 15 ft. 1 in. from the top to the sling links which are held together with a shackle. It has 12 shrouds, each 3 ft. long, Three shrouds are picked up by each sling link. The air inlet is 3/4 in. located on top and in the center of the pontoon. The bottom of the pontoon is open. Two "Dee" rings are located on top to facilitate handling.

All tests were performed in the Naval Ordnance Laboratory tank located in the Navy Yard, Washington, D.C. The tank is 25 ft. in diameter and it is 60 ft. deep. The bottom is covered with a 5 ft. layer of coarse gravel. The water was fresh and fairly clean.

The weights used were scraps of steel billets. Thirty eight billets were used ranging from 800 to 3000 lbs. The aggregate weight was 46,269 lbs. A one inch pad eye was welded to each of these. No weights over 3,300 lbs. could be used since this was the capacity of the hoist at the tank. Five clusters of weights were made, each with seven billets. Six billets were secured to one central billet which was fitted with a large pad eye. A weight was secured on one end of the pendant. It was then passed through the large pad eye and then secured to the other billet. Hence each strap passing through the large central billet eye had two weights, one on each end.

All the connecting and grouping of the clusters was done o[illegible] bottom of the tank with deep sea diving suits used. The u[illegible] the latter was necessary because of the need of telephone c[illegible]munication between the diver and topside in the operation o[illegible] hoist.

Wire straps 35 ft. long, 1 1/8 in. were used in most of the lifts. They were used single or double. The air connection was a 1/2 in. inside diameter, diving hose, fitting to a 3/[illegible] in. connection on top of the pontoon. A depth gauge was inserted on the discharge side of the blow valve so that the difference in water level between the water line and the water line inside [illegible] the pontoon could be obtained at any time by closing the bl[illegible] valve. A valve open ot the atmosphere was also inserted on [illegible] discharge side of the blow valve so that the pontoon could vented when desired. One hundred feet of hose was used with an air pressure of 90 lbs/in^2. The blow valve was 3/4 in. of the globe type. The same was true of the vent valve.

For test 9, 10, and 11, a canvas skirt was attached to the balloon extending 2 ft. farther than the original bottom of the pontoon. The diameter of it was 30 in. This decreased the cross section area about 50%. The bottom opening in the pontoon was 42 in. in diameter.

DISCUSSION OF RESULTS

It is seen that from the above data that loads equivalent to approximately three quarters of the stalling load or more often porpoise out of the water, sometimes lose air and sink again. The sinking may or may not be accompanied by the loss of air. The greater the load the greater seems to be the bouncing out of the water effect. This was always accompanied by a great deal of splashing and wave production.

As near as could be ascertained, there was no appreciable difference in the time of ascent regardless of the load. The time ranged between 4 and 6 seconds for 15 to 20 ft. lifts. Placing a skirt on the pontoon, thus reducing the area of the opening about 50%, did not seem to alter this characteristic. This may be partially explained by the fact that the vent restriction increased the pressure in the pontoon. This would tend to expand the pontoon, thus increasing the buoyancy. The net effect is not much different than when a larger vent area is used. In test number 10, the time of ascent was about 5 seconds for 30 ft. this would indicate a rather high average and maximum velocity.

There are several forces tending to accelerate the pontoon. The first is the unbalanced force of the displaced water volume of the pontoon over the load weight. This force increases until the pontoon is blown dry. At this point it becomes constant. The second is the reaction or the jet effect of the escaping water or air acting on the cross sectional area of the vent. This also increases until a constant velocity is reached. The latter effect is dependent on the pressure differential between the pontoon and the water, and the cross section area of the bottom opening. This may partially explain the failure of the skirt to decrease the velocity of the pontoon. Although the area was halved, obviously the pressure differential would increase because of the smaller vent. Thus, the effect was that of a greater pressure differential acting on a smaller area with the net force almost the same. The above forces are opposed by the load and the resistance of pontoon and weights moving through the water. The load, of course, remains constant with the water resistance, increasing with the velocity. When the opposing forces reach equilibrium consitions, a constant velocity is obtained. It is doubtful that any of the above experiments approached this condition since the depth was never great enough. However, it is seen that equilibrium conditions can be quickly reached by lifting a load just a little less than the capacity of the pontoon.

It must be borne in mind that the water resistance of the load of billets is considerably less than a load used in actual work. This would naturally be accompanied by a reduction in velocity.

The effects of the pontoon jumping out of the water above its normal load position due to its velocity, are manifold. There is some loss of air, but this is believed to be of secondary importance in the sinking of the pontoon after surfacing. At any rate, the loss of air is not excessive as shown in test number 4. There is little difference in the time required to blow up the pontoon regardless of whether it stayed up or not. Had a significant amount of air been lost, the time required to inflate the pontoon would have changed considerably. In this test, the blow up time was a few seconds over or under one minute. It is believed the dominating effect is due to the force produced by the fall of the weights past their normal position at equilibrium, It can be safely assumed that the terminal velocity of the pontoon as it is emerging out of the water is about 6 ft. per second since the average velocity ranges from 3 to 4 ft. per second. Even with no pontoon attached, it would still take a finite distance for these weights to stop and then start down again. When the weights would reach their normal position, they would be going at a velocity of roughly 6 ft. per second. Since the average force seting on the weights past the datum line going up and down are approximately the same, it can be safely ignored. Obviously the velocity of the 5 to 6 ft. per second must be decelerated to zero. The only force capable of doing this is the excess buoyant volume of the pontoon. Water resistance is ignored at this point although it does play a part in the deceleration. If the excess buoyant volume is not great enough to decelerate the weight to zero before the air column in the pontoon is reduced to below the displacement equal to the weights due to the increased hydrostatic pressure, the pontoon will sink. Another factor tending to pop the pontoon out of the water is the diminution of the water resistance of the pontoon as it breaks the surface.

In the deceleration of the weight, the maximum force acts at the point when the pontoon is just at the surface of the water. Below this point, two factors diminish that formerly tended to act in favor of keeping the pontoon afloat. As the downward velocity decreases, the water resistance also decreases. The greater effect if the reduction of the excess buoyant column in the pontoon due to increased hydrostatic pressure. The weight must be stopped in its descent before this volume reaches zero. Otherwise the balloon will continue to sink.

In a hypothetical case of a 400 cu.ft. pontoon at 3/4 load with the pontoon 90% full at the point when the top was at the water line on its descent, it would be necessary to stop the weights before the top of the pontoon reached a point 8.5 ft. below the water level, plus the distance the water level changed in the pontoon due to the increased hydrostatic pressure.

It is doubtful that the upward ascent of the pontoon could be checked substantially by restricting the vent and/or lengthening the pontoon by means of a skirt. In the former case, the restriction must be great enough so that there would be pressure equilibrium condition after the balloon reached the surface. However, this would cause a high pressure differential and would necessitate a pontoon of stronger construction. The addition of a skirt in combination with a restriction would in addition to the above in effect increase the capacity of the pontoon. In the addition of any restriction, it is to be remembered that the vent area necessary is greater for water than for air. Hence, if the pontoon rises when half blown, a high pressure differential may be produced until such a time when the pontoon is blown clean. This pressure increase will also cause an increase in the buoyant volume.

The pontoon handled easily in water when care was taken so that no air pockets were trapped. Upon hooking up, the diver must avoid standing in a position where the exhaust air will enter the pontoon. This would cause the pontoon to blow up. After hooking up, the diver must avoid working under the pontoon for any length of time. The ascent of the pontoon with the load while the diver is down is obviously dangerous. Both deep sea and shallow water types of diving gear were used. Deep sea gear is preferred primarily because of telephone communication. It is also a help in handling heavy gear such as shackles and wire. The average time of hook up was about 10 minutes.

The general shape of the pontoon at stalling load is that of a tear drop. The maximum diameter at the top was 9 ft. 8 in. the diameter of the bottom vent was 42 in. The distance from the top of the pontoon to the bottom vent was 11 ft. 10 in. From the vent to the shackle it was 3 ft. 9 in. The weight of the pontoon in water was 120 lbs. In air it weighed 330 lbs. This would give the pontoon a specific gravity of 1.57. The maximum capacity of the pontoon was determined by the change of tank water level before and after blowing as indicated in test number 8.

There was little spinning of the pontoon upon surfacing and during ascent. In most cases, very little air was lost. This was rather difficult to observe because of the splashing and wave action produced by the surfacing. When the pontoon was floating, the portion above the water line was a perfect sphere. The fabric appeared rather taut.

One of the "Dee" rings came loose of its own accord after test number 6. The shackle after test number 9, was distorted and the pin bent. The time of venting was excessive and especially in the case of small loads. In most cases, the hose was disconnected at the pontoon to facilitate this operation. A large vent is needed when the diver is working under the pontoon to prevent it from blowing up. The 1 3/4" shackle is inadequate because there is a shock load upon emerging. It is also too small in the sense that it is not capable of taking a load that is supported by several pendants. When several other shackles are hooked into it, there is a tendency for them to jam. This may have produced the distortion in the 1 3/4" shackle.

Aside from the failure of the shackle there was no evidence of structural failure. Except for the "Dee" ring patch and the split the fabric was in good shape. It remained in water for 13 days.

The addition of the skirt did not alter the pontoon characteristic appreciably. It is difficult to judge this effect on the few number of trials, since the pontoon ripped. There does not seem to be a decrease in the average speed. In trial number 11, the 5 and 4.5 seconds required for ascent from a 30 ft. depth would indicate a high velocity.

The pontoon ripped on the last trial and sunk. The rip may have been caused by a protuberance in the vicinity of the surfacing pontoon, but there is no indication of it on the fabric. It may also have been due to the increase in pressure due to the restriction of the skirt.

These tests were of a preliminary nature since the pontoon burst. Tests remain to be made in the tank and at sea to evaluate the pontoon.

This pontoon is capable of lifting loads approximately three quarters of its stall load consistently for depths used in this experiment. Since the velocity increases with the depth at which a load is lifted until the equilibrium speed is reached, the pontoon could be used to lift greater loads from shallow water.

This pontoon could be used for auxiliary lifting up to its stall load capacity if the controlling lift is made by other means such as lifting craft, cranes, etc. Due to its rather high velocity upon surfacing when alone on loads in deeper water, it must have enough reserve buoyancy to check the fall of the weight before the pontoon sinks to its critical depth. Water resistance increases with speed and hence this effect is continually decreasing when the weights are being decelerated. This leaves the steadily decreasing excess volume the main decelerating force.

If this pontoon were used for lifting an object that had much area relative to its weight, the emerging velocity would be greatly reduced. This would result in its ability to lift a load of this sort greater than when steel billets were used.

The vent time is excessive. The structural design, except for the shackle, is satisfactory. The rip in the bag may have been caused by the protuberance or the increased pressure caused by the restriction in the area of the skirt.

The condition of the fabric after the tests except for the tear and the "Dee" ring was satisfactory. Several of the straps have also started to come loose.

The pontoon with the skirt showed no appreciable change in its characteristics. There is little change in velocity regardless of load, but the heavier the load, the more noticable is the bouncing effect. If the vent area is decreased with a resultant increase in pressure, the bag will tend to expand and produce more buoyant volume. For this reason the net upward buoyant force may not be decreased substantially.

The pontoon can be handled and hooked up easily.

The inflation time is satisfactory. There is relatively little air spilled upon surfacing.

There is little rotation with the load carried on a doubled wire.

Tests were performed under almost ideal conditions. Therefore, such important characteristics such as towing and action in a sea or well remain to be evaluated.

The pontoons of this type have advantages such as little weight, occupy little space and do not have to be towed to a job.

It would be reasonable to assume that the greater the capacity, the greater would be the velocity of the pontoon. The volume or the unbalanced force changes as the cube of the radius, whereas the area and surface presented to water resistance varies as the square of the radius.

RECOMMENDATIONS

On basis of the above tests, the following recommendations are made:

(a) Replace 3/4" valve fitting with a 1 1/2" fitting.
(b) Attach "Dee" rings and handles so they will not pull off. Locate "Dee" rings father from the center to provide a better moment when handling.
(c) Replace present shackle arrangement with one similar to that used in tests 9 through 11.
(d) Conduct tests to depths of 100 feet, and at sea to determine towing characteristics and behavior in rough seas.

DATA SHEET

TEST I - 22 September 1947
Weight (gross); Weight (net) - 8674.

Dist. top of pontoon to w.l. prior blowing	17 feet
Inflation time	20 min. with valve open 1/2 turn
Ascent time	4 - 5 sec.
Vent time	30 min.

REMARKS: One clump of weights was used. One 1 1/8" strap 35' long doubled was used for the lift. It bounced about half way out of water upon surfacing. No air was spilled. Very little rotation of the balloon. Diameter of balloon was 9'10". It had an almost perfect spherical shape relative to its above water shape. When blown clean, the top of the pontoon was 6'6" above the w.l. Time of hook-up 10 minutes. Ascent time taken without stop watch.

TEST II - 23 September 1947
Weight (gross) - 27,410: Weight (net) - 23, 847.

Dist. top of pontoon to w.l. prior blowing	17 feet
Inflation time	8 min. with valve wide open
Ascent time	4 - 5 sec.
Vent time	20 min.

REMARKS: Three clumps used with three 1 1/8" pendants. Bounced about half way out of water upon surfacing. No air spilled and no rotation, when blown clean, top of pontoon was 3'4" above w.l.

TEST III - 25 September 1947
Weight (gross) - 35,335; Weight (net) - 30,742.

Dist. top of pontoon to w.l. prior blowing	17 ft.	17 ft.	17 ft.	17 ft.	17 ft.
Inflation time	13 min.	1 min.	.3 min.	2 min.	2 min.
Ascent time	4-5 sec.	4-5 sec.	4-5 sec.	4-5 sec.	4-5 sec.
Vent time	SUNK	12 MIN.	SUNK	SUNK	SUNK

REMARKS: Four clumps used with four 1 1/8" pendants. In the one successful try, some air was spilled, but it stayed afloat after some bouncing. When blown clean, top of pontoon was 22 inches above w.l. Approximately 70 cu. ft. buoyancy in reserve.

TEST IV - 26 September 1947
Weight (gross) - 33,135; Weight (net) - 28,828.

Dist. top of pontoon to w.l. prior blowing	14 f.	14 f.	14 f.	14 f.	14 f.	14 f.	14 f.	14 f.
Inflation time	8.5 m.	1 m.	1 m.	1 m.	1 m.	1 m.	1 m.	1 m.
Ascent time	4-5s.	4-5s.	4-5s.	4-5s.	4-5s.	4-5s.	4-5s.	4-5s.
Vent time	SUNK	15m.	SUNK	SUNK	17m.	SUNK	18m.	SUNK

REMARKS: Three out of eight trails were successful. Air was lost on the others and then it sunk. When air was lost, the pontoon seemed to bounce out of the water more than when it stayed afloat. Pontoon bounced out of water from 5 - 7 feet. When blown clean, top of pontoon was 2'3" above w.l. Time required to sink is about 5 seconds. Four clumps were used with four 1 1/8" straps.

TEST V - 1 October 1947
Weight (gross) - 34,472; Weight (net) - 29,991.

Dist. top of pontoon to w.l. prior blowing	14 ft.	14 ft.	10 ft.
Inflation time	9 min.	1 min. 48 sec.	2 min. 10 sec.
Ascent time	5 sec.	8.5 sec.	4 sec.
Vent time	Sunk	Sunk	18 min.

REMARKS: Four clumps were used with four 1 1/8" straps. The successful lift was only 10 ft. It bounced out of the water less on the successful lift. At floatation the balloon was 2'4" out of the water. A fair amount of air lost on the unsuccessful lifts.

TEST VI - 1 October 1947
Weight (gross) - 10,907; Weight (net) - 9,570.

Dist top of pontoon to w.l. prior blowing	12 ft.	30 ft.
Inflation time	1 min. 45 sec.	3 min. 25 sec.
Ascent time	3 sec.	
Vent time	9 min.	5 min.

REMARKS: One clump was used. On the short lift, the balloon came up alowly. On the longer lift, the pontoon came out of the water 6 ft., but did not spill air.

Test VII - 2 October 1947
Weight (gross) - 18,832; Weight (net) - 16,184.

Dist. top of pontoon to w.l. prior blowing	32 ft.	32 ft.	32 ft.
Inflation time	6 min. 15 sec.	2 min. 25 sec.	2 min. 30 sec.
Ascent time	7 sec.	7 sec.	7 sec.
Vent time	16 min.	12 min.	12 min.
Decent time	8.5 sec.	9 sec.	9 sec.
Max. dist. out of water upon surfacing	8 ft.	8.5 ft.	8.5 ft.

REMARKS: No air spilled in any of these trials. Very little splashing. Distance from top to w.l. - 3 ft. 9 in. When blown clean, distance from top to w.l. - 5 ft.

TEST VIII - 2 October 1947
Weight (gross) - 44,767; Weight (net) - 38,947.

Dist. top of pontoon to w.l. prior blowing	15.5 ft.
Inflation time	15 min.
Deflation time	75 min.
Change in w.l. in tank	14 3/8 in.

REMARKS: $W = \# r^2 62.4 = \# 156.25 \times 1.198 \times 62.4 = 36{,}600$ lbs. disp. fresh water. W in salt water = 37,600 lbs disp. in salt water. The tank diameter is 25 ft. The lifting capacity of the pontoon was determined by placing a stalling load on it and then noting the change of the water level of the tank before and after blowing. The pontoon was left with this load over night. It was then taken out of the water. One "Dee" ring patch came off. The screw pin shackle was distorted and the pin bent. Could not be taken off. Wt. of balloon in air - 330 lbs. wt. of balloon in water 120 lbs. sp. gravity - 1.57. Dimensions of pontoon under full load. Distance from top to vent -11 ft. 10 in. Distance (vertical) from vent to center line shackle - 3 ft. 9 in. Diameter of opening - 42 in.

TEST IX - 13 October 1947
Weight (gross) - 31,342; Weight (net) - 27,268.

Dist. top of pontoon to w.l. prior blowing	15 ft. 4 in.	15 ft. 4 in.
Inflation time	10 min.	2 min. [illegible] sec.
Ascent time		5 sec.
Vent time	11 min.	9 min.
Descent time	6.5 sec.	

REMARKS: A canvas skirt was attached to the balloon which extended 2 ft. below the original bottom of the pontoon. It was cemented 6 inches inside of the balloon with neoprene cement. The diameter of the skirt at the bottom was 30 inches. This gave a cross sectional area of approximately one half of what it was formerly when the diameter was 42 inches. Since the skirt was inside of the shrouds, the area was somewhat reduced due to the indentation of the shrouds.

In this test, two sling links were picked up by a 1 1/4 in. shackle. The two shackles were in turn picked up by a 1 3/4 in. ring. After the test, the shackles unscrewed easily and there was no indication of bending or distortion.

In the above tests, the pontoon came up from 6 - 8 feet out of the water upon surfacing. Little if any air was lost.

All the ensuing tests were performed with the above skirt and shackle arrangement.

TEST X - 13 October 1947
Weight (gross) - 36,752; Weight (net) - 31,974.

Dist. top of pontoon to w.l. prior blowing	10 ft.
Inflation time	7 min.
Deflation time	19 min.

REMARKS: The pontoon rose slowly and surfaced without bouncing or loss of air. Distance from top of pontoon to w.l. after surfacing was 2 ft. 3 in..

TEST XI - 14 October 1947
Weight (gross) - 35,202; Weight (net) - 30,625.

Dist. top of pontoon to w.l. prior blowing	30 ft.	30 ft.
Inflation time	13.5 min.	3 min.
Ascent time	5 sec.	4.5 sec.
Vent time	Sunk	Sunk

REMARKS: In the first test, the pontoon sunk after bouncing out of water about 8 ft. upon surfacing. The pontoon bounced about the same distance out of the water in the secodd test and then ripped vertically. The rip was about 10 ft. long running from the head of the reinforcing patch. This may have been due to a prothuberance in the tank in the vicinity of the surfacing pontoon. However, there is no evidence on the pontoon that it was cause of tear.