NAVIGATOR PROP BUILDING INSTRUCTIONS & PHOTOS

Science under the ice

Ice sheet
At regional competitions the ice is simulated by 8 ft x 4 ft ½-inch foam sheeting (Home Depot part #703990 [in store only], model#320811). To construct the ice sheet, attach the foam sheeting to a framework of 1 ¼-inch PVC pipe. The PVC pipe framework stabilizes the ice sheet and also keeps the algae samples within the product demonstration area.

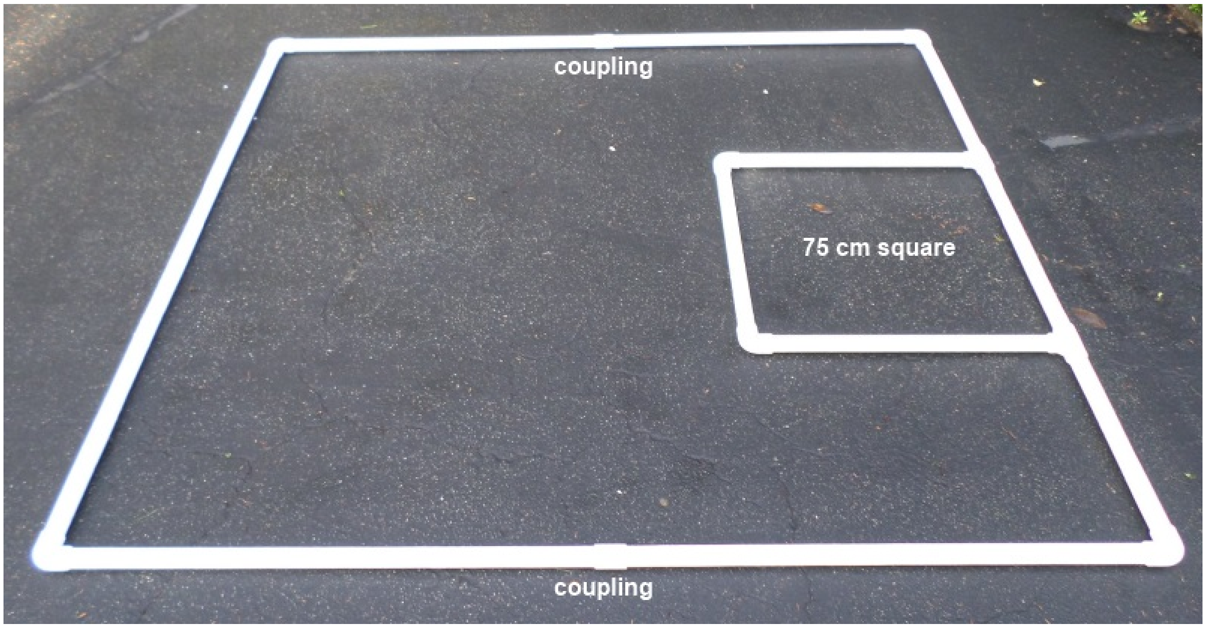
To construct the framework for the ice sheet:

1. Cut four 75 cm lengths of 1 ¼-inch PVC pipe. Attach a 1 ¼-inch 90^o elbow to both ends of one 75 cm length of pipe. Insert another 75 cm pipe into each open end of the 90^o elbows. Attach the middle opening of a 1 ¼-inch PVC tee to the other end of the pipes. Insert the final 75 cm section of pipe into the side openings of a PVC tees to make a square with inner dimensions of 75 cm x 75 cm. This square will serve as the launch area that the ROV must go through.
2. Cut two additional lengths of ¼-inch PVC pipe approximately 75 to 90 cm. Insert these pipes into the remaining side openings of the PVC tees. The overall length of these combined pipes should be approximately 2.5 meters (less than the 8 ft length of the foam sheet). Attach a 90^o elbow to the end of each length of pipe.
3. Cut two 1.25 meter sections of 1 ¼-inch PVC pipe. Insert them into the openings of the two 90^o elbows. Attach a 1 ¼-inch PVC coupling to the end of each pipe. Cut two more 1.25 meter sections of pipe and install them into the ends of the coupling. Attach a 90^o elbow to the end of each pipe.

Design note: Combining each 1.25 meter section with a coupling allows the ice sheet to be taken apart in the middle. This allows for much easier movement and transportation of the ice sheet. If this is not a factor for your company, you may cut a 2.5 meter to 2.6 meter length of PVC instead of two 1.25 meter lengths of pipe joined by a coupling.

4. Measure the overall length of the combined PVC pipe that consists of the 75 cm section and two 75 cm to 90 cm sections of pipe. Cut a length of pipe equal to the length of the three combined pipes. Complete the square / rectangle by inserting this length of pipe into the open ends of the two 90^o elbows.

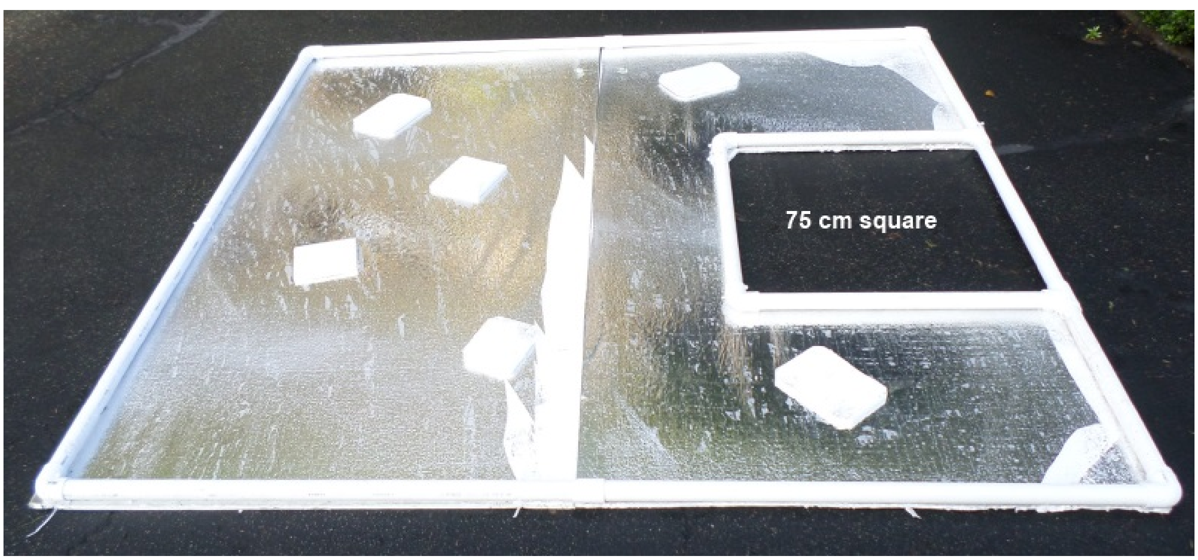
At this point you should have a square or rectangle of 1 ¼-inch PVC pipe approximately 2.6 meters by 2.6 meters. The exact dimensions of the ice sheet are not important provided that the overall dimensions are smaller than two 8 ft x 4 ft foam sheets.



NAVIGATOR prop build photo #1: 1 ¼-inch PVC framework for the ice sheet.

5. Use two 8 ft x 4 ft ½-inch thick foam sheets to completely cover the PVC framework. Use 11-inch cable ties to secure the foam sheet to the framework. Use a knife or box cutter to remove the 75 cm x 75 cm square section of foam for the vehicle to launch through. Also remove any excess foam from outside of the PVC framework.

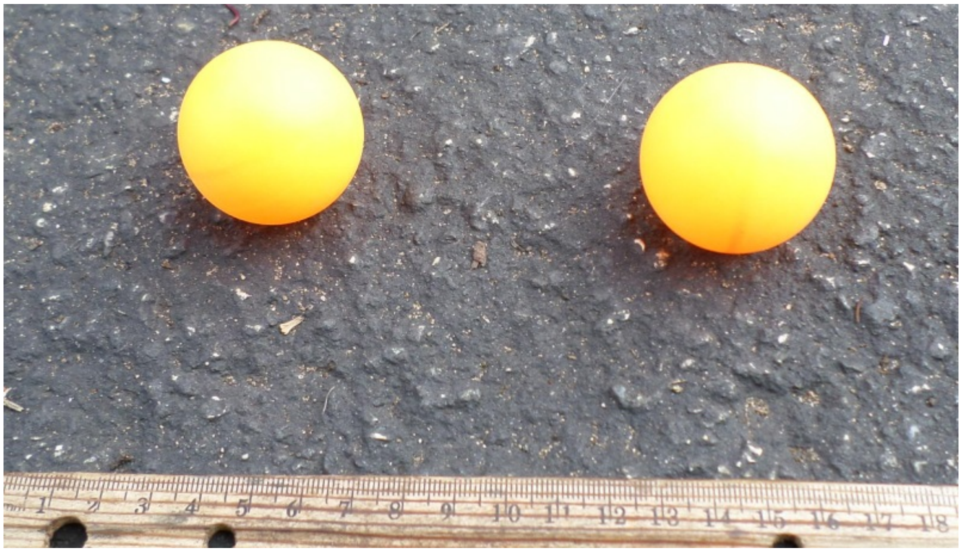
The excess foam is used to create contours on the underside of the ice sheet. Cut or break the extra foam into random shapes approximately 10 to 20 cm in size. Use glue or epoxy to secure these shapes to the bottom side of the ice sheet (the bottom side is the side with the PVC framework).



NAVIGATOR prop build photo #2: Upside down ice sheet showing framework with foam sheet attached. Note the extra foam used a bottom contours.

Algae sample

Ping pong balls will be used to simulate algae on the underside of the ice sheet. These ping pong balls will be positioned inside the 1 ¼-inch PVC framework of the ice sheet. Check local sporting goods stores or big box stores (Walmart, Target, etc.) for ping pong balls



NAVIGATOR prop build photo #3: Algae.

Sea urchin

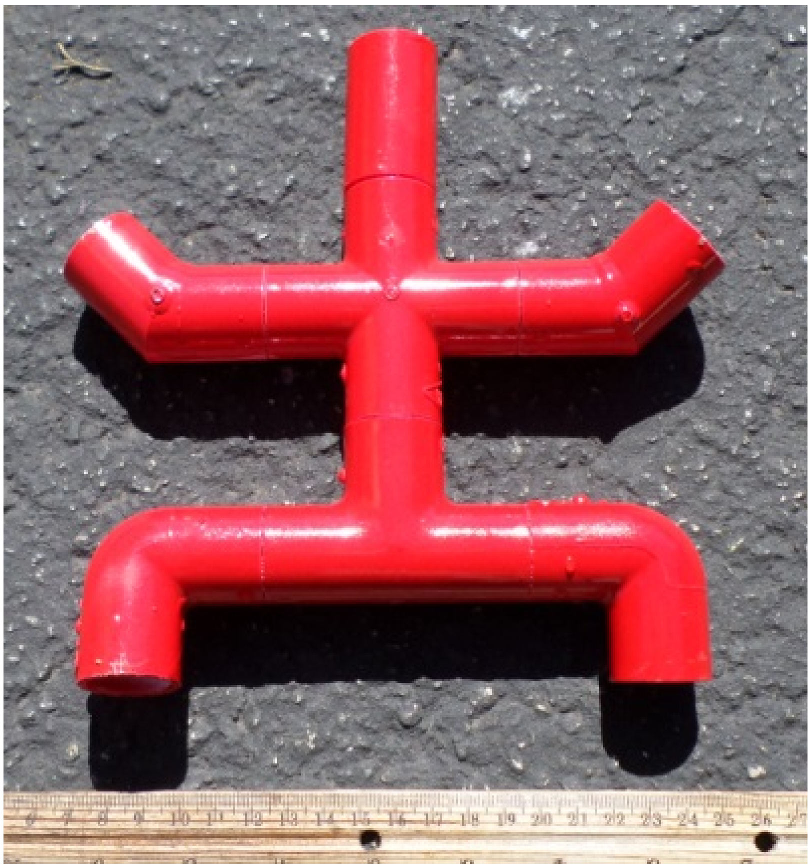
Sea urchins will be simulated by 4-inch [O-balls](). Check local toy stores for O-balls.

NAVIGATOR prop build photo #4: Sea urchin.

Sea star

Sea stars are constructed from ½-inch PVC pipe and ½-inch fittings. To construct a sea star:

1. Cut six 3 cm lengths of PVC pipe. Insert four of the 3 cm lengths of pipe into each opening of a ½-inch PVC cross.
2. Attach the middle opening of a PVC tee to one of the 3 cm lengths of pipe on the cross. Insert the remaining two 3 cm lengths of PVC pipe into the side openings of the PVC tee.
3. Attach a 90° elbow to each of the 3 cm lengths of pipe on the side openings of the PVC tee. Attach a ½-inch coupling to the 3 cm length of pipe on the cross opposite the PVC tee. Attach a 45° elbow to remaining two 3 cm lengths of pipe on the PVC cross. Align the elbows to simulate a star pattern.



NAVIGATOR prop build photo #5: A sea star.

The sea stars are painted different colors to represent different species. See the [NAVIGATOR Sea Star Identification Handbook] for color schemes of sea stars.

Certain sea star species have longer arms. Cut five 5 cm lengths of PVC pipe. Insert them into the five open ends of the PVC fittings.

Passive acoustic sensor

The base of the passive acoustic sensor is constructed out of ½-inch PVC pipe. A 3-inch length of pipe (ABS or PVC) floats above the base. To construct the passive acoustic sensor:

1. Cut a 7 cm length of ½-inch PVC pipe. Attach the side opening of a PVC tee to each end of the 7 cm length of PVC pipe.
2. Cut four 3 cm lengths of ½-inch PVC pipe. Insert two of the 3 cm lengths of pipe into the other side openings of the two PVC tees. Attach a 90^{o} elbow to the end of each 3 cm length of pipe. Insert the other two 3 cm lengths of PVC pipe into the remaining openings of the 90^{o} elbow. Attach the middle opening of a PVC tee to the other end of each 3 cm length of pipe.

This makes two of the "legs" of the passive acoustic sensor. Repeat steps 1 and 2 to make a second set of legs.

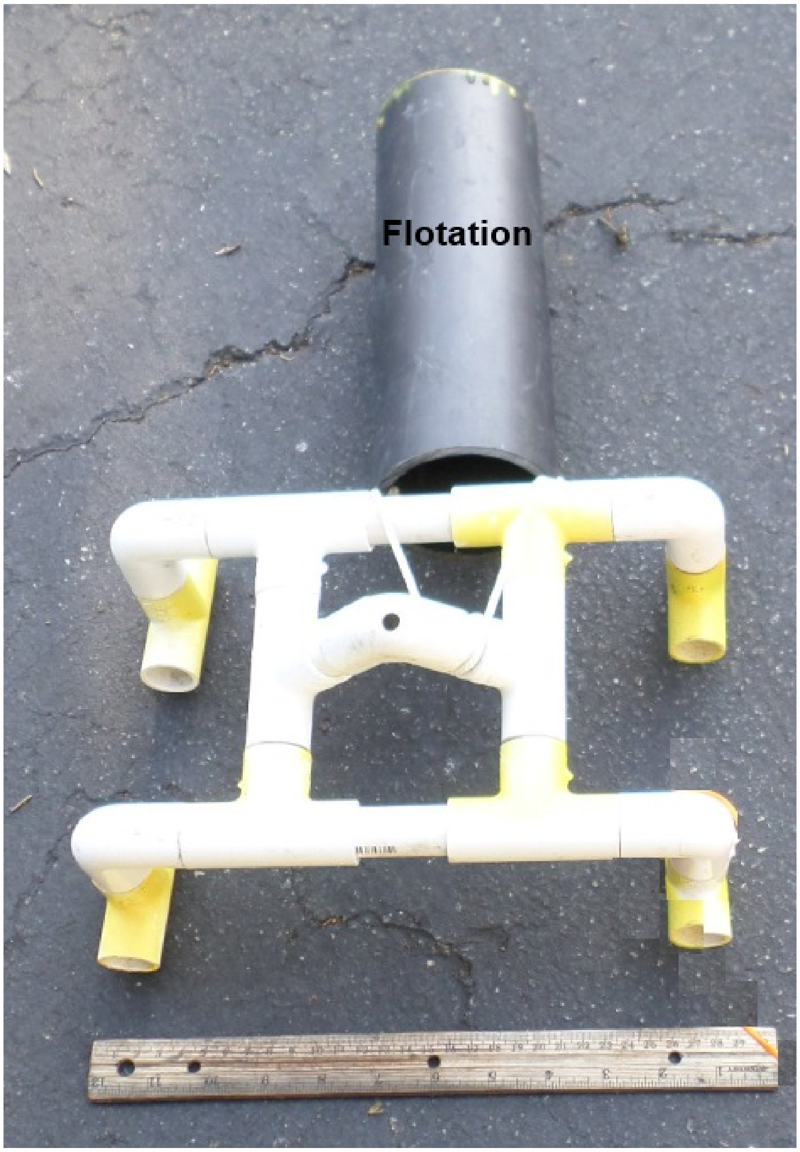
3. Cut two 4 cm lengths of ½-inch PVC pipe. Insert these two 4 cm lengths into the openings of a 90^{o} PVC elbow. Attach the middle opening of a PVC tee to the ends of the 4 cm lengths of pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert the four 3 cm lengths of pipe into the four side openings on the two PVC tees. Rotate the two PVC tees so they are parallel to each other.
5. Attach the two middle openings on the 'legs' (step 1 and 2) to the 3 cm lengths of pipe. Attach the two middle openings on the other 'legs' too the other 3 cm lengths of pipe.
6. Orient the base of the passive acoustic sensor so all four 'legs' are down and the 90^{o} elbow sticks up in the middle. Drill a hole in the middle elbow to release any air trapped in the base.

To construct the flotation:

1. Cut a 25 cm length of 3-inch ABS or PVC pipe. Drill six 3/8-inch holes into the pipe, four holes at one end, two holes at the other end. The four holes at one end should be approximately 1.5 cm from the end of the pipe. The two holes at the other end should be 1 cm from the end.
2. Insert a 3-inch knock out cap (Home Depot model #39102, internet #100122751, Store SKU #508260) into the end of the 25 cm length of 3-inch pipe with four holes. Secure the knockout cap with glue or screws. The end with the knock out cap is the top of the sensor.
3. Cut a 30 cm length of 1/8-inch nylon and polypropylene rope (Home Depot model #65225, Internet #202957449, Store SKU #140287). Loop the rope under the top most 90^{o} elbow on the base of the sensor. Insert the ends of the 30 cm rope into the two holes on the bottom of the 25 cm length of pipe. Insert the rope from the outside of the pipe to the inside.
4. Tie an overhand knot to secure the end of the rope inside the pipe.
5. Insert flotation into the top of the 25 cm length of pipe. There should be enough flotation to make the pipe positively buoyant and float above the base structure, but should not lift the base off the bottom.
6. Attach weights to the base to provide sufficient negative buoyancy.

The passive acoustic sensor should weigh less than 20 Newtons in an EGADS solution of water (SG 1.025).

The designated area to deploy the passive acoustic sensor is a 50 cm x 50 cm square constructed out of ½-inch PVC. Cut four 48 cm length of ½-inch PVC pipe and connect them with 90^o elbows. Rebar inside the ½-inch pipe can be used to weight the designated area.



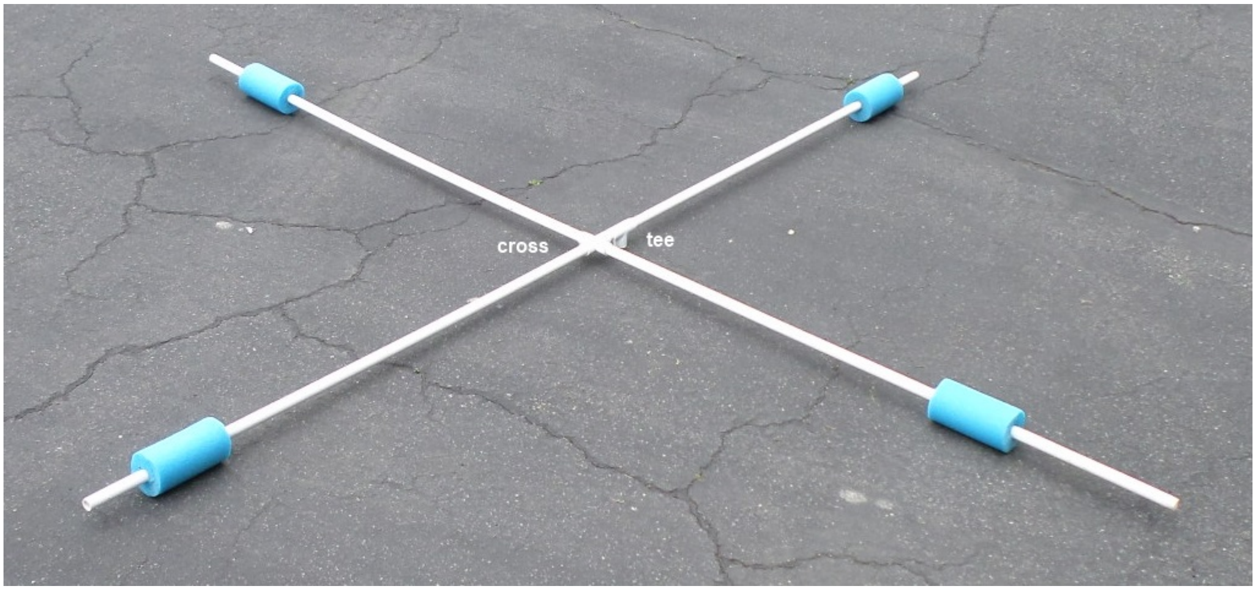
NAVIGATOR prop build photo #6: The passive acoustic sensor.

Iceberg

The iceberg is simulated with ½-inch PVC pipe with ½-inch foam sheeting or bubble wrap above the ½-inch PVC framework. To construct the framework:

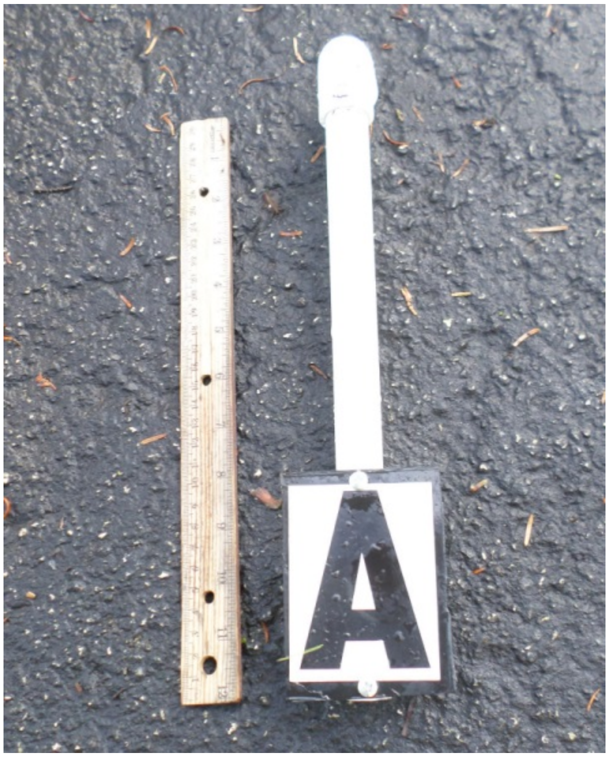
1. Cut three identical lengths of ½-inch PVC pipe, between the lengths of 0.75 cm and 1.75 cm. Cut another length of PVC pipe 7.2 cm shorter than the other three. Attach the side opening of a PVC tee to one end of the shorter length of pipe. Cut a 3 cm length of ½-inch PVC pipe and insert it into the other side opening of the PVC tee. You should now have four identical lengths of PVC pipe, one of which has a tee at one end.

2. Insert the other end of the 3 cm length of PVC pipe into one side of a ½-inch PVC cross. Insert the other three lengths of pipe into the other openings of the PVC cross. Attach a 90^o elbow to each end of the four lengths of pipe.



NAVIGATOR prop build photo #7: Top construction for the iceberg with light blue flotation

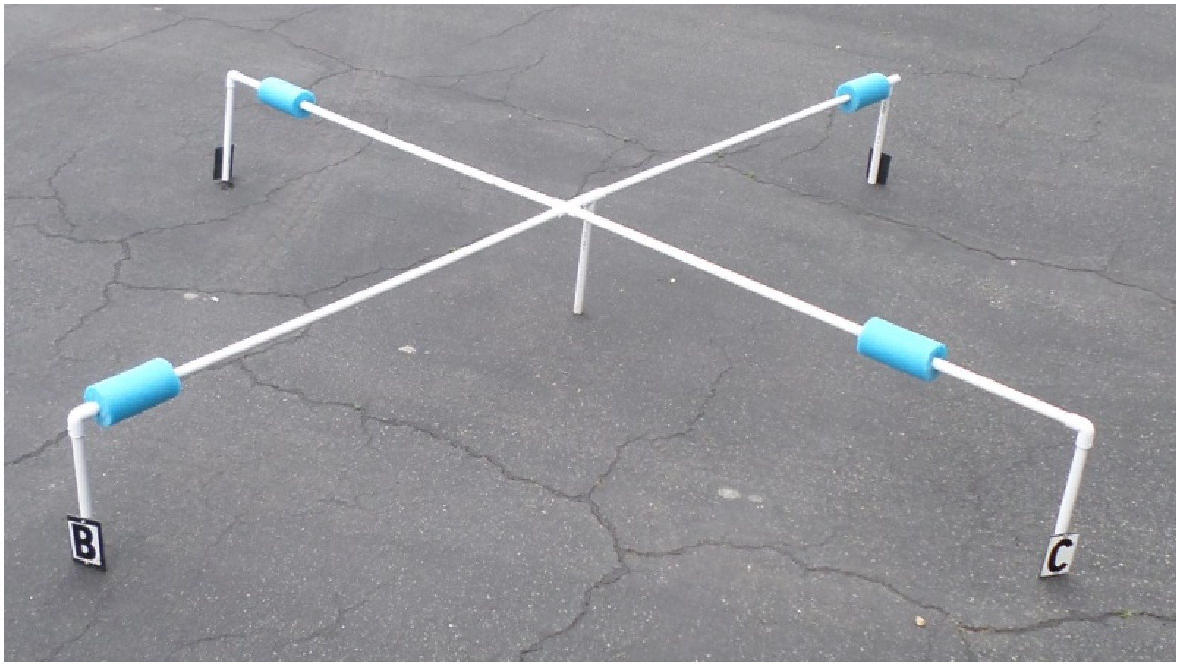
3. Cut four 30 cm lengths of PVC pipe. Insert these pipes into the four 90^o elbows at the perimeter of the iceberg.
4. Cut four 10 cm x 7 cm rectangles out of 1/8-inch black ABS sheeting. Attach 3-inch lettering (Home Depot model #847015, Internet #202982489, Store SKU#881277) to the flat, smooth side of the ABS sheet. The 3-inch letters should be A, B, C and D. Screw the ABS sheets to the bottom ends of the 30 cm lengths of pipe. Position the letters so they are right side up and facing away from the center of the iceberg.



NAVIGATOR prop build photo #8: Lettering on perimeter of iceberg.

A longer length of pipe descends from the middle of the iceberg. This length of pipe is the keel of the iceberg. Companies must measure the length of the keel to determine the keel depth of the iceberg. To construct the keel of the iceberg:

5. Cut a length of pipe for the maximum keel depth of the iceberg. The length of this pipe should be approximately 1/3 to 3/4 of the depth of the pool at the mission station. Insert this pipe into the middle opening of the PVC tee near the center of the iceberg.



NAVIGATOR prop build photo #9: Iceberg with lettering. Note that the keel length of PVC at the center of the iceberg has been shortened for photo.

Use ½-inch foam sheeting or bubble wrap to create the top of the iceberg. Cut the foam or bubble wrap to the approximate dimensions of the ½-inch framework. Attach the foam or bubble wrap with cable ties to secure it to the PVC framework of the iceberg.

Subsea pipeline inspection & repair

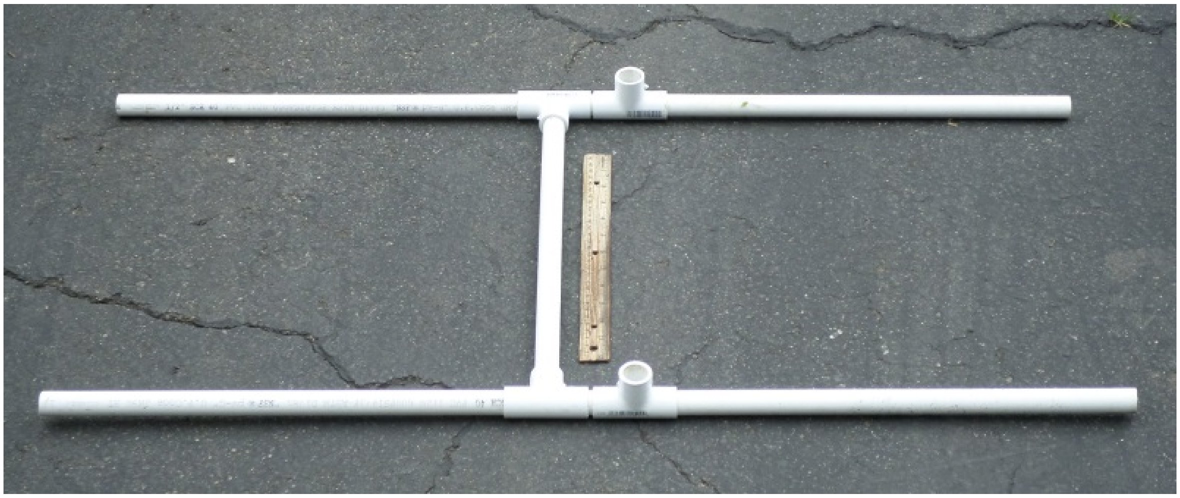
Pipeline

The pipeline is constructed out of 2 sizes of PVC pipe. 1 ½-inch inch PVC pipe painted gray is used for the pipeline that companies must simulate cutting, lifting, and installing the flange. ½-inch pipe is used for the remainder of the pipeline. Corrosion is simulated by a brown circle, less than 2 cm in diameter.

Stands

Four stands hold the 1 ½-inch pipeline off the seafloor. The two middle stands are constructed from ½-inch PVC pipe and 2-inch tees. The outer two stands are constructed from ½-inch PVC pipe, 1 ½-inch pipe and 2-inch tees. To construct the stands:

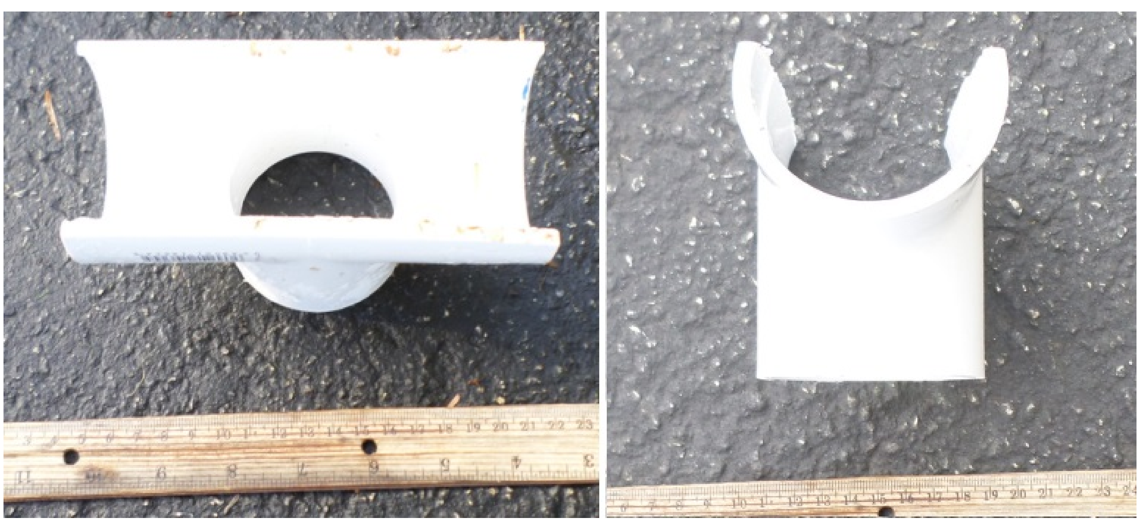
1. Cut two 3 cm length of ½-inch PVC pipe. Attach the side opening of a ½-inch PVC tee (four tees total) to each end of the two 3 cm length of PVC pipe.
2. Cut five 40 cm lengths of ½-inch PVC tee. Insert one 40 cm length of PVC pipe into the middle openings of two of the tees connected by the 3 cm length of pipe. Insert the other four lengths of 40 cm PVC pipe into the four remaining side openings of the PVC tees. Align the two remaining middle openings of the PVC tees so they point up.
3. Repeat build steps 1 and 2 until you have four stands.



NAVIGATOR prop build photo #10: Base of oil pipeline stand.

4. Cut four 30 cm lengths of ½-inch PVC pipe. Insert one 30 cm length of pipe into each of the upwards facing middle opening of a PVC tees on one of the stands. Attach a 2-inch to ½-inch reducer bushing (Home Depot model # C437-247, Internet # 100343810, store SKU # 744724) to the top of each 30 cm length of pipe on the stand.
5. Cut a 2-inch PVC in half lengthwise, bisecting through the side openings. Attach the middle opening of each cut 2-inch PVC tee to the 2-inch to ½-inch reducer bushing. Align the 2-inch cut PVC tees so they are parallel.
6. Repeat these two steps to make a second stand.

These two stands are the inner two stands of the oil pipeline.

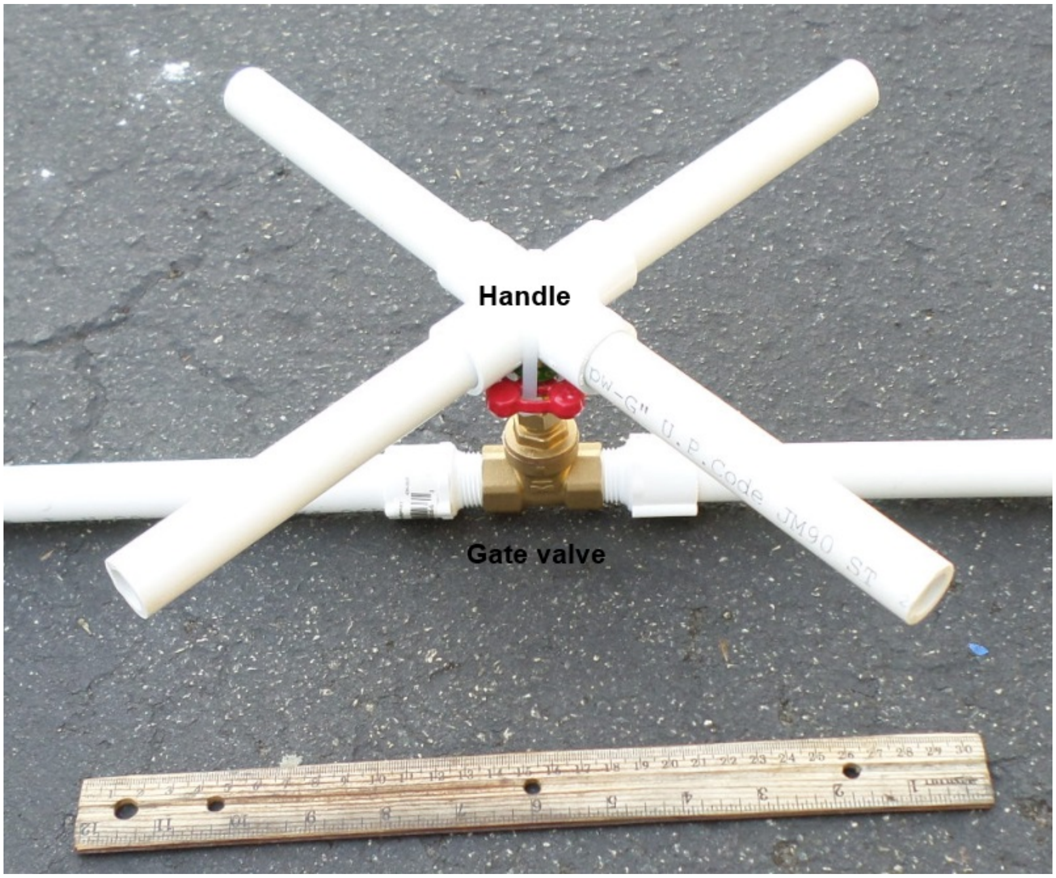


NAVIGATOR prop build photo #11: 2-inch tee cut in half lengthwise.

NAVIGATOR prop build photo #12: A completed inner stand.

The outer two stands are slightly different in their construction, but use the same base structure as the inner stands. The base structures were completed in steps #1 through #3 above. The first outer stand has the valve and handle that companies must turn to simulate shutting off the flow of oil through the pipeline. To construct the valve and handle:

1. Insert two ½-inch male adapters into both ends of a ½-inch gate valve (Home Depot model # 100-403NL, Internet # 202250434, Store SKU # 867855).
2. Drill a ½-inch hole in the center of one side of a ½-inch PVC cross. Place this cross on top of the handle of a ½-inch gate valve. The drill hole should slip over the nut at the center of the gate valve. Use two cable ties to tightly secure the cross onto the top handle of the gate valve.
3. Cut four 15 cm lengths of ½-inch PVC pipe. Insert these four lengths of pipe into the four openings of the cross.

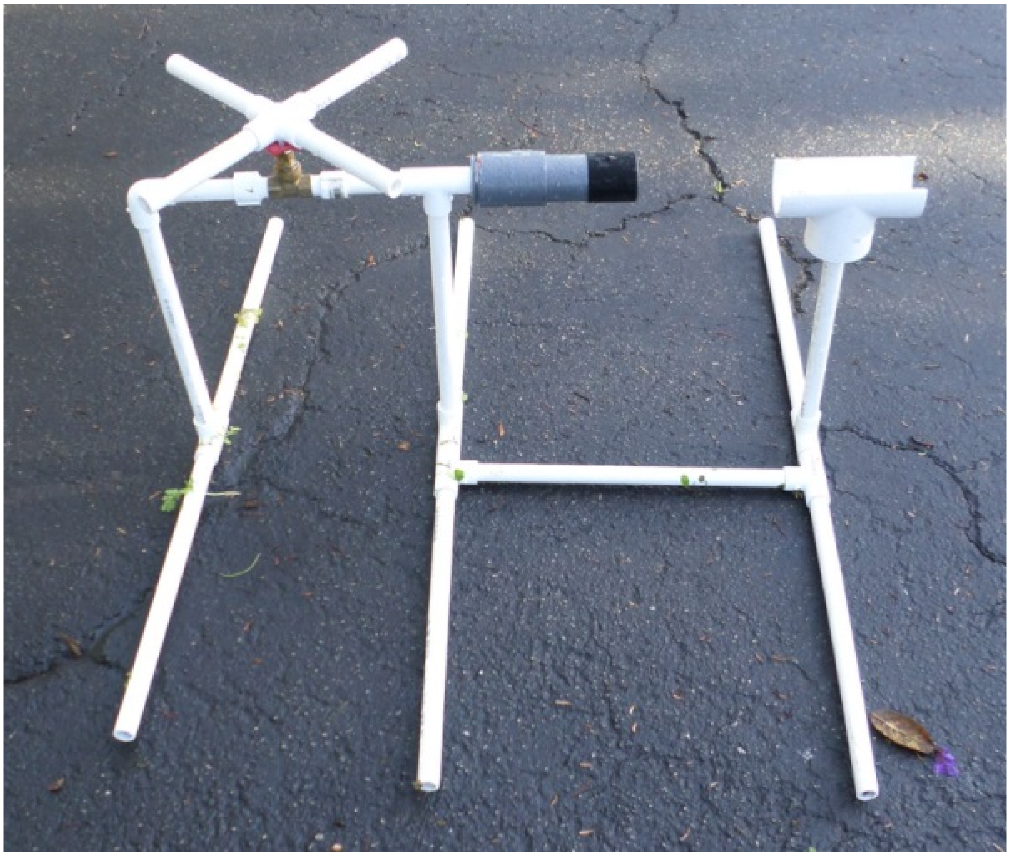


NAVIGATOR prop build photo #13: Gate valve with handle extensions.

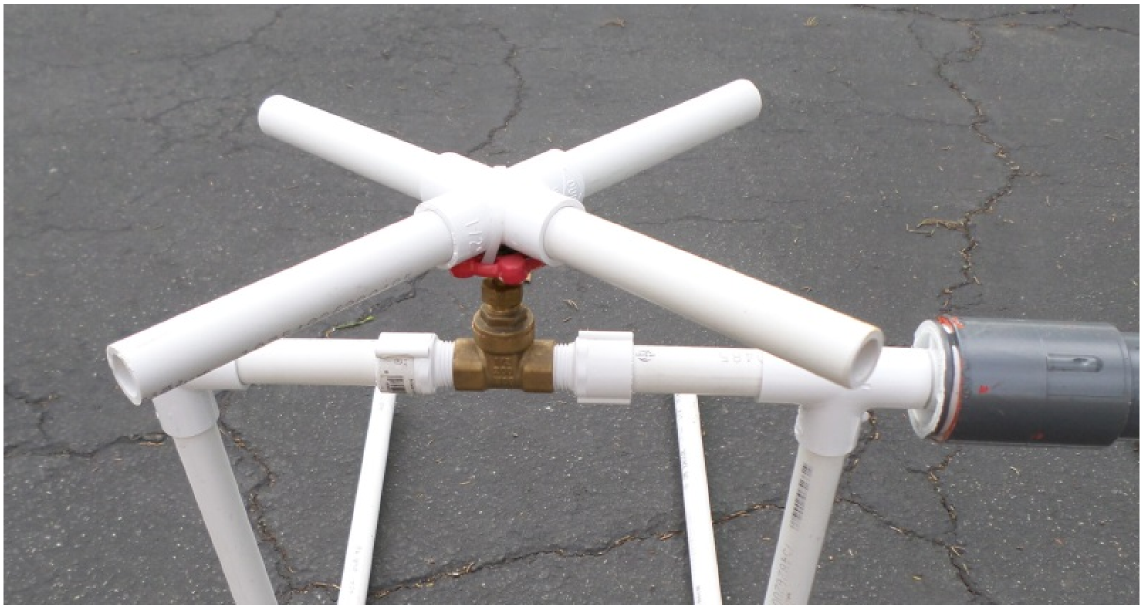
The gate valve and handle are attached to one of the out stands on the pipeline structure. Use one of the base stands constructed earlier. To complete the construction:

4. Cut a 30 cm length of ½-inch PVC pipe. Insert this 30 cm length of pipe into one of the upwards facing middle openings of a PVC tees on one of the stands. Cut a 32 cm length of pipe. Insert this 32 cm length of pipe into the other upwards facing middle opening of a PVC tee on one of the stands.
5. Attach a 2-inch to ½-inch reducer bushing (Home Depot model # C437-247, Internet # 100343810, store SKU # 744724) to the top of the 30 cm length of pipe on the stand. Cut a 2-inch PVC in half lengthwise, bisecting through the side openings. Attach the middle opening of the cut 2-inch PVC tee to the 2-inch to ½-inch reducer bushing.
6. Attach the middle opening of a ½-inch PVC tee to the top of the 32 cm length of pipe. Align the tee so the two side openings are parallel to the cut side openings of the 2-inch tee on the other side of the stand.
7. Cut a 10 cm length and a 4 cm length of ½-inch PVC pipe. Insert the 4 cm length of pipe into the side opening of the tee facing the 2-inch tee on the other side of the stand. Insert the 10 cm length of pipe into the other side opening of the PVC tee; the one furthest from the cut 2-inch tee.

8. Attach a 1 ½-inch to ½-inch PVC reducer bushing (Home Depot model # PVC021081400HD, Internet # 203851132, store SKU # 744917) to the 4 cm length of PVC pipe. Attach a 1 ½-inch PVC coupling to the reducer bushing.
9. Cut a 10 cm to 15 cm length of 1 ½-inch PVC pipe. Insert this pipe into the 1 ½-inch coupling. Paint the coupling and length of 1 ½-inch PVC pipe gray.
10. Attach one of the male adapters on either side of the ½-inch gate valve to the end of the 10 cm length of ½-inch PVC pipe. Twist the male adapter – pipe connection until the gate valve handle is straight above the pipeline.
11. Cut another 10 cm length of PVC pipe and insert it into the other male adapter on the other side of the gate valve. Attach a ½-inch 90^{o} elbow to the other end of the 10 cm length of pipe. Cut a 32 cm length of pipe. Insert the 32 cm length of pipe into the other opening of the 90^{o} elbow. Align the elbow so the 32 cm length of pipe drops to the seafloor.
12. Cut two 40 cm lengths of ½-inch PVC pipe. Insert these lengths into the side openings of a ½-inch PVC tee. Attach the middle opening of the PVC tee to the 32 cm length of pipe descending from the gate valve.



NAVIGATOR prop build photo #14: Outer stand with valve handle on end. Note the gray 1 ½-inch pipe.



NAVIGATOR prop build photo #15: Stand with valve and handle.

The other outer stand will hold the 1 ½-inch PVC pipe and have a pipe pressure gauge that companies must read. This stand will use the base structure constructed previously. To complete the construction:

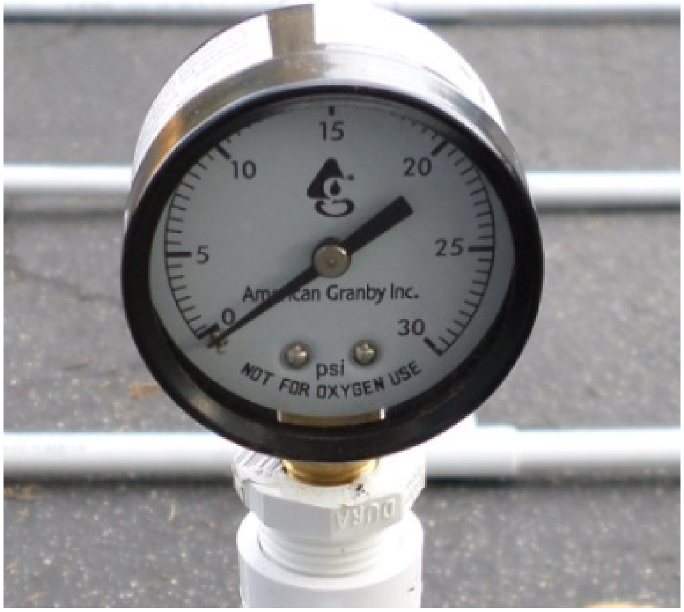
1. Cut a 30 cm length of ½-inch PVC pipe. Insert this 30 cm length of pipe into one of the upwards facing middle openings of a PVC tees on one of the stands. Cut a 32 cm length of pipe. Insert this 32 cm length of pipe into the other upwards facing middle opening of a PVC tee on one of the stands.
2. Attach a 2-inch to ½-inch reducer bushing (Home Depot model # C437-247, Internet # 100343810, store SKU # 744724) to the top of the 30 cm length of pipe on the stand. Cut a 2-inch PVC in half lengthwise, bisecting through the side openings. Attach the middle opening of the cut 2-inch PVC tee to the 2-inch to ½-inch reducer bushing.
3. Attach the middle opening of a ½-inch PVC tee to the top of the 32 cm length of pipe. Align the tee so the two side openings are parallel to the cut side openings of the 2-inch tee on the other side of the stand.
4. Cut a 30 cm length and a 4 cm length of ½-inch PVC pipe. Insert the 4 cm length of pipe into the side opening of the tee facing the 2-inch tee on the other side of the stand. Insert the 30 cm length of pipe into the other side opening of the PVC tee; the one furthest from the cut 2-inch tee.
5. Attach a 1 ½-inch to ½-inch PVC reducer bushing (Home Depot model # PVC021081400HD, Internet # 203851132, store SKU # 744917) to the 4 cm length of PVC pipe. Attach a 1 ½-inch PVC coupling to the reducer bushing.
6. Cut a 10 cm to 15 cm length of 1 ½-inch PVC pipe. Insert this pipe into the 1 ½-inch coupling. Paint the coupling and length of 1 ½-inch PVC pipe gray.
7. Attach the side opening of a ½-inch PVC tee to the end of the 30 cm length of PVC pipe. Cut a 32 cm length of PVC pipe. Insert this 32 cm length of PVC pipe into the middle opening of the PVC tee. Align the tee so the 32 cm length of pipe drops to the seafloor.

8. Cut two 40 cm lengths of ½-inch PVC pipe. Insert these lengths into the side openings of a ½-inch PVC tee. Attach the middle opening of the PVC tee to the 32 cm length of pipe descending from the PVC tee.
9. Cut a 30 cm length of ½-inch PVC pipe. Insert this 30 cm length of pipe into the remaining side opening of the PVC tee (step 7).

A pipeline pressure gauge goes on the end of the 30 cm length of pipe. An alternative to using a real pressure gauge is to use a fake pressure gauge. 2-inch lettering, a zero, may be used as a substitution for the real pressure gauge. To construct the real pressure gauge:

1. Attach a pressure gauge into the middle opening of the tee at the end of the 30 cm length of pipe. Rotate the gauge so the reading is facing away from the oil well.

NAVIGATOR prop build photo #16: Outer stand with pressure gauge on end.



NAVIGATOR prop build photo #17: Close up of pressure gauge.

NAVIGATOR prop build photo #18: Four completed stands in a line.

Pipeline sections

The pipeline sections are constructed from three variable lengths of 1 ½-inch PVC pipe. These lengths of pipe will sit on the four stands. To construct the sections of pipeline:

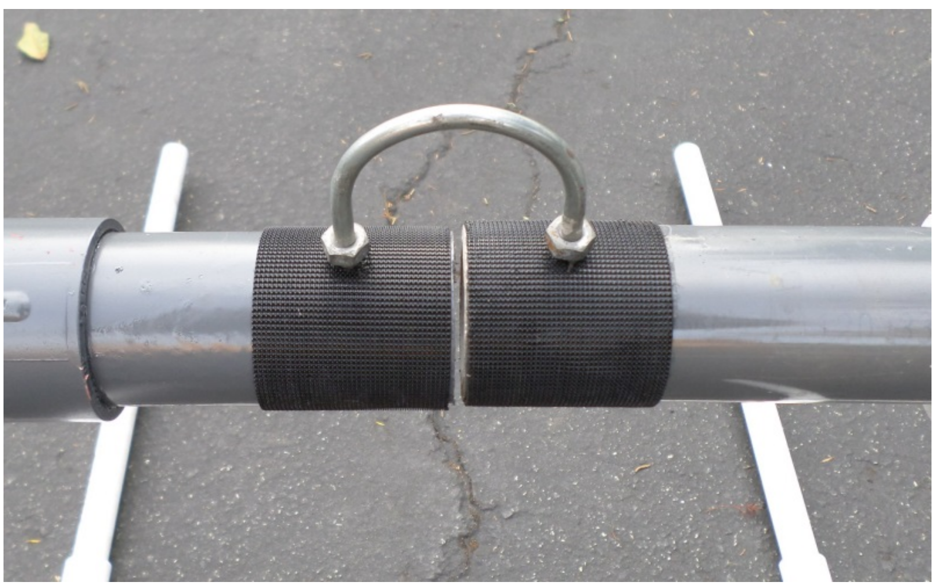
1. Cut three lengths of 1 ½-inch PVC pipe between 75 cm and 175 cm. The three sections of pipe should be of three different lengths.
2. Paint the pipe gray.
3. Cut eight 16 cm x 5 cm lengths of industrial strength Velcro hooks. Attach six of the Velcro hooks around both ends of each length of 1 ½-inch pipe. Attach the other two Velcro hooks around the 1 ½-inch pipe on the outer stands of the pipeline. Note that 16 cm of Velcro is just enough to go around the outer circumference of the 1 ½-inch PVC pipe.
4. Drill a 3/8-inch hole through the 1 ½-inch PVC pipe. The center of these holes should be 2.5 cm from the end of each pipe. These holes are drilled through the Velcro as well. The drill holes on one end of the variable length of pipe should be parallel with the drill holes on the other end of the pipe. The drill holes on the 1 ½-inch pipe on the outer stands should be parallel to the ground. Make sure the holes are smooth from any burrs or excess melted Velcro.
5. Attach a #310 U-bolt (Home Depot model #806826, internet # 204273753, Store SKU # 117996) across the middle of the pipe as a grab point.

NAVIGATOR prop build photo #19: Pipeline section with grab point.

Position the four stands along the pool bottom so that all six cut 2-inch PVC tees are parallel. The 1 ½-inch PVC pipe sections on each of the outer stands should be parallel with the cut PVC tees as well.

1. Take one variable length of pipeline and set it into the cut 2-inch tees on an outer stand and an inner stand. Bring the end of cut pipeline flush with the 1 ½-inch pipeline on the outer stand. Align the drill holes so they are parallel to the sea floor.
2. Insert a #310 U-bolt through the drill holes to secure the two sections of pipeline together. The #310 U-bolts are the pins that must be pulled out to simulate cutting of the pipe.

NAVIGATOR prop build photo #20: One section of pipeline on outer and inner stand.



NAVIGATOR prop build photo #21: Close up of a #310 U-bolt through both ends of pipe

3. Install a second section of variable length pipeline and set it into the cut 2-inch tees of the two inner stands. Note that you may need to adjust the distance between the various stands to match the length of the cut 1 ½-inch pipeline. Align the drill holes on both pipes so they are parallel to the ground.
4. Insert another #310 U-bolt through the drill holes to secure the two sections of pipeline together.

5. Install the third section of variable length pipeline and set it into the cut 2-inch tees of the inner and remaining outer stand. Align the drill holes on both pipes so they are parallel to the ground.
6. Insert another #310 U-bolt through the drill holes to secure the two sections of pipeline together. Adjust the outer stand so the end of the variable length pipe is flush with the 1 ½-inch pipe secured to the outer stand.
7. Insert a #310 U-bolt through the drill holes to secure the two section of pipeline together.

Design note: Once the pipeline is set up and all pipes are aligned properly, use small set screws to secure the ½-inch pipeline in the stands so it does not move or rotate.

Design note: Water, simulating oil, will not actually be flowing through the pipeline.

Design note: Use weights on the base of the stands to keep the pipeline from moving.

NAVIGATOR prop build photo #22: The entire pipeline assembly.