Construction of Large Enclosures for Experimental Studies in Lakes

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ABSTRACT

Cruikshank, D.R., J. Penny, and S. Levine. 1983. Construction of large enclosures for experimental studies in lakes. Can. Tech. Rep. Fish. Aquat. Sci. 1210: iv + 9 p.

Details on the construction and installation of 10 m diameter enclosures (tubes) used at the Experimental Lakes Area are presented. Tube walls were constructed of a reinforced vinyl coated polyester, suspended from a styrofoam floatation collar, supported by an aluminum structural ring. Various methods of weighting and installation are presented. Tubes took 2 man days to install and cost $867 (Cdn 1978).

Key words: Enclosures; tubes; limnocorrals.

RESUME

Cruikshank, D.R., J. Penny, and S. Levine. 1983. Construction of large enclosures for experimental studies in lakes. Can. Tech. Rep. Fish. Aquat. Sci. 1210: iv + 9 p.

Ce rapport décrit la construction et l'installation d'enceintes (tubes) de 10 m de diamètre dans la Région des Lacs Expérimentaux. Les parois de chaque tube ont été construites en polyester renforcé enduit de vinyle et suspendues à une bague de flotation en mousse de polystyrene entourée d'un anneau d'aluminium. Le rapport présente également diverses méthodes de lestage et d'installation. La mise en place des tubes a nécessité deux jours-personnes de travail et l'affectation d'une somme de 867 $ (cdn 1978).

Mots-clés: Enceintes; tubes; limnocoraux.

INTRODUCTION

Large diameter enclosures (tubes) are relatively new innovations. They provide a useful experimental middleground between small scale laboratory experiments and whole lake studies. Prior to the development of clear durable plastics, large tubes (10 m - 30 m dia.) were impractical. One of the earliest versions of enclosures were 20 ft diameter polyvinyl chloride bags used in marine photosynthesis studies (Strickland and Terhune 1961). Some of the largest tubes constructed were of butyl rubber with inflatable chambers. They had a diameter of 45.5 m and were 11 m deep (Lund 1972). The use of large-scale enclosures in marine research over the last decade is documented in a treatise of 30 papers on marine biological and chemical research (Grice and Reeve 1982).

Large diameter enclosures (ranging from 1-10 m) have been used at the Experimental Lakes Area (ELA) in Northwestern Ontario since 1976. Triangular tubes (4.9 m) were used in a vertical eddy diffusion study in 1972 (Hesslein and Quay 1973). Studies have included radiocarbon uptake by algae and gas exchange (Bower and McCorkle 1980), phytoplankton succession (Levine 1981), radionuclide geochemistry (Jackson et al. 1980), mercury and selenium dynamics (Rudd et al. 1980), toxicity of pollutants to zooplankton (Marshall and Mellinger 1980) and periphyton (Muller 1980), eutrophication studies (Schindler et al. 1971) and various acidification studies.

Three basic types of tubes have been used at ELA. The first type is a small diameter (1 m) tube constructed of clear or cross-woven polyethylene. The tube is suspended from a ring of 1" (I.D.) P.V.C. piping that is inserted in a pocket sewn into the top of the tube. The tube or tubes (usually 3) are supported by a wood frame that floats on the water using styrofoam floats. The ring sits on the frame and the lip of the tube is 0.45 m above the lake surface. The floating dock assembly is anchored in place and the tubes sealed to the lake bottom.

Large tubes (10 m dia.) prior to 1978 were constructed of wood, reinforced polythylene and polystryene foam (Schindler et al. 1979; Levine 1981). Tubes consisted of a wooden ring constructed of pieces of 1" spruce that were nailed and glued together to form a circular ring 3" thick and 100 ft in circumference. These rings were supported by 6"x6"x4' styrofoam blocks banded to the ring in a continuous circle with plastic banding material. The inside of the ring was padded with used fire hose. The tube was constructed of 6 mil cross-woven polyethylene. The material was sewn where necessary with double-lapped seams or fastened with "Poly Zip", a two part fastener manufactured from rigid polyethylene (Appendix A). "Poly Zip" was also used to attach the wall material to the wooden frame. Nails were driven through the "Poly Zip" for additional security. Tubes were anchored with five, 10 m lengths of 1/4" steel cable running from the frame to concrete anchors. The wall material was then sealed to the lake bottom using rocks.

Several problems became apparent with the first design. While the wood material was inexpensive, the wooden frames were labour intensive, taking about 2 man days to assemble and install each ring, plus the labour of constructing the rest of the tube. After 5 years, the wooden rings were waterlogged and rotten, and had to be replaced. The transparent polyethylene wall material was severely weakened by ultra-violet light within one year. Based on this experience ten tubes of a new design were installed in 1978. Six were removed four years later and were still in a serviceable condition.

This report is intended to outline a design for large scale enclosures that will incorporate the following features, ease of assembly and disassembly, a curtain material that is resistant to U.V. light and acid, inexpensive and able to weather storm and winter conditions.

MATERIALS AND CONSTRUCTION

STRUCTURAL RING

Each tube is supported by a ring of 8 sections of 1 1/8" O.D. (outside diameter) structural aluminum conduit in 12 foot sections. Each 12' section is connected to the next by a snug fitting oversized 135° elbow. Elbows were made of stainless steel pipe with an 1 3/16" I.D. (inside diameter) x 1 1/2". A 6" bend separates a 9" straight section at either end of the bend (Fig. 1).

Each elbow is attached to the 12' section of alumunium conduit at either end by two 5/16" bolts through pre-drilled holes. One of the 4 bolts can be replaced by an eye bolt for attaching guy lines to the finished ring.

CURTAIN

The curtains for recent tubes have been constructed of two materials. The floatation collar and upper part of the curtain (31") were made of an opaque reinforced vinyl coated polyester ("DuraPro"). This material was not easily degraded by ultra-violet light. The lower curtain was made of 10 mil reinforced polyethylene ("DuraFab"). Completed curtains were one piece, measuring 102' in circumference with varying depth, depending on the particular experiment to be done. Materials were supplied and tubes manufactured by a local company.

Tubes can have three types of bottoms depending on the experiment in question. The lake bottom itself can be used with the tube walls tightly sealed to the sediment. Sewn-in plastic bottoms made of the same material as the walls can be used. Lastly, the tubes can be bottomed in the lake's thermocline using the water density gradient as a barrier.

To prevent leakage along seams, double-sided adhesive backed tape should be sandwiched between the two overlapping curtain pieces.

Seams were sewn using a "French" seam (Fig. 2). It is also suggested that generous overlapping of the curtain material along the seams be used to provide extra strength.

A pocket of about 30" circumference was sewn in the vinyl to accept 6"x6"x4' styrofoam floats. A pair of large grommets are attached every 4" along the lower outside edge of the vinyl pocket for ring attachment (Fig. 3).

A 6" pocket is also sewn into the bottom edge of the polyethylene to accept weights. A ring of 1/4" polypropylene rope sewn into the bottom edge of the hem provided a buffer to prevent ripping of the material from the weights (lead bars or steel reinforcing rods). This may not be necessary depending on the type of sediment the tube is being sealed to.

WEIGHTING

Sediment

The method of sealing the tube to the lake bottom must be adapted to the type of bottom substrate. If the bottom is very soft flocculent material the weight of the curtain, as previously described, will sink about 10 cm into the sediment. SCUBA divers can later push them down even farther (50 cm). In harder substrates such as sand, clay or gravel the weights couldn't penetrate the sediment thus divers were required to pull some of the slack curtain material out over the sediment surface and piled a continuous ring of rocks or sand bags around the enclosure. Sandbags have less tendency to tear the tube material. Additional weighting may be required in tubes in larger lakes where longer fetchs may cause more wave action. Enough slack should be left in the tube walls to compensate for any expected rise in lake level.

Water

Tubes that were bottomed in the thermocline of the lake had a different weighting system. It consisted of two lengths of "Aqua Pipe" (2" I.D.) filled with sand and threaded through the bottom pocket. The two free ends were joined with fittings. "Aqua Pipe" is a black flexible water pipe readily available from plumbing suppliers. The "Aqua Pipe" not only provided weight but maintained a circular bottom shape to the tubes.

ANCHORS

Six, 75-200 lb anchors are used per tube. Anchors can be made either of concrete blocks with loops of reinforcing bar cast into them or by drilling holes in rocks using a star drill and inserting 3/8" eye bolts. Each anchor is attached to the aluminum ring via plastic coated or stainless steel cable and cable clamps.

Another effective method was used in Clay Lake (Rudd et al. 1980) and later at ELA. It involved driving "T" shaped steel bars into the sediments at an angle and 3-5 metres from the tube. Cable was then looped around and clamped securing the tube in place. This method is especially suited for tubes exposed to long fetches.

Tubes anchored in the thermocline require additional anchors attached to the "Aqua Pipe" weighted bottom. This is to prevent lifting of the enclosure walls by currents, especially during storms.

In most cases, two rows of sandbags will be sufficient weight and anchoring may not be necessary.

ASSEMBLY AND INSTALLATION

Tubes can be assembled on a smooth area of shoreline or on the ice. Once the floats have been installed, only part of the tube need be on shore at any one time. Floats should be installed first, then the weighted tube and finally the ring. The aluminum ring can be attached by rope, tie straps etc., through the pairs of grommets spaced along the bottom edge of the vinyl pocket.

The tube walls were tied as close as possible to the floatation ring for towing to the installation site by boat. Tubes bottomed in the sediment can have their walls lowered using ropes anchored from the floatation ring to the weight on the inside of the tube. The walls are lowered against the ropes preventing the walls from dropping with an inward slope. Divers can assist the curtain lowering from the outside of the tube with minimal disturbance of the sediment. The tube can then be sealed to the bottom as previously described.

Tubes should be sealed as soon as possible. In productive lakes, cyprinids and zooplankton tend to gather around the tubes and higher than normal densities of animals may be trapped. This could complicate the results of some experiments.

In tubes bottomed in the thermocline a different approach was used. The bottom ring consisting of "Aqua Pipe" filled with sand should be heavy enough so that when lowered, the water column is not disturbed. Care should be taken to keep the bottom ring horizontal as tubes are lowered. Additional weight can be added in the form of steel bars inserted into the bottom pocket. The curtain can also be lowered using a pulley and float system. A cable is run from the "Aqua Pipe" through a ring on an anchor on the lake bottom to a float suspended in the water column. We used a 5 gallon collapsible plastic container (Fig. 3). The container is filled underwater with air from a diving regulator and tank. As the floats rise they pull the curtain down. As many floats as necessary can be used (usually two).

SCUBA divers are useful in installing and checking the deployment of tubes and making modifications. Routine SCUBA inspections should be made frequently during critical experiments especially after storms. Inspections should be made near mid-day, when light conditions are best. Each tube takes approximately 2 man days to install and costs $867.00 in materials. Divers can miss serious leaks especially in lakes with poor light penetration. Leaks can be checked by adding NaCl and measuring the rate of loss of conductivity in the tube. If a scintillation counter is available and tube locations allow it, tritium (H^5) or Na^{00} spikes can be used.

ACKNOWLEDGMENTS

W. Curry of Curry Industries of Winnipeg played a large part in the design of our tubes. D. W. Schindler and M. Turner provided valuable criticisms and suggestions during the preparation of this report.

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STRICKLAND, J.D.H., and I.D.B. TERHUNE. 1961. The study of *in situ* marine photosynthesis using a large plastic bag. Limnol. Oceanogr. 6: 3-96.

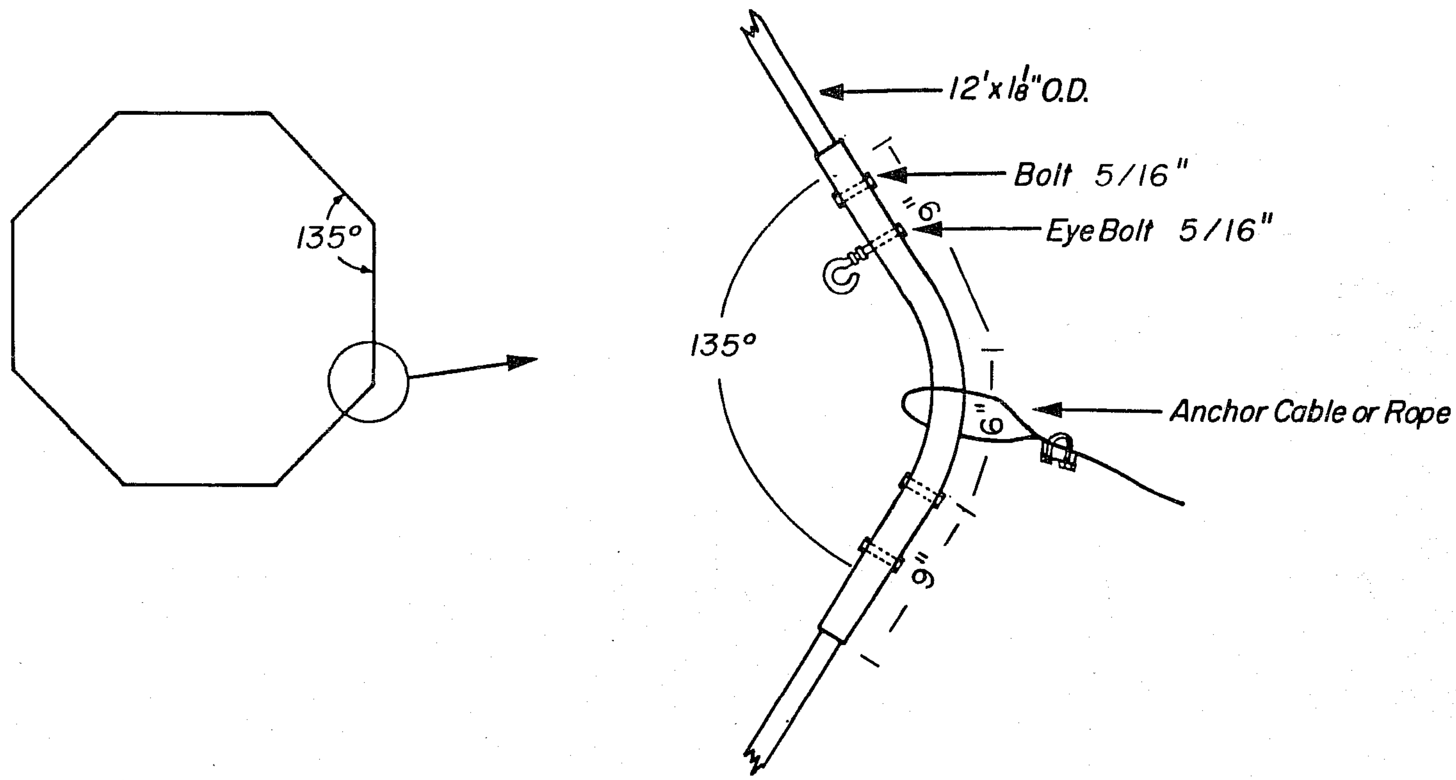


Fig. 1. Tube frame elbow.

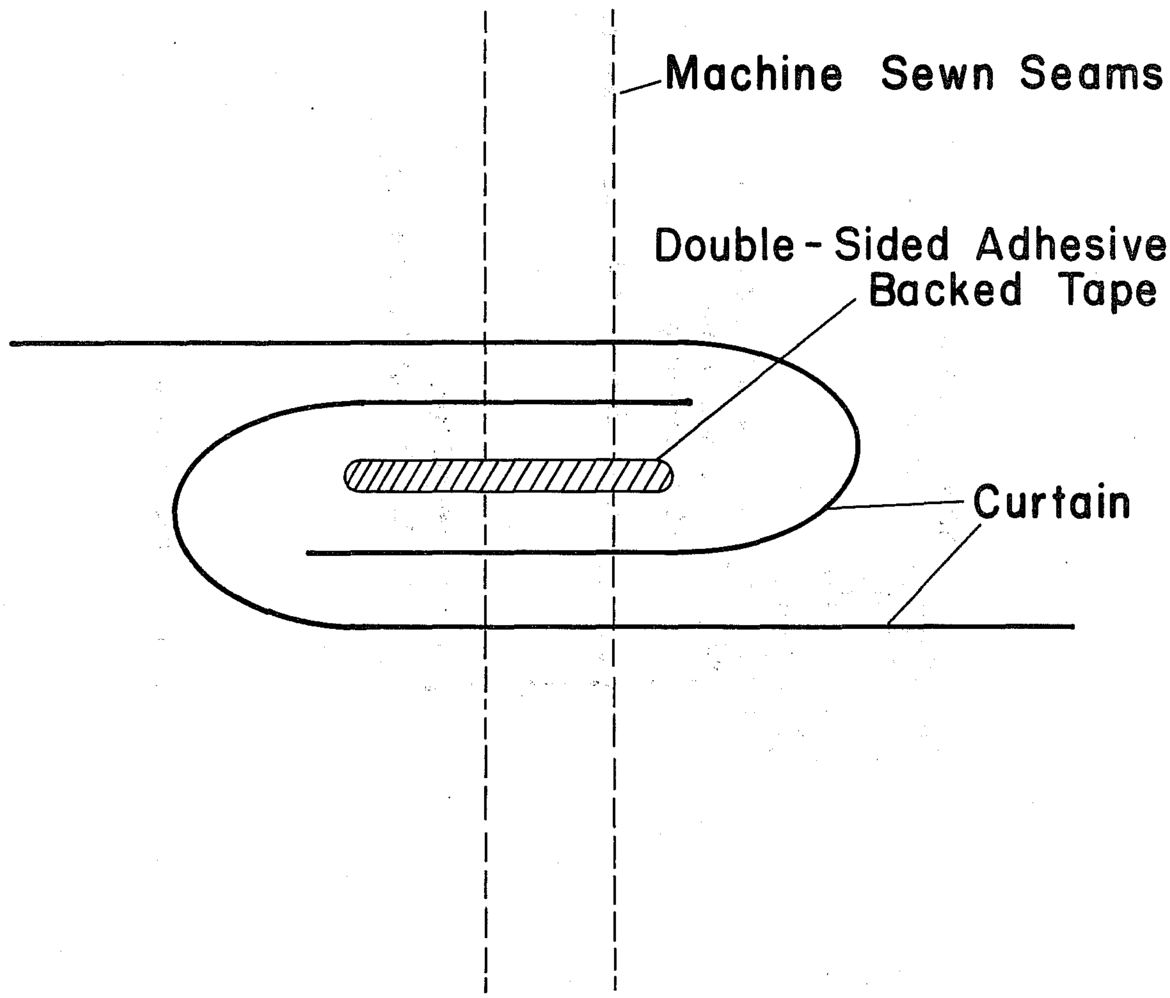


Fig. 2. "French" seam.

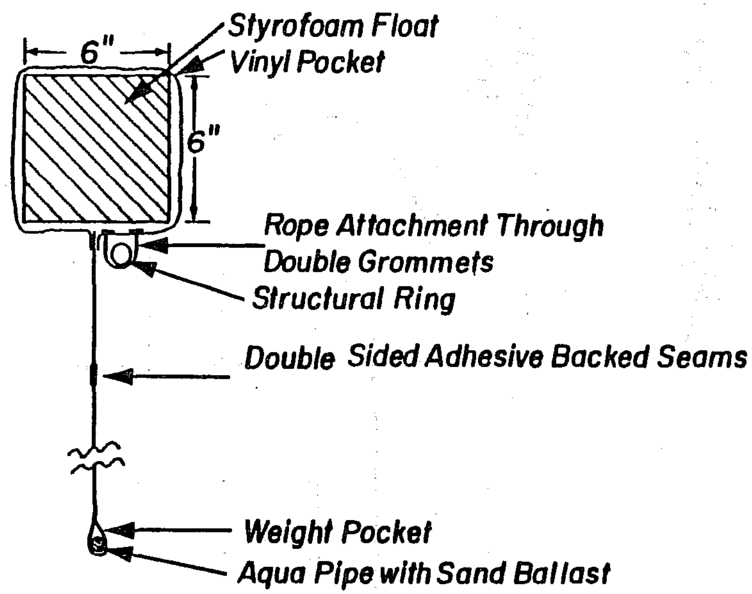


Fig. 3. Tube cross-section.

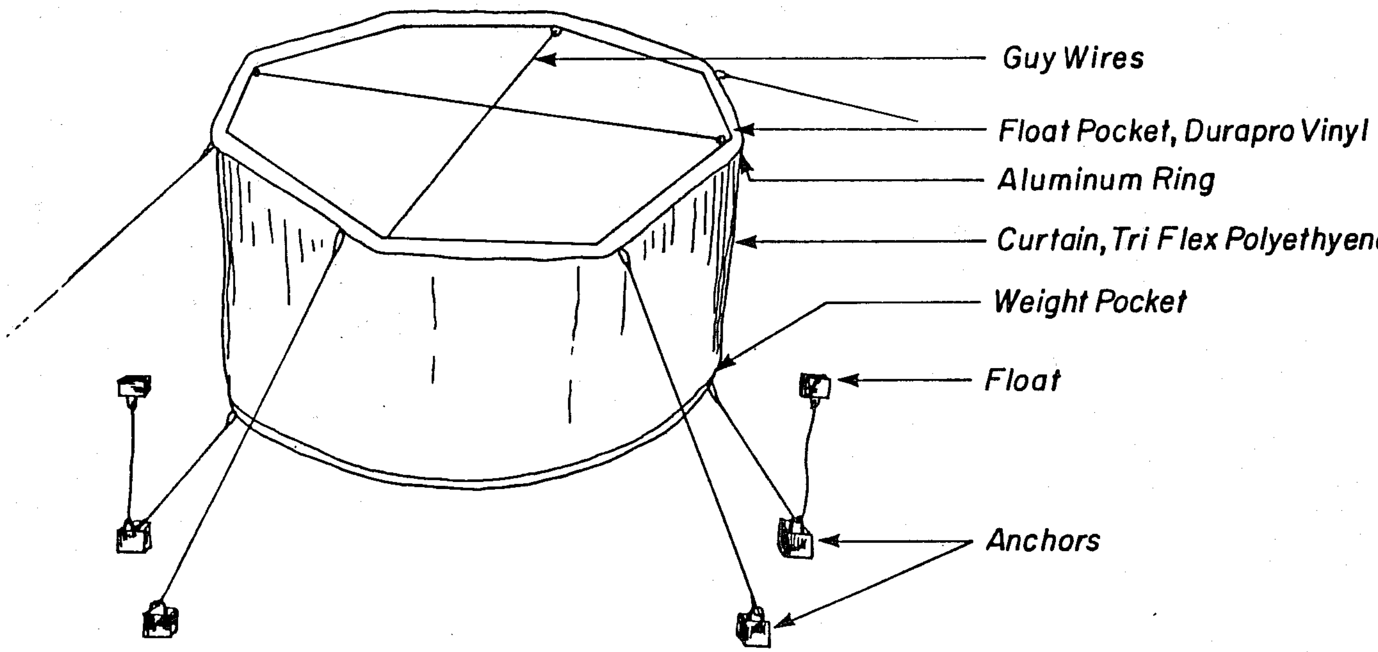


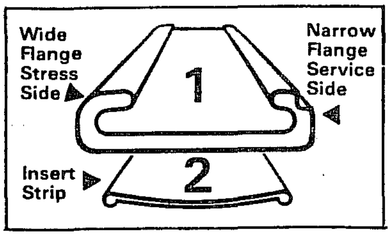
Fig. 4. Tube Installation.

APPENDIX A

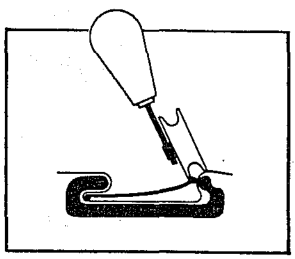
THE ZIP POLY-FASTENER INSTRUCTION SHEET

For using perimeter type channel to fasten on plastic films on to greenhouses and other perimeter hold down applications

THERE ARE TWO BASIC PARTS TO THE SYSTEM:

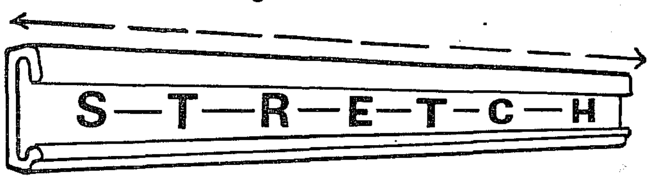


There's two parts to the Poly Zip fastening system. The Channel, and The Tape. The tape is the thin strip with beaded edges on the underside. On the sides of the channel are two flanges which the tape fits into.



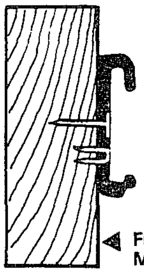
Recommended also is the Poly Fastener Tool that makes it easy to get the tape into the channel. It's available separately. Please ask for it.

Important — Before attaching - the channel must be stretched:



Always pre-stretch the channel before attaching: 1½" for every 10' at 50° F; 1¾" for every 10' under 50° F. This is to prevent buckling between fastening points and expansion of the channel lock during the summer periods.

How to attach the channel:



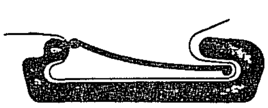
Use roofing nails, staples about 2 to 3 inches apart, or 5/32 pop rivits at 5 to 6 inches apart, driven through the bottom of the channel.

A. The WIDE flange of the perimeter channel must be fastened toward the top tension area.

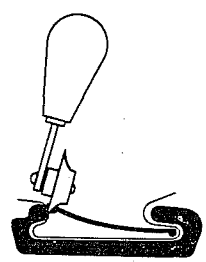
B. Using 18 or 16 gauge staples with a ½" crown, 1" or 1-1/8" long. Staple at 3" intervals. Be sure that staples are driven in FLUSH with the surface of the channel. (For light duty work, shorter staples may be used, but test holding power first.)

C. BEFORE APPLYING films (poly or other highly lubricated films) dust the channel with chalk dust or any other slightly abrasive material to avoid slipping of film.

Laying the material into the channel:



1. Place your film over the channel, leaving an extra 3" - 5" over the edge.
2. Starting at one corner of the perimeter, take the tape (BEADED EDGE DOWN) and force it and the film under the WIDE STRESS FLANGE.
3. Force about 2" of tape under the NARROW BEADED FLANGE as well.



4. Tack the tape in place at the starting end to prevent slipping.
5. Stretching the tape as you go, force it and the film under the wide flange for a short distance.
6. Run the POLY FASTENER TOOL down the narrow flange for the same distance and the tape will flow into place.
7. Continue applying as per steps 5 and 6, completing one side at a time until the job is finished.

Joining sheets of film together:

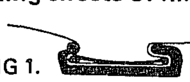


FIG 1.

End channel showing heavy stress flange leading toward stress area.

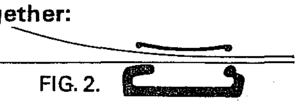


FIG. 2.

Place two sheets of film over the channel, ends as shown, leaving 2 - 3" extra over the edge.
Use same method as per steps 5

FIG. 3.

and 6 above, making sure you tack through the two sheets of film at the starting point to prevent the film slipping.

FIG. 4.

After tape is all in place, fold back the top sheet of film and pull in opposite direction as shown.

Removing tape: To dismantle, use the new tape removal opener — simply work the curved hook end in and under the tape in the narrow flange side and run the opener along the channel. The tape will pop right out.

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APPENDIX B

Costs (1978 Cdn $) for one 6 m deep x 10 m diameter enclosure.

-structural aluminum tubing 1 1/4" O.D. x 12' (3.18 cm x 30.5 cm)	$ 81.60
-stainless steel elbows (bent and drilled) 1 1/4" O.D. x 1 1/3" (3.18 cm x 3.38 cm) at 10.20 ea x 8/tube	84.00
-bolts	4.00
-curtain (finished) (Dura Fab) 102' x 20' (31.11 x 6.10 m) 2040 sq. ft/tube at $0.145 sq ft.	295.80
-"Aqua Pipe" .21 ft x 100	21.00
-fittings and glue	2.00
-anchors	15.00
-polypropylene rope 240' x .20/ft	48.00
-floats: styrofoam blocks at 4.00 ea. x 25 per tube	100.00
-miscellaneous	25.00
Total	$866.71