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INSTALLATION TRAINING MANUAL

Steelplast CC
Engineering Plastics

SYSTEM FLEX-LINE® LININGS INSTALLATION TECHNIQUES

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Chapter 1 - Introduction to Flex-Line® Low Friction Linings

1.1 Introduction to the Problems

Bulk materials don't always flow reliably. They compact, rat-hole and arch and results can be costly. Production shuts down. Work hours are wasted and safety is compromised. But you can achieve mass flow and get your business moving again.

Problems that are frequently encountered involve:

- Erratic flow
- Flooding of feeder interface
- Blockages and rat-holing
- Mechanical and cohesive arching
- Product segregation
- Product degradation
- Lack of storage capacity
- Structural failure

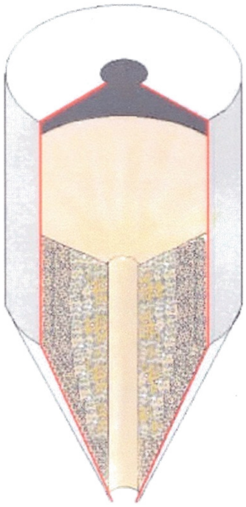


Figure 1 – Rat-holing

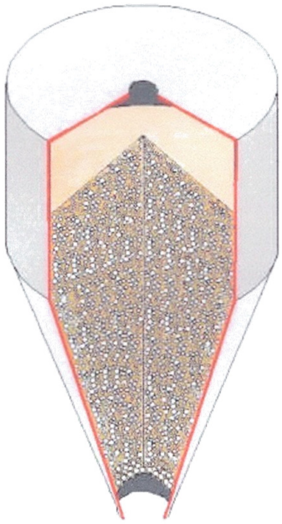


Figure 2 – Mechanical Arching

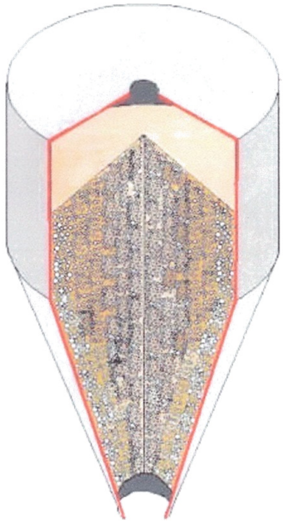
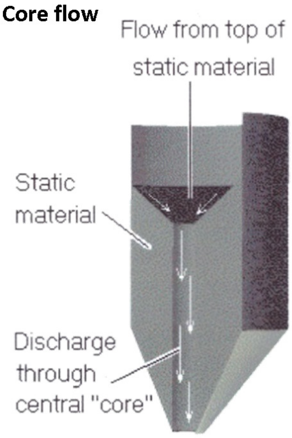


Figure 3 – Cohesive Arching

1.2 Types of bulk material flow

1.2.1 **Core flow**



Key features:

- "first in last out" discharge
- "dead" regions of product
- Erratic discharge caused by product on shear during emptying
- Central discharge channel
- Exaggerates segregation effects of particulars
- Hopper half angle typically great than 25° (from vertical)
- Poor stock rotation
- High storage capacity for a given headroom

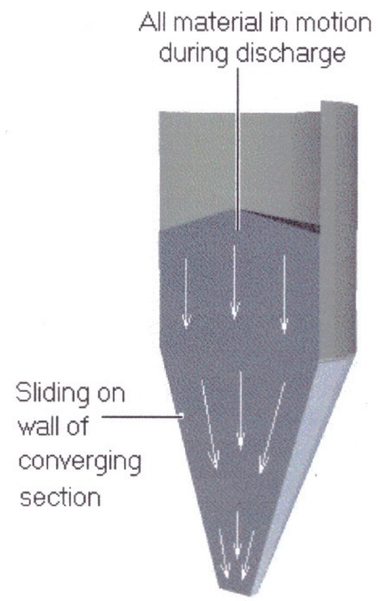
When discharge has been initiated from a silo exhibiting core flow, the material will start from the area above the outlet of the silo and extend to create a flowing channel of material down from the top surface of the stored material (see above). The top surface then commences to slough off down into and through the central channel. Thus, the first material to come out of the sile will tend to be that most recently introduced to the vessel. If the silo is left totally discharge then eventually the material which was first put into the silo (and resides at the bottom) should come out. Unfortunately, although this sequence of events is typical for some materials (e.g. dry grain, etc.) in a core flow vessel, the picture changes when cohesive materials (such as concentrates & fine powders, etc.) are subjected to this type of storage and discharge. Such materials can exhibit a trait known as "rat-holing", in which instances the material creates a central channel to the top surface but due to the cohesive strength of the material, the sides of the channel are able to support themselves and the sloughing off of material from the top surface does not occur. If it is possible to gain access to the top of a silo which has developed a "rat-holing", a central core of material will be seen to have discharged, whilst leaving the majority of the inventory supporting itself around the inside of the silo.

If, however, the silo is not discharged fully (as would be the case where only batches of material are required), but is replenished after the level within has dropped part way, then a situation can arise where the material at the bottom does not actually ever come out. For time dependant materials that consolidate (gain strength) with time, this can result in a bonding together of deposits which eventually build up and reduce the "live" capacity of the silo. Not only is the "live" capacity reduced, but contamination of fresh material can take place. Even pelletized products (e.g. wheat feed or soya) stored in this way can sometimes undergo fermentation and bond together creating an extremely hard deposit which will require manual removal. This build up also presents a face of static material over which the discharging material hat to pass on its way to the outlet. This shearing of moving material encourage erratic flow by virtue of the "rougher" surface offered by the static material compared to the relatively smooth silo wall. The core flow discharge pattern can also exaggerate segregation (separation) of fine and coarse particles, giving rise to an inconsistent material quality in the discharge.

1.2.2 Mass flow

Key features:

- **"**first in last out" discharge
- "dead" regions of product
- Even discharge encouraged by the reduced level of shear generated as the product discharges (shear takes place against the relatively smooth wall material – not static or slower moving product)
- Degree of remixing during discharge minimises segregation effects
- Hopper half angle typically less than 25° (from vertical)
- Relatively low storage volume for a given headroom (but all the product can be retrieved)



Mass flow silo's (see above) require steeper wall angles than those of core flow silos and offer an even flow of material from across the width of the silo. The even flow of material possible with a mass flow silo occurs as a result of the material sliding down relatively smooth walls (as opposed to over static material in the case of core flow discharge). The most important benefit of this mode of flow is that the material which is loaded into the silo first actually comes out first, and the most recently loaded material is allowed time in residence to de-active and settle before it is discharged. The other attraction of the design is that all of the silo's capacity is "live" and can be reclaimed without resorting to discharge aids or hammers! It also has the added benefit of introducing an even flow of material to any feeding device mounted below the outlet and of encouraging a degree of re-mixing of material at the outlet, which minimises the effects of segregation. In the situation where product may be left within a silo for an extended period of time, the internal stresses within the product will increase with time and the "resistance" to flow initiation will increase. If the silo is of a mass flow design the strength gain in the material can be relieved by the simple act of discharging a small amount of material periodically over the storage time. In a core flow silo this approach will not work as all material would have to be emptied out in order to get it all to move.

If a core flow silo is giving unreliable flow, often the lower section can be removed and replaced with a mass flow discharge section. This will improve discharge, although a reduction in total volume must be accepted for the same headroom (by virtue of the taller converging section used).

1.3 The Flex-Line® Solution

Flex-line® High Performance Low Friction Linings.
Flex-line® low surface friction promotes flow of cohesive, non-free-flowing bulk materials. Its unique surface permits shallower hopper wall angles in new construction design. Flex-line® improves performance of existing structures with linings on interior surfaces of chutes, hoppers and process equipment. Linings are mechanically fastened to substrates of steel, stainless steel, aluminium and concrete.
Engineering firms and flow consultants worldwide specify Flex-line® linings more often than any other polymer.

1.4 Properties of Ultra High Molecular Weight Poly Ethylene

See attached at the back of the training manual – Technical Properties compared to other engineering plastics.

Chapter 2- Flex-Line® Applications & Different Grades

For the lining of:

Chutes, hoppers, bins, bunkers, silos, vibratory feeders, slider beds, conveyor skirting, drag conveyors, dragline buckets, front end loader and excavator buckets, off / on-road tipper truck bodies, railcars, dust collectors, cyclones & many more.

Bulk Material Handled:

Animal feed, anthracite culm, bauxite, bituminous coal, chemical powders, copper concentrate, dust, fertilizers, fly ash, foundry sand, grains, raw sugar, gypsum, iron ore, kaolin, lime, limestone, nickel ore, platinum ore, phosphate, salt, sand, silica sand, soap detergent, sub-bituminous coal, waste coals, wood chips & many more.

Sharp and / or large rocks must be avoided, especially crushed or blasted rock still in large form, as Flex-Line® is primarily a flow liner and not an impact or wear liner although it has the properties of high abrasion resistance and good impact resistance.

Examples of materials Handled:

Fine river sand

Fine Slurry

UHMW-PE Lined storage silo

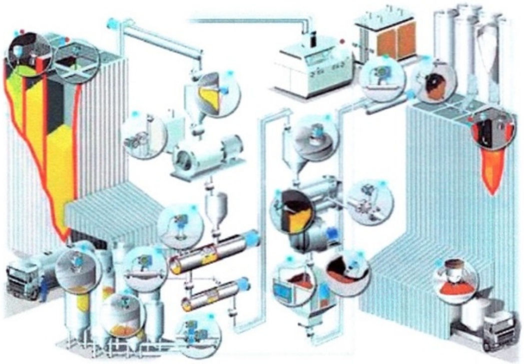
Crushed Limestone

Crushed Gypsum

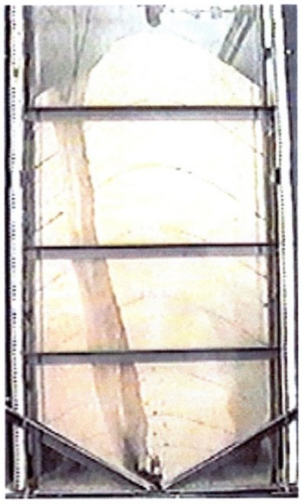
Fine coal

Silica sand

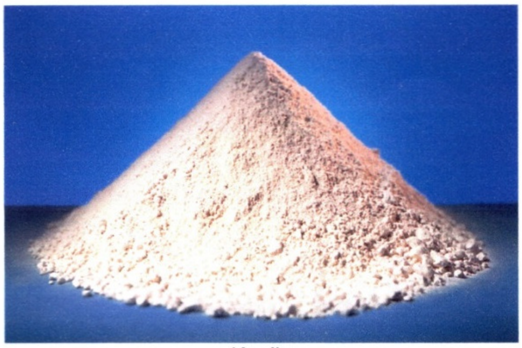
Raw sugar



Applications in the animal feed industry



Problems with flow in animal feed storage bin



Kaolin

Grain storage

Limestone Ammonium Sulphate

Fine Copper Concentrate

Examples of material which will damage Flex-Line® - High impact & sharp cutting edges

Large sharp rocks

Blasted rock

Glass recycling

Rock Pile

Lining Grades

Flex-Line® UHMW-PE Green Sheet

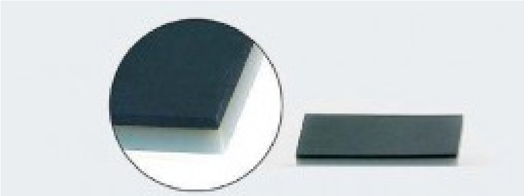
Excellent general purpose, free flowing lining material combining high impact resistance with good wear resistance. Light green in colour.

Flex-Line 8800® UHMW-PE Blue Sheet

Premium grade lining material with highest sliding and wear resistance properties. Dark Blue in colour.

Flex-Line® UHMW-PE (GREEN RUBBER BACK) & Flex-Line® UHMW-PE (BLUE RUBBER BACK)

Rubber absorbs impact and thermal Expansion better and avoids straight corrosion. Avoids fasteners and is easily bonded to material. Metal primer and cement are used for bonding to sub straight.



Chapter 3 - Installation Techniques & Fastening Methods

3.1 Installation Team (manpower), Transport, Tooling & Training Requirements

3.1.1 **Team:**

A full installation team, which can install an average of 10 to 12m^2 Flex-Line® liners per day, irrespective of the fastening method and under normal working conditions, must consist of ± 4 or 5 crew members including a component boiler maker supervising and installing at the time or a person with similar skills.

Certain installations may take longer, for instance if liners have to be marked out and cut to size on site or if old liners have to be removed from the structure.

Pre-cut and drilled panels are easier to install for obvious reasons, but a certain amount of timing on site is never avoidable as workshop drawings and the actual structures are almost never identical.
When large area (more than average installation rates) need to be lined in a short period of time, due to short shut downs, extra man power should be allowed for in some instances 2 teams have been used.

3.1.2 **Transport:**

For most installations we transport up to 2000 mm x 1000 mm sheets including equipment, tooling and 1 installation team. If pre-cut and drilled panels are larger than 2000 mm x 1000 mm sheets, alternative transport will be arranged.

3.1.3 **Tooling:**

Basic electric hand tools required per installation team:

- Jig saw with spare blades
  (use correct blades for cutting plastic)

- Circular saw
  For straight cuts or scoring lines

- Hand planer

- 9” and 115mm Angle grinder

- Hand drills
  (±3 per team each set up with a different size drill bit)
  These can also be used to drive in thread forming bolts and fasten nuts for stud weld system – variable speed & high torque required.

HILTI SR16 for screw / nut fastening
& Metabo SBE 1010 Plus for drilling

- Inverter Arc welding machine
  These are smaller and lightweight compared to other welders, but more expensive.

Other tools required:

- Rubber hammers to insert plugs or position panels and when rubber backed liners are glued to steel substrates.
- Normal claw hammer
- Screw driver set
- 90° counter sunk bit for counter sinking holes to suit M8 or M10 csk set screws
- G clamps
- De-burring tool
- Gas bottle and heat gun
- Spanner set (13 mm is most commonly used)
- Other customised tooling and special sockets or adapters
- Straight edge
- Allen keys
- Various ¼" driving bits
- Carpet knife
- Permanent marking pens
- Pliers

<u>Specialised equipment required:</u>

- Power actuated nail gun to temporarily position large panels on sloped faces.
  Make: HILTI DX A40

- Stud welding machine including earth cables, signal cable with gun & Special Adaptors for M10 Knock-off stubs.

Supplier: Refractory Fibre & Anchor Systems (Pty) Ltd
Make: Taylor System 1000 or equivalent

- Thermo plastic extrusion welding gun and hand held hot air stick welder.
  Make: LEISTER
  Supplier: Plasti-Weld

Extrusion welder with PTFE shoe

Hand held stick welder
Requires welding nozzle

3.1.4 **Training:**

Why Installation Fail:

- Incorrect lining material used;
- Incorrect Liner Thickness;
- Incorrect Fasteners;
- Ignorance of thermal expansion & contraction;
- Incorrect fastener Spacing (see figure 3.1.4a & 3.1.4b);
- High Impact Zones;
- Aggressive Bulk Material (Initial application did not involve flow problems);
- Neglecting installation of capping (cover) strips (see figure 3.1.4c);
- Abuse normally occurs in truck liners where excavators damage the liners and cause bulging of loose panels (see figure 3.1.4e)

Training of sales staff and installation teams before the sale or installation take place is highly important to overcome the potential for failure.

Program

- Installation training will be done ……

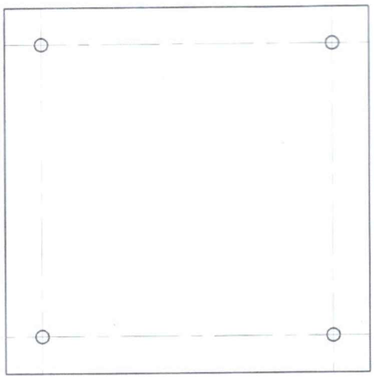


figure 3.1.4a – Incorrect fastener spacing similar to steel liners

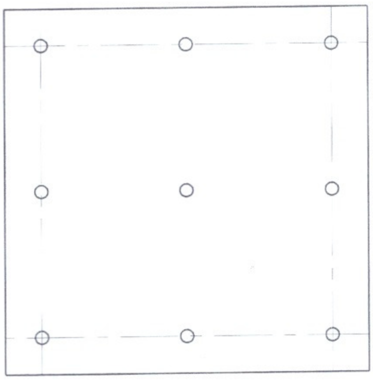


figure 3.1.4b – More fasteners are required to overcome buldging due to expansion

figure 3.1.4e – Poor installation technique, not enough fasteners and no leading edge protection, inconsistant bending of panels.

figure 3.1.4c – Neglecting protection of leading edges

figure 3.1.4d – Abuse from excavator operator

3.2 Fastening Methods

3.2.1 **Flex-Line® Rubber backed installation System:**

Benefits

- No Fixtures are required for liner installation;
- Substrate drilling is not required;
- Fair degree of substance corrosion protection;
- Rubber layer provides added impact absorption;
- Thermal expansion is contained by rubber (to a certain extent)

Ideal Application

- New structures where substrate cannot be drilled;
- Access is limited to inside of structure;
- Where liquids / slurries are conveyed and sealing is required;
- Sliding beds where fixtures could be obstructions;

Limitations

- Substance has to be as even as possible;
- Sandblasting or grinding of entire lines areas are required;
- Thermal expansion & contract of thin sheet steel can cause separation of rubber back from substrate;
- Long waiting periods or curing time of adhesive and primer

Installation Procedure with TRS cold vulcanising cement kits.

This procedure applies to all thickness and grade of Flex-Line® Rubber backed materials.

✓ Substrate ration:
The ideal situation is where the substrate can be sand and shot blasted to remove all rust, scale, old paint or any other metal primer. The surface of the substrate should be clean to bare steel.

Where no such facilities are available or it will be too impractical and costly to hire, or buy expensive shot blasting equipment, rotating wire brushes or sanding discs should be used to clean the substrate. The whole are should then be wiped off with thinners or acetone.

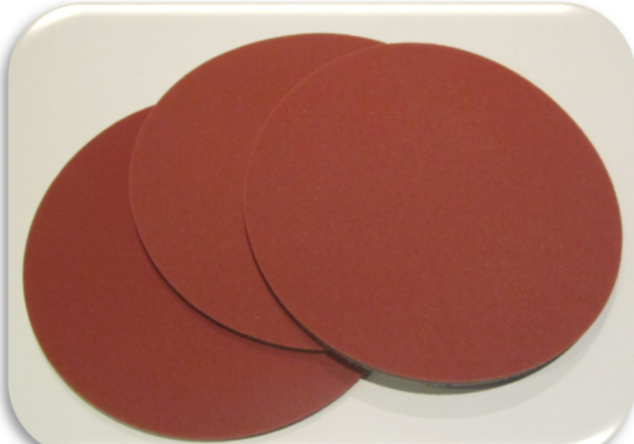
For the best rubber to metal bond, 1 coat of TRS Metal primer has to be applied to the substrate with a paintbrush to the ratio of approximately 1 kg tin of primer to ±4m^2 of area to be lined.

TRS 2002 cold vulcanising cement is mixed in the tins with the supplied TRS hardener and the first coat of cement is applied to the substrate after the primer is left to dry completely. The applied ratio should be ½ of 1kg tin of cement to ±1m^2 of substrate. Allow the first coat of cement to dry well. Minimum drying time on metal is 1-2 hours.

Use 100mm Paint brushes for small to medium areas   OR rollers for large areas covered

✓ <u>Rubber back preparation</u>
The rubber back should be pre-cut to the required sizes and plates before surface preparation is started.

The surface of the rubber should be roughened with sanding or grinding discs after or during the same time that the steel substrate is cleaned.



MEK Solvent used for cleaning the surfaces prior to primer & adhesive application.

TRS 2002 cold vulcanising cement is mixed in the tins with the supplied TRS hardener and the first coat of cement is applied to the rubber during the same time that the first coat is applied to the steel substrate. The applied ratio should be ½ of 1kg tin to ±1m^2 of rubber. Allow the first coat of cement to dry well. Minimum drying time is 1-2 hours.

A Second coat TRS 2002 cold vulcanising cement is applied to both the steel substrate and the rubber and left to become slightly tacky to back of finger. This take about 10-15 minutes, use the same ratio of application as the first coat. In case of over drying, apply 3rd coat.
The total amount TRS 2002 used per 1m^2 should add up to 2 x 1kg tins. This is an approximate amount and may vary according to different areas and shapes of structures lined.
Note: the mixture TRS 2002 / hardener must be used within 2 hours.

✓ <u>Applying the Flex-Line® Rubber back to the Substrate:</u>
When the second coat of TRS 2002 cold vulcanising cement on both the substrate and the rubber has become tacky as described in the previous section, the sheets or panels should be applied where required on substrate and pressed down firmly and with even pressure from the top to bottom. The rubber back panels should be rolled upwards slightly when applying at the top to prevent uneven contact to the substrate. A rubber hammer or mallet should be used to tap lightly over the whole area, from the centre

of the panel outwards or from one side to the other, to remove any air trapped between the rubber and the steel. Once the panel has made contact with the steel, it is very difficult to remove it. Ensure that the panels are applied correctly the first time. If the panel are pulled away from the steel, the cement will pull away from either the steel of the rubber, which will create a bad contact area.

✓ Safety precautions:
TRS 2002 contains Trichloroethylene R20/22 detrimental to health, breathing and swallowing. Avoid contact with eyes. Necessary safety precautions should be taken always to prevent inhalation of rubber dust or smoke or rubber particles from getting into the eyes.

Oxygen respirators with the correct cartridges (for organic vapours) should be used if the installation is being carried out in confined spaces or areas where ventilation is not sufficient.

Other products that may be less harmful to health & environment are being tested on a continuous basis.

3.2.2 **Stud Weld Fastening System with drawn arc process:**

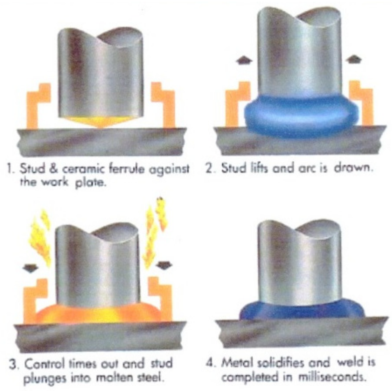
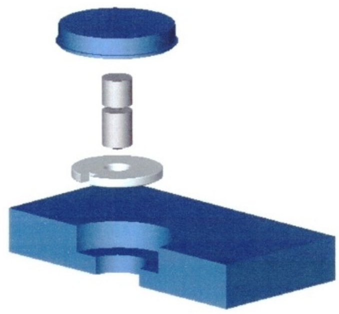


Illustration with drawn arc process


Tivar stud weld sample

Flex Line stub weld sample

Benefits

- Quick and easy installation;
- One sided fastening;
- Substrate drilling is not required;
- Can be used with cover plug to minimize sticking and corrosive leakage

Ideal Applications

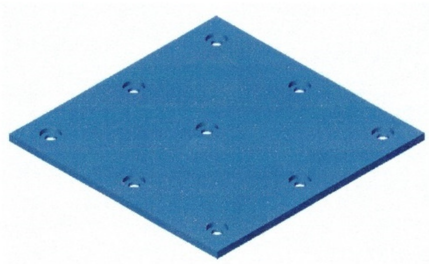
- When drilling the substrate is not desirable;
- When Flex-Line® liners are placed over weldable substrates such as dragline buckets, dump truck bodies, hoppers, bins, silos, etc.

Limitations

- Can only be used with a weldable substrate;
- Can only be used in conjunction with a cover plug on 15mm liners or thickener;
- Special stub welding equipment is required for installation – high equipment cost;
- Substrate needs to be clean of paint, mill scale and rust;
- Can only be used where 380V 3-phase power supply is available;
- Minimum liner thickness of 15mm for successful plugging of holes.

Installation procedure

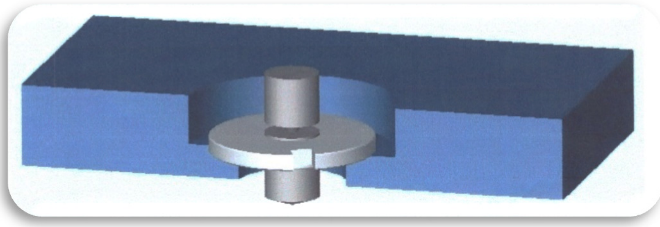
- Cut drill & counter bore the Flex-Line® panels as per detail drawings:



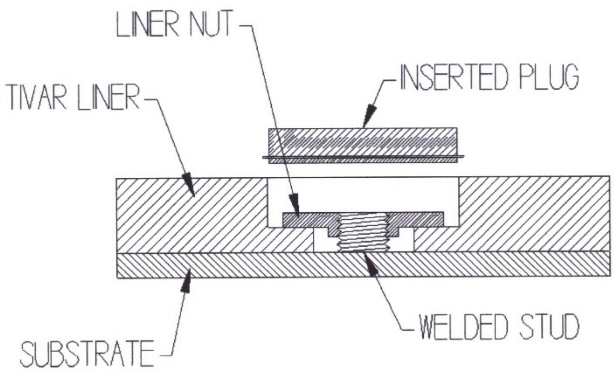
- Cut & Counter bored panel

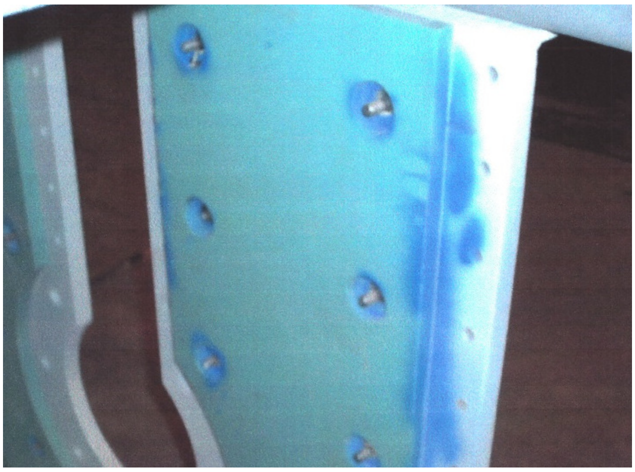
- Place panels in position on substrate, trim if required and mark hole positions;
- Grind substrate clean on marked hole positions to ensure proper weld.
- Take care not to place panels where expansion can occur after marking of hole positions as stubs will be off-centre when panels are repositioned;
- Reposition panels on substrate and weld knock-off stubs to substrate using aluminium centring spacer on gun. Present stub welder and test welds on separate plate;
- Remove panels again, clean out holes and remove ceramic ferrules around stubs;
- Reposition panels on substrate, insert clear silicone in area around stubs to prevent corrosion of weld;
- Insert special liner nuts with socket and electric screw gun. Nuts should be tightened but still allowing the panel movement during expansion and contraction in operation;

- Break off knock-off section on stub only after liner nut is tightened. The liner panels are normally pulled by tightening the nuts and if the knock-off section is removed before tightening, it is very difficult for the nut to catch the thread on the remaining part of the stub;

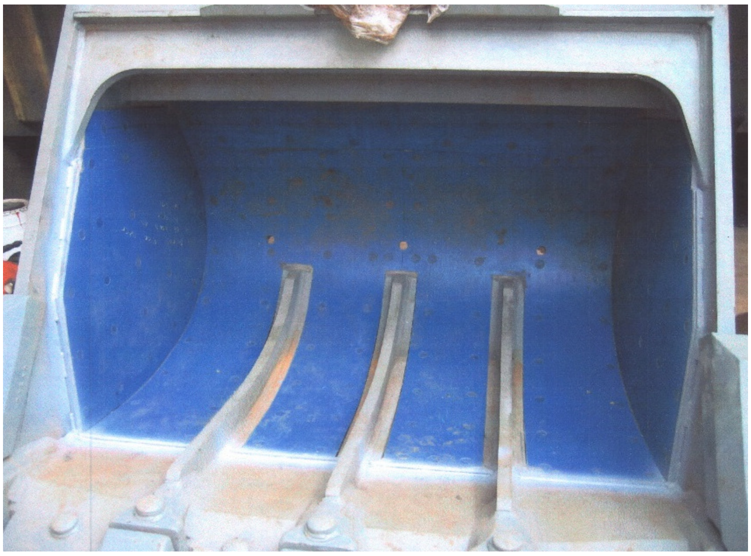


- Insert plugs by covering plug with small section of plastic and hitting it with a rubber mallet. Note direction of insertion;





Example of stud welded panel showing knock-off section still in place.
Marking of holes can be done with spray paint to speed up process.



A complete stud weld installation on an excavator bucket.

3.2.3 <u>Drilling & Bolting Method</u>

Benefits

- Most common installation type with standard fixture used;
- One side fastening (for thread forming bolts only);
- Can be used with cover plug to minimise sticking (Minimum liner thickness of 15 mm for successful plugging of holes);
- Panels are easily replaceable;
- Cheaper option;
- No specialised equipment.

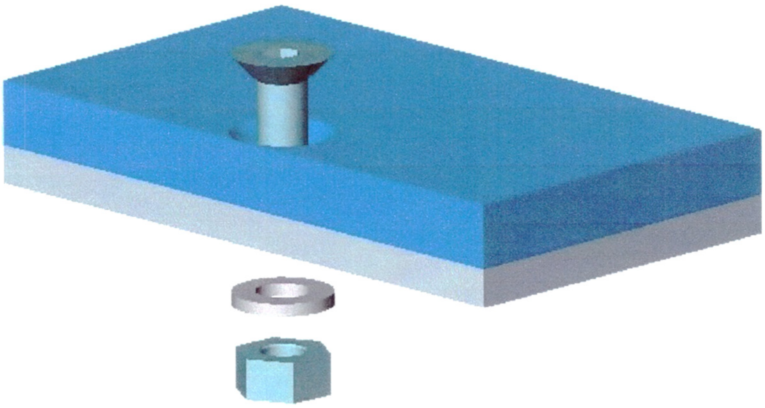
Ideal Applications

- When access is available to both sides of structure;
- When panels must be replaced often;
- When liners 10 mm thick and less are to be installed.

Limitations

- Substrate drilling is required – labour intensive;
- Installation rate is slower than other options, especially if substrate is of a thick/hard steel.

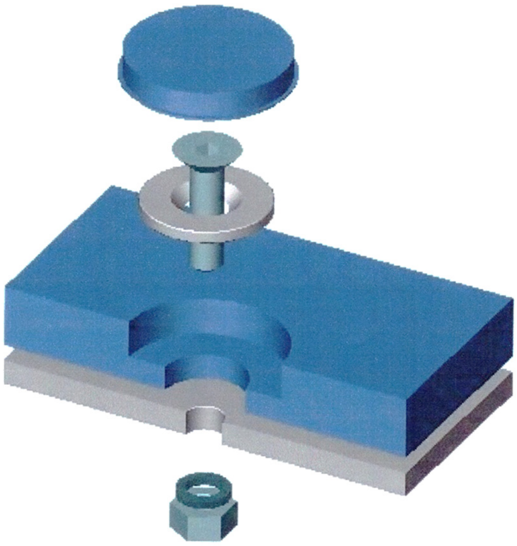
3.2.3.1 *Counter sunk set screws*



Installation Procedure

- Mark, cut & counter sink liner panels as per details drawings;
- Place panels in position on substrate, trim if required and mark hole positions;
- Drill clearance holes in substrate (See ISO metric Threads drilling table for clearance hole for M8 or M12 bolts as required);
- Reposition panels and start inserting set screws, spring washers & hex nuts;
- Tighten nuts with socket wrench while holding head of set screw with suitable allen key driving bit.

3.2.3.2 Counter bore with set screws & cover plugs



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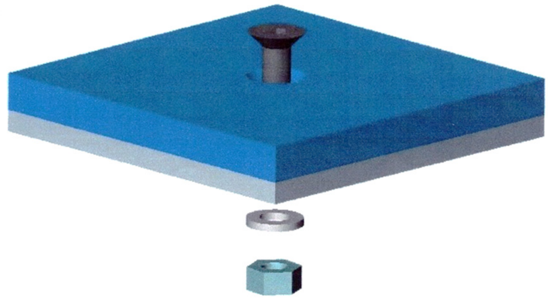
- Mark, cut & counter sink liner panels as per details drawings;
- Place panels in position on substrate, trim if required and mark hole positions;
- Drill clearance holes in substrate (See ISO metric Threads drilling table for clearance hole for M8 or M12 bolts as required);
- Reposition panels and start inserting set screws, spring washers & hex nuts;
- Tighten nuts with socket wrench while holding head of set screw with suitable allen key driving bit.
- Insert plugs by covering plug with small section of plastic and hitting it with a rubber mallet. Note direction of insertion;

3.2.3.3 Counter sunk Thread forming Bolts



Installation Procedure

- Mark, cut & counter sink liner panels as per details drawings;
- Place panels in position on substrate, trim if required and mark hole positions;
- Drill pilot holes in substrate with 5 mm drill bits;
- Drill 7.3 mm holes through pilot holes;
- Reposition panels and start inserting thread forming screws with Pozi #4 bits;
- Tighten screws until panels are flush with substrate.

Annexure 3A

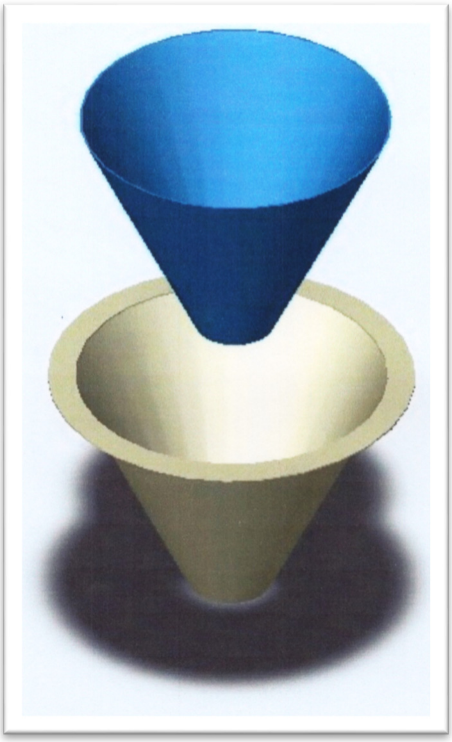
ISO Metric Threads - Coarse Pitch: Nuts Dimensions : mm

Nominal diameter choices		Pitch	Minor diameter		Tapping drill	Depth of thread
1st	2nd		max	min		
1.0		0.25			0.75	0.1353
	1.1	0.25			0.85	0.1353
1.2		0.25			0.95	0.1353
	1.4	0.30	1.160	1.075	1.10	0.1624
1.6		0.35	1.321	1.221	1.30	0.1894
	1.8	0.35	1.521	1.421	1.50	0.1894
2.0		0.40	1.679	1.567	1.65	0.2165
	2.2	0.45	1.838	1.713	1.80	0.2436
2.5		0.45	2.138	2.013	2.10	0.2436
3.0		0.50	2.599	2.459	2.55	0.2706
	3.5	0.60	3.010	2.850	2.95	0.3248
4.0		0.70	3.422	3.242	3.30	0.3789
	4.5	0.75	3.878	3.688	3.80	0.4059
5.0		0.80	4.334	4.134	4.20	0.4330
6.0		1.00	5.153	4.917	5.10	0.5413
8.0		1.25	6.912	6.647	6.80	0.6766
10.0		1.50	8.676	8.376	8.60	0.8119
12.0		1.75	10.441	10.106	10.30	0.9472
	14.0	2.00	12.210	11.835	12.00	1.0825
16.0		2.00	14.210	13.835	14.00	1.0825

ISO Metric Threads - Coarse Pitch: Bolts Dimensions : mm

Nominal diameter choices		Major diameter		Effective diameter		Clearance drill
1st	2nd	max	min	max	min	
1.0		0.982	0.915	0.820	0.767	1.2
	1.1	1.082	1.015	0.920	0.867	1.3
1.2		1.182	1.115	1.020	0.967	1.4
	1.4	1.382	1.307	1.187	1.131	1.6
1.6		1.581	1.496	1.354	1.291	1.8
	1.8	1.781	1.696	1.554	1.491	2.2
2.0		1.981	1.886	1.721	1.654	2.4
	2.2	2.180	2.080	1.888	1.817	2.6
2.5		2.480	2.380	2.188	2.117	2.9
3.0		2.980	2.874	2.655	2.580	3.4
	3.5	3.479	3.354	3.089	3.004	4.0
4.0		3.978	3.383	3.523	3.433	4.5
	4.5	4.478	4.338	3.991	3.901	5.0
5.0		4.976	4.826	4.456	4.361	5.5
6.0		5.974	5.794	5.324	5.212	6.6
8.0		7.972	7.760	7.160	7.042	9.0
10.0		9.968	9.732	8.994	8.862	11.0
12.0		11.966	11.701	10.829	10.679	14.0
	14.0	13.962	13.682	12.663	12.503	16.0
16.0		15.962	15.682	14.663	14.503	18.0

3.2.3.4 Drop-in Liner Systems

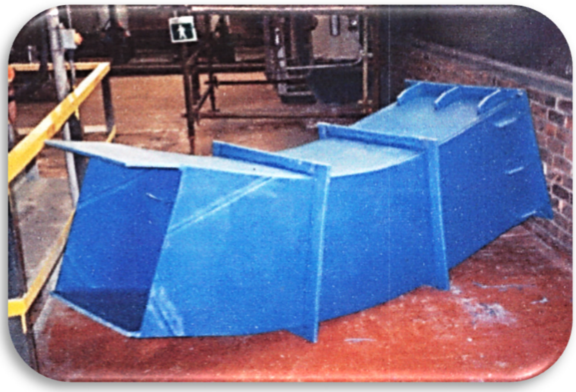


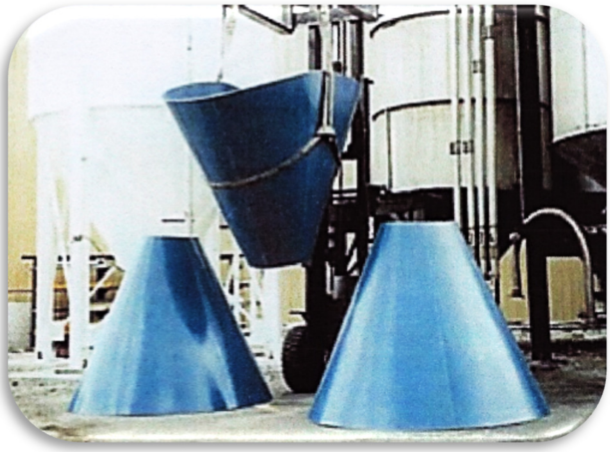
- One piece drop-in liners are generally used in smaller hopper types such as small cones and rectangular tapering hoppers, for example bagging machines.

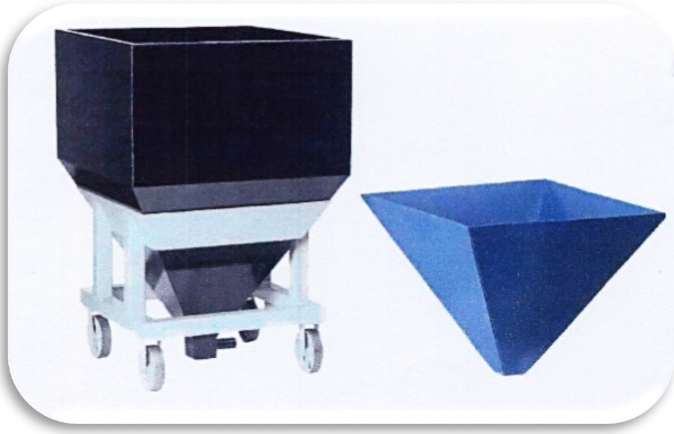
- Panel sections are welded together to create a seamless drop-in liner normally without any fixtures required in the flow stream.

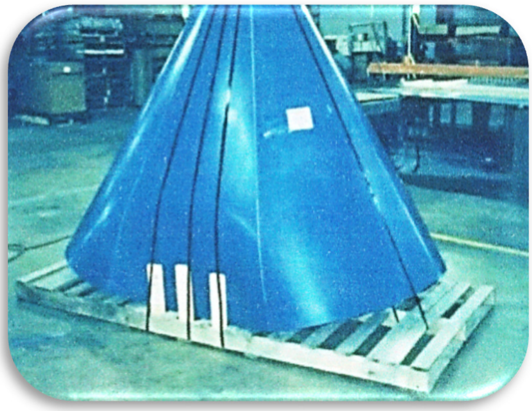
- Capping such as rolled square bar or an overlapping strip can be welded / bottle above the top edge for protection.

- It is require for at least one certified plastics welder to be present on site when an installation requires extrusion welding, as this is a specialised process and the quality of welding is extremely important.



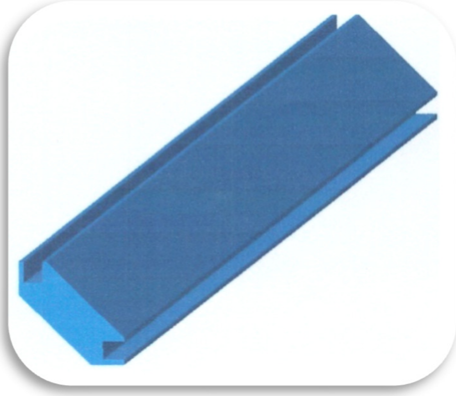






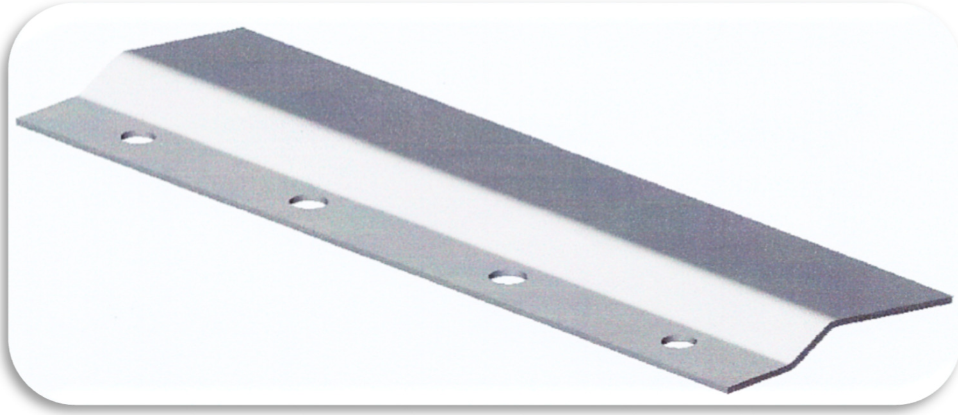
3.3 Additional necessities & specifications for installations

3.3.1 Corner pieces



Machined corner pieces are expensive to manufacture and are only feasible to use when structures have long valley corners, which mean that long production runs of the profile, is possible. These items are manufactured from thicker material than the liners itself and is also bolted to the substrate or held in position with special sliding joints. These items are made to order per installation.

3.3.2 Cover / Capping strips

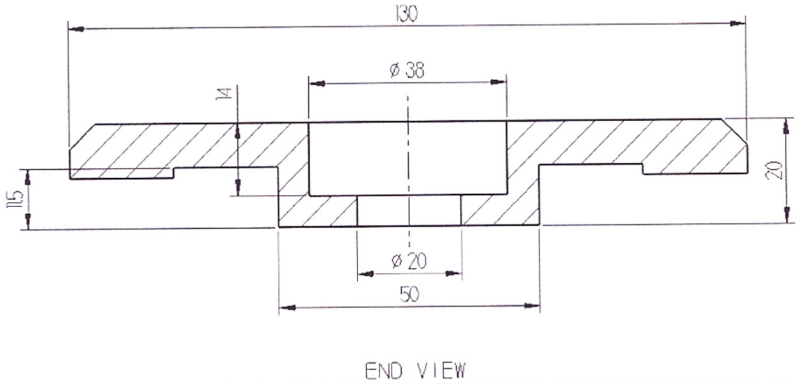


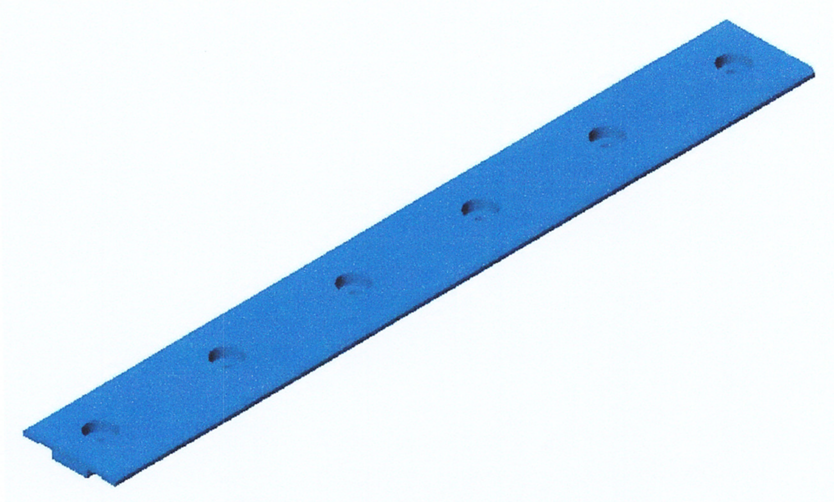
Capping strips are manufactured from stainless steel (different grades available) and bent to a standard profile. Some applications require the strips to be welded to substrate (use 308L or 309L low hydrogen welding rods) and others should be bolted by means of M8 cup square bolts. These strips protect the leading edge of the liners from extensive wear & bulk material migrating behind said liners.

Capping strips for conical bins are normally custom made for the specific circumference of each bin.

About 50 mm clearance is required above top edge of liners for installation of capping strips.

3.3.3 T-Fixing / Centre Strips





T-Fixing strips are used mainly on truck body linings when joining two adjacent sheets in the length. This allows the sheets to expand and contract freely, yet allowing no bulk material to migrate underneath the sheets. The same strip fastening method can be used in other applications to minimize fixture usage.

Fixing the strips to the substrate can be done by either drilling and bolting or stub welding as shown in sections 3.2.2