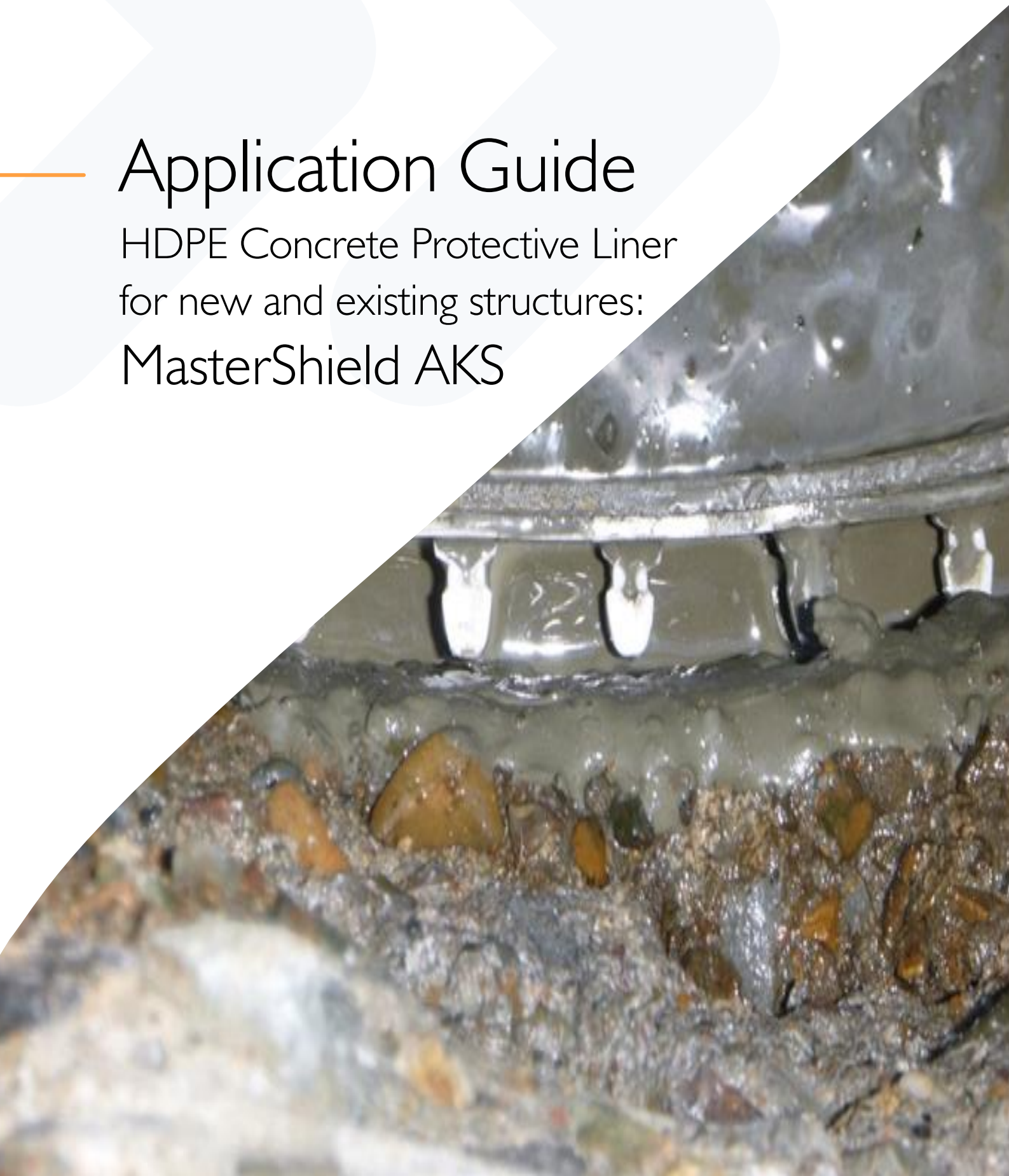
MASTER® BUILDERS SOLUTIONS

Application Guide

HDPE Concrete Protective Liner for new and existing structures:

MasterShield AKS



Contents

GENERAL

This application guide applies to the MB Solutions Australia Pty Ltd, Concrete Protective Liner (CPL) system, known as **MasterShield AKS** brand family (formerly BluSeal AKS). This application guide shall be read in conjunction with all project specifications (including drawings) -by others- and the current material Technical Data Sheets (TDS) and Safety Data Sheets (SDS). Should any of our recommendations need further elaboration or explanation, please contact Master Builders Solutions for additional advice.

Product Info

MasterShield AKS is supplied in rolls, flat sheets or prefabricated, depending on project needs. It can be customised for larger orders to meet specific client requirements, including color, thickness, width, and length. The general packaging details are as below table:

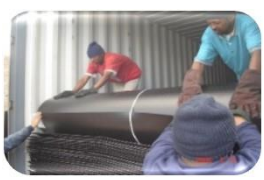
Renamed Brand	Type	Thickness mm	Width m	Length m	Nominal Mass kg per m^2
MasterShield AKS	HDPE Anchor knob sheet	2.0-10.0	2.0-3.2	1.0-26.0	2mm: 2.47 2.5mm: 2.94 3.0mm: 3.42 4.0mm: 4.35 5.0mm:5.31 10.0mm:10.00

MasterShield AKS KNOB

Width and Length: MasterShield AKS can be produced in any width up to 3.2m. Standard stocked widths in Australia are 2.6m and 3.0m.

- **Thickness:** from 2 to 10mm. A 2.5mm thickness is the most cost-effective option for delivering a 100-year service life in corrosion protection of sewer structures.
- **Minimising Wastage:** Consider structure dimensions when determining widths and lengths to reduce material wastage and welding requirements.
- **Color:** Standard range: Black, Grey, light green and white. Other colours also available as Made To Order.
  Pale-coloured MasterShield AKS includes short-term UV protection for up to 2 years during transport, temporary storage, and pre-fabrication.
  For extended UV exposure or operation, use MasterShield AKS Black, which provides full UV protection.

- **Transport:** Flat sheets are ideal for shipping containers. Sheets are packed with knobs and smooth sides facing each other to optimise space. 6.0m or 12.0m containers accommodate flat sheets of 5.9m or 11.8m respectively.



- **Pre-cast concrete pipes:** 2.4–3.0m lengths benefit from single panel lining. Sheets can be coiled and packed horizontally or vertically in Hi-Cube containers (allowing coils up to 2.6m).

- **Tailor-made orders:** MasterShield AKS can be customised for larger orders to meet specific client requirements, including color, thickness, width, and length. The material can be supplied to installers in either coiled or flat sheets, depending on project needs.

Ancillary Products

MasterShield AKS SMTH

- Master Builders Solutions can supply smooth HDPE sheet in the same thickness and colour as the MasterShield AKS anchor knob lining. This sheet can be cut and bent to fabricate such items as cover strips, corner angles and pipe sleeves.
- Alternatively, the installer can remove the knobs from the MasterShield AKS to provide a smooth sheet for cover strips and corner pieces.

MasterShield AKS FLC

- Smooth HDPE Fleece-Back sheet is a composite product consisting of smooth HDPE sheet with a fleece geofabric heat-cast into one face.
- The fleece side can be coated with an epoxy resin such as MasterStrength 1444/1446/1475 or MasterStrength 2525 and adhered (on the fleece surface) to surfaces of concrete, Steel, PVC, or GRP. This in turn provides a HDPE surface onto which the MasterShield AKS can be welded and closed onto these non-HDPE surfaces and provide a gas tight seal for corrosion protection.
- The HDPE smooth fleece back sheets are manufactured in 3.0-5.0mm x 3.0m x 1.5m sheets.

MasterShield AKS ASLIP

- Master Builders Solutions can supply Anti-slip HDPE sheet in 3-5mm thickness and in the same colour as the MasterShield AKS anchor knob lining.
- Anti-slip HDPE sheets are manufactured in 1.0-3.0m width and 1.0-15.0m lengths and can be cut and bent to the desired size and shape.

MasterShield AKS WLDRD

- Master Builder Solutions supplies 4mm and 5mm welding rods for Hot Air Blowers and Speed Welding.

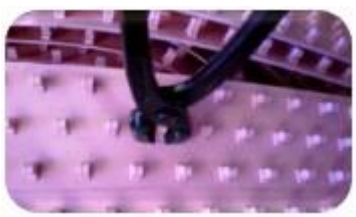
Application Requirements

- **Training:** The effective functioning of any Concrete Protection Lining (CPL) system is largely dependent upon the design detailing, quality of the installation, welding and Quality Control performed by the installer.
  All work shall be carried out by adequately trained and skilled applicators/installers, under appropriate supervision. Master Builders Solutions has established its own installation course through Partec in Queensland.
- **Safety:** Always ensure the appropriate use of adequate PPE (gloves, goggles, long sleeves etc) and comply with all other safety related requirements when applying Master Builders Solutions materials.
- **Handling of Rolls or Sheets:** The benefits of having large sheets or rolls of lining material should be considered in conjunction with its handleability. The Product Info table shows the weight per square meter of MasterShield AKS, various thicknesses.
- **Quality Systems:** The applicator shall operate under a fully compliant quality system, to ensure the on-site quality of applied material. The applicator shall keep fully documented work records for all works undertaken.
- **Quality Control:** The jointing and testing of any geosynthetic lining should only be undertaken by fully experienced installers with qualified welding technicians, using appropriate equipment. Quality Control must be an integral part of every geosynthetic / corrosion protection lining installation. Do not underestimate the importance of correct installation procedures and jointing details. The quality of a liner system can be no better than the quality of the welded joints and the sealing around penetrations. If after application and/or testing, any applied material is deemed as unsatisfactory by the specifying consulting engineer and/or MB Solutions Australia Ltd, it may need to be rectified at the applicator's cost. Refer to: QUALITY ASSURANCE & TESTING PROCEDURES" section of this document.
- **Responsibility of Installers:** The comments and advice made in this guide are intended to assist installers to achieve the best possible quality of CPL installation. The advice provided is based on our experience in a range of applications, under various conditions and with a variety of welding and testing equipment. The installer is always responsible for ensuring that the methods employed on site are compatible with the prevailing conditions and equipment to be used. Please contact Master Builders Solutions with any queries.
- **Selection of material:** When selecting a CPL there is a simple but important list of operating conditions which must be clarified to ensure that the demands on the liner will be within the capabilities of the material you are choosing. Variables such as Operating environment, chemical conditions, temperature range and variance should be taken to account.
- **Design and Planning:** Design must be completed in accordance with the lining manufacturer's Installation manual and/or the German Standard DVS2227. Detail design must be complete prior to commencement on site.
- For further info and details on selection of material, design and technical details, please Refer to: "**MasterShield AKS Design Manual** "or consult Master Builders Solutions.

WELDING METHODS

- Asset owners require an installed CPL system which provides total protection to their concrete structures. A failure in jointing is a failure of the whole system.
- The jointing performance relies on several points and each of these must be taken as extremely important. True welding will only take place when the correct temperature is applied, for the correct amount of time and under the correct pressure. To achieve this, experienced technicians must be employed, who know how to deal with each situation and condition, appropriate equipment, in good working order, and use welding rod which is compatible with the liner used.
- Whilst a variety of welding methods is widely used around the world, the condition under which the welding is performed is unique to each application.
- Three permanent welding methods are commonly used to joint MasterShield AKS. They are extrusion welding, double hot wedge welding and butt welding.
- This section covers the welding methods employed in jointing MasterShield AKS starting with Excursion Welding, which is the most used in-situ welding method.
- Wedge Welding and Butt Welding are commonly used in the prefabrication of MasterShield AKS and are both considered permanent jointing systems.
- Each of these has its own strengths, making it vital that the most appropriate method is used for each application.
- Ancillary Welding methods are also discussed including Hot air tacking and Speed Welding which are used only as temporary welding techniques but can play an important preliminary role in ensuring the final weld quality.
- The jointing of MasterShield AKS follows very similar procedures to the normal jointing of smooth HDPE liners.
- As MasterShield AKS is manufactured of premium quality resins, which conform to the standards required by GRI-GM13, and as CPLs are normally thicker that smooth liners; adjustments must be made to pre-heating temperatures and both the width and thickness of extrusion weld beads when comparing to thinner smooth sheet. Good quality welds will only be achieved on clean and dry surfaces.
- The utmost care must be taken to ensure that the MasterShield AKS lining is not placed in any area where it can become contaminated by e.g. oils. Even poorly set diesel engines such as generators can emit oily fumes onto plastic liners. These oily deposits will severely affect the quality of the weld.
- The liner will need to be thoroughly cleaned with detergent before welding can be carried out in such situations. The same care must be taken with form-release oils.

Anchor Snippers



- To remove MasterShield AKS anchors without causing damage to the lining it is important to have use equipment which will maintain a cutting height slightly above the lining base thickness.
- Master Builders Solutions can supply a modified router, fitted with guide plates that will guide it along the MasterShield AKS anchors and prevent over-cutting into the lining.
- Anchors can also easily be removed using hammer and a sharp carpenters chisel.

Extrusion Welding

- Extrusion welding machines create a weld seam by converting solid welding rod into molten extrudate, which is deposited through a shaped Teflon shoe onto the edges of the liner being joined. The surfaces are preheated by a hot-air blower mounted in front of the welding shoe.
- These machines must have two temperature controls: one for preheating the surfaces and the other for controlling the extrudate temperature.
- The welding rod must be manufactured from the same raw materials as the MasterShield AKS sheet to ensure identical physical and chemical properties.
- The choice of extruder depends on the application. Larger machines provide higher output but can be heavy and impractical for welding in confined areas or handling complex details.
- Experienced installers of MasterShield AKS often use a mix of large and small machines for flexibility across various applications.
- Extrusion welding is the most versatile method for jointing, ideal for on-site welding. It is the only method capable of joining sheets after they have been cast into concrete.
- Various weld details such as butt, overlap, and internal or external corners; can be achieved using different Teflon shoe shapes and designs.
- Typical extrudate usage for overlap extrusion welding is 5-6 meters per 1kg of welding rod, with extrusion rates ranging from 0.5 to 0.7 meters per minute, depending on the machine's output and the welding bead shape.

Heavy Duty Extruders

- Heavy duty extruders have an output of 4-6 kg/hr and weigh between 10kg -14kg.
- Based on a typical overlap extrusion weld for MasterShield AKS 2.5mm thick this equates to 25-35m of weld per hour.
- Most heavy-duty extruders will take both 4mm and 5mm welding rod. An example of a heavy-duty extruder is the Leister S6.
- Heavy duty welders are most suitable for welding joins on floors where the technician does not need to support the weight of the machine.

Light Weight Extruders

- For detailing and confined space work small light machines are important.
- The quality of the weld is highly dependent on the skill and diligence of the operator.
- To complete complex detailed work particularly in situations where the operator must bear the weight of the machine for long periods, a small light extrusion machine will often produce the best results. Examples of the lightweight extruders are the Leister S2 and Fusion 3C. Another good extruder for detailing works is the Munsch MA25B. The machine is light and easy to use and has variable output control. It is good for welding in tight spaces and is very low maintenance.

Welding Rod

- The welding rod to be used for extrusion weld jointing must be compatible with the lining material (colour, MFI, resin UV additives, antioxidants, etc) produced to quality standards regarding dimensions and freedom of air inclusions.
- Welding rod must be stored in a clean and dry environment. Welding rod which has been stored in damp conditions may absorb some moisture from the environment - especially if it is black welding rod, as this contains carbon black which is hygroscopic.
- When extruding the damp rod, moisture within the material will be heated and converted into steam, which causes bubbles in the extrudate and a rough surface appearance as though sand has been sprinkled on the weld. This will be unsightly and can cause failure.

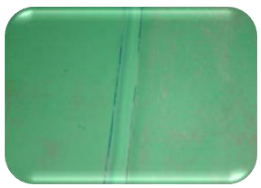
Extrusion Weld Configurations

- The fundamental principle in welded connections is that the weld should not be a weak point in the system and testing should show that the weld itself is stronger than the lining material it is joining. It is therefore important to remember that the thickness of the lining governs the weld shape for each type.
- Generally, at the intersection of the parent material and weld, the thickness of the weld should be at least as thick as the lining itself above the lining. It does not mean that the thicker the weld the safer or better. Due to differential cooling a thick weld may have induced stresses within it which make it weaker than a well dimensioned weld.
- It is critical that the Teflon welding shoes are replaced regularly to avoid worn shoes producing a flatter, thin extrusion weld. Refer to “Detailing” section for weld configuration details.

Flat Extrusion Overlapped Weld

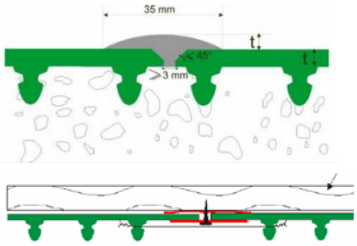
- This is the most employed weld in applications such as sewers. Precast concrete pipes will either have an overlap piece cast-in or will require a cover strip, both of which will require one or two flat extrusion overlap welds respectively.

Flat Extrusion Butt Jointed Weld



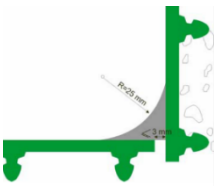
- Sheets of MasterShield AKS can be butted together on formwork
- The gap between the two sheets should be no more than 3.0mm.
- This limit is common for all the remaining weld types and is to limit the extraction of heat from the weld by the concrete.
- Concrete at this joint will affect the preheating and it has been shown that for gaps larger than 3.0mm the resulting joint will not be as strong as the parent lining and is therefore of inferior quality.

- Where gaps are likely to be greater than 3.0mm due to the formwork installation process it is recommended to utilise a cover strip over the joint, with two extrusion welds, or to overlap the sheets by around 50mm and apply one extrusion weld.
- Use of ALS H-profile will prevent the concrete from acting as a heat-sink and therefore assist in creating a better-quality weld.



Inside Corner Welds

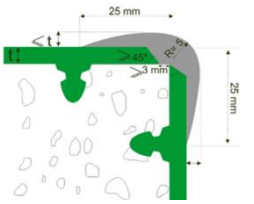
- Where possible, corners should be thermoformed to avoid having to extrude welds into the corners and execute more difficult surface preparation. There are certain situations where a corner weld is necessary (circular intersections with a horizontal plane being one).



- Preparation works in these situations is often more awkward and difficult to execute correctly than flat extrusion welding so extra care should be taken.

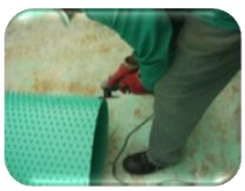
Outside Corner Welds

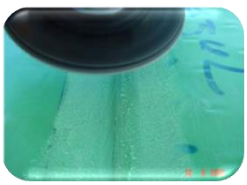
- Outside corner welds are the most difficult welds to execute as adequate preheating can be difficult.
- The use of an additional hand-held hot air blower can be beneficial in executing these welds. The maximum gap between lining sheets should be 3.0mm and the lining edge chamfered.



Extrusion Weld Preparation

- The edge of the lining to which an extrusion weld will be applied should be chamfered to avoid a stress peak in the bead.
- For overlap welds, the edge of the top sheet must be chamfered at approximately 30 to 45-degree angle prior to hot air tacking the lining in place.
- It is best to chamfer the edge of the top sheet before tacking the two sheets together to prevent over-grinding into the bottom sheet when grinding the edge.
- In a butted weld the two adjoining sheets should be chamfered.





- Once the top has been tacked in position so that it fully adheres to the base; grinding of the surface oxidation layer must be completed. Grinding the lining is essential for extrusion welding due to oxidation of the surface of the HDPE lining. If grinding is not done the extrudate cannot bond properly with the molecules of the base material and the weld will fail.
- Excessive grinding has a negative side. It makes the lining thinner, and thus weaker.

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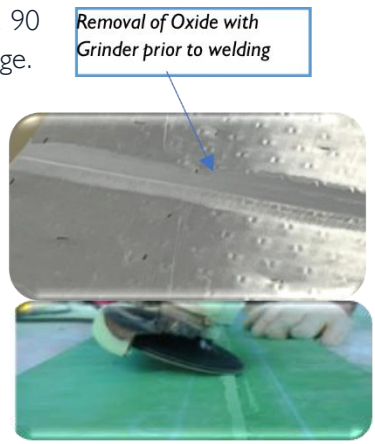
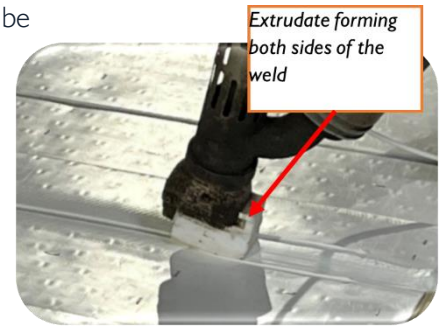
- Excessive grinding has a negative side. It makes the lining thinner, and thus weaker.
- HDPE is "notch sensitive" which means stresses will concentrate in grooves or next to thickness changes. Grinding can therefore increase the risk of failure if not properly executed. Grinding should not remove more than 10% of the sheet thickness. The oxidation layer is very thin, and only the surface of the HDPE lining must be removed.
- The importance of grinding should not be underestimated. The operator must be as competent in grinding as in welding.
- Grinding should be completed using a hand-held orbital grinder with 80 grit sanding disc and rubber backing disc. Make the grinding the same width of the weld bead. Guidelines can be drawn (chalk line or marker) to assist in maintaining the correct width.
- Where possible the orientation of the grinding marks should be at 90 degrees to the edge of the sheet; particularly towards the weld edge. This is important in preventing weakening of the lining surrounding the joint.
- Depth of grinding should be kept to a minimum. Grinding should be limited to the oxidised surface.
- In summary. the preparation sequence is as follows:
  - Chamfer edge of top sheet at 30 to 45 degrees.
  - Hot air tacking
  - Grinding of oxidation layer



Extrusion Weld Execution

- In addition to machine output, the welding speed that can be achieved is dependent on the flow rate of the extrudate, the material thickness, the cross-sectional area of the seam and the size and design of the welding shoe.
- Maintaining a consistent angle of the extruder in relation to the joint is extremely important, to ensure an even pre-heat of the substrate and an even flow of the extrudate. This angle must be kept consistent throughout the welding process to ensure preheating remains constant.
- If incorrect parameters are used, (i.e., too cold) the surface of the weld will be very rough and irregular in appearance and the resulting weld will have low bond strength.
- If the weld is too hot, the surface will have a shiny look and the weld will again have low bond strength. A similar effect can be observed adjacent to the weld due to excessive preheating.



Extrusion Equipment Settings

- Extrusion welders are designed to ensure that certain parameters are accurately defined to ensure the weld quality, and are variable so that adjustments can be made to allow for changes in ambient conditions these parameters are:
  - Temperature of the welding material (extrudate)
  - Mass flow rate of the welding material
  - Temperature of the air for substrate pre-h eat.
  - Quantity of air for substrate preheats.
- Optimum temperature settings for both extrudate and preheat are dependent on ambient conditions. Weld trials should always be conducted, as outlined in the following section of this guide, to determine the correct settings for a given environment.
- The executions of trial welds are essential to confirm that the settings selected are adequate.
- A pyrometer with probe is an essential piece of equipment that each welder should use to confirm the actual temperatures of the hot air blower and the extrudate and compare them with the settings on the equipment. This should be done before any production welds are done.
- In summary:
  - Start and end extrusion welds on scrap material.
  - Use and maintain equipment settings that have been verified by testing.
  - Purge the extruder as required.
  - Maintain consistent welding angle to ensure adequate preheat.
  - Follow testing procedures outlined in the following section of this guide.
  - Refer to “Detailing” section for welding configurations of Pipe penetrations, Top of wall details, Sealing of steel connections as well as typical welding detailing.

Welds inspected for:

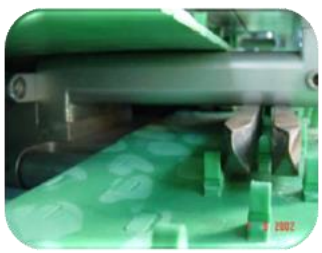
- excessive squeeze out
- weld shape conformance
- footprint / width
- colour
- evidence of air bubbles
- change of surface texture
- extensive heat deformation
- folds
- foreign matter
- and general appearance

Wedge Welding

- This method is used for the prefabrication of MasterShield AKS into large panels on-site prior to installation.
- In this process two sheets are overlapped by 40 mm and a hot metal wedge is drawn between the overlap, heating the surfaces of the MasterShield AKS sheets, and pressing them together between pinch rollers immediately behind the wedge.
- Two parallel welds are formed in the process, separated by a channel of unwelded material.
- This is the fastest method of welding, and it also greatly simplifies the joint testing process as the gap between the welds can be pressurised to test the weld integrity in a quick and simple process.
- It is suitable for welding MasterShield AKS sheets up to 3mm thick.
- Modified wedge welding machines are used to accommodate MasterShield AKS anchors, as the anchor spacing differs in the X and Y directions.
- Wedge welding is ideal for prefabricating large panels wider than 3m, improving productivity and allowing weld testing to be conducted in advance or post-installation.

Preparation for Wedge Welds

- Grinding of the oxidation layer is not required for wedge welding as it is for extrusion welding. This is because the wedge itself removes the oxidised layer prior to fusion by the rollers.
- The necessary preparation is cleaning and removal of the anchors. This is best performed by way of an anchor stripping machine guide.
- Once the anchors have been stripped the lining surfaces in the weld zone must be thoroughly cleaned.
- Any dirt or oils can seriously affect the integrity of the weld.



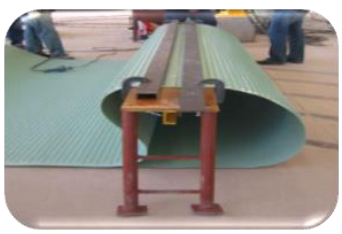
Wedge Weld Execution

- When the machine has reached its set temperatures it must be quickly positioned between the two sheets, the wedge slid into position, the pinch rollers engaged, and the drive mechanism activated. The wedge welder cannot effectively weld at the leading edge of the panel and so the initial portion is left un-welded. This portion is either within the trim area or will need to be extrusion welded to complete the panel.

Wedge Welder Equipment Settings

- There are three main parameters which can be altered on a wedge welding machine: wedge temperature, roller speed, roller pressure. Equipment settings vary widely with the type of machine and extensive testing should be undertaken to determine optimum speed and temperature combination.

Butt Welding



- Butt welding equipment is ideal for the prefabrication of MasterShield AKS which is to be positioned on the forms used to manufacture pre-cast concrete pipes.
- Butt welding equipment is being successfully used to weld MasterShield AKS 2.5mm thick and upwards.
- Although this type of equipment is far more expensive than wedge or extrusion welders, it has a special function and will provide excellent quality welds and greater efficiency when the applications justify it.
- Butt welding is used in factory prefabrication of MasterShield AKS.
- In this process, two sheets are laid alongside each other with their edges inserted into the welder.
- The welder automatically heats the edges, removes the heating element, and presses the sheets together which fuses the molten plastic along each edge.
- Butt welding is the most efficient form of factory welding and is the fastest and neatest welding method available.
- Prior to installing the tube into forms, the excess material on the smooth side may be removed to ensure a tight fit on the mould and to avoid possible flow disruption.

Ancillary Welding Methods

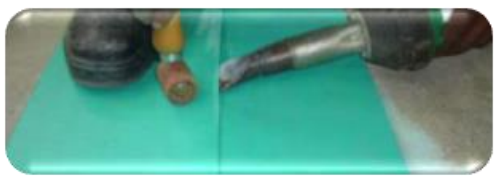
Hot Air Tacking

- The application of hot air between two HDPE surfaces followed by pressure can be used to "tack" the sheets together prior to welding.
- Hot air tacking will fail under relatively small loads and therefore should never be considered as a permanent jointing system of MasterShield AKS systems but can be very useful for preliminary alignment or to exclude moisture prior to extrusion welding.
- Prior to the execution of any extrusion welding to overlapped sheets, temporary tacking should be carried out. This ensures that the two sheets to be extrusion welded are positioned correctly with no gap between them along the length to be extrusion welded. This is critical to the success of subsequent extrusion welding as any gap between the sheets could cause localised thinning of extrudate and potential failure of the weld.

Preparation for Temporary Tacking

- The surface of the two sheets must be dry and clean and especially free of oil. There may be grout material between the two surfaces. This should be removed and can be done so with a paint scraper or wire brush. A cloth can then be used to clean between the two surfaces and the air-blower can also be used to both dry the surfaces and remove any remaining dust.
- Overlaps should be kept to a minimum.
- Creases or folds on the top sheet should be cut back until it can lay flat on the bottom sheet. Depending on the length of this cut a patch repair may be required.

Hot Air Tacking Procedure



- The hot air blower should have a 40mm wide flat perforated nozzle attached and must be switched on, the heat is increased and be allowed to reach temperature.
- The nozzle of the blower is pushed between the sheets with the perforations pointing towards the top sheet. The main airflow will be directed to the lower sheet, while the top sheet is also being pre-heated.
- The operator pushes the end of the nozzle to the full depth of the tack weld.
- With their free hand the operator uses the roller to press the preheated materials together forming a bond as the nozzle is withdrawn towards the edge of the sheet.
- The roller is used to press the two sheets together and then repeated along the joint.
- The use of blunt objects such as hammers and knife handles, timber is not recommended practice. Such objects can contaminate the weld area. Rollers are the best way to execute the process correctly without causing damage to the lining.
- Once hot air tacking is complete a visual check of the weld and knife edge run along the joint can determine if the tack has been completed correctly.

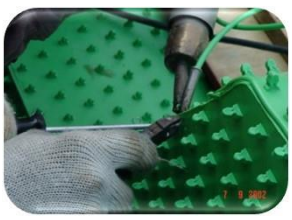
Hot Air Tacking Equipment Settings

- The common hot air blowers do not have temperature gauges, and the temperature required to successfully tack two surfaces together will vary considerably depending on ambient conditions and lining temperature. For instance, the temperature setting required for tacking material that has been in the sun during a hot day will be different from that required in an underground tank in a cool climate.
- The TRIAC S has a temperature range of 20 to 700°C.
- As a general rule the operator should use the minimum amount of heat necessary to partially melt the two surfaces and form a bond. Overheating should be avoided.

Note: Hot air blowers must be carefully handled. Elements become more brittle when hot and impacts during this time can cause failure. The element should always be turned off before the blower and allowed to cool down before storing. A hot nozzle can cause fire!

Temporary Speed Welding

- Speed welds are not considered suitable for permanent and safe jointing of MasterShield AKS sheets but can be very useful for preliminary alignment or to exclude moisture prior to extrusion welding.
- Speed welds are created using a hot air blower with a speed welding nozzle attachment.
- Welding rod is fed into a receptacle in the attachment and the hot air channelled to meet the welding rod at the end of the nozzle. When placed in contact with the lining the hot air melts the welding rod and fuses it to the lining material.
- Speed Welding is commonly used in prefabrication of complex shapes that will be cast in-situ. The weld can both maintain alignment during casting and prevent liquid and fines from leaking through the joint.
- Speed welding can be used to close observation or vibrator access windows in the lining.
- Speed welding can also be used on site to provide temporary and fast fixing of the MasterShield AKS sheets to hold them in place while being securely fixed in position.
- The surface of the lining must be dry and clean and especially free of oil and dust.
- Welding rod should always be kept clean and dry. No surface grinding is required as this is a temporary weld.

Speed Weld Execution

- Fix correct nozzle to blower.
- Switch on air blower and allow to reach temperature.
- Preheat the lining at the speed weld starting point for a few seconds.
- Feed the rod through the receptacle to the end of the nozzle and apply pressure to fuse the welding rod to the lining joint.
- Once the end of the welding rod is fused in place the operator moves the speed welder along the joint at a rate that allows the rod to fuse to the lining as pressure is applied. The welding rod will be drawn through the speed welder as the operator moves it along the joint.
- If the rate is too slow the lining will be damaged so careful operation is required.

Equipment Settings

- The air blower temperature should be at approximately 250°C.
- Visual inspection of these temporary welds is sufficient.
- Any speed welding must be followed by permanent extrusion welding for permanent jointing of MasterShield AKS.

APPLICATIONS- NEW STRUCTURE

Concrete Mix Design & Placement

- Concrete shall be prepared in accordance with the MasterShield AKS Guidelines.
- Placement of concrete and stripping of formwork should be supervised by trained installers.

Slump

- Concrete slump should be selected to suit the placement and vibration methods to be used.
- Low Slump Applications: MasterShield AKS has been successfully applied in pipe production using automated vertical dry-cast and horizontal spinning methods, both of which utilise very low slump concrete with intense localised vibration to ensure full anchor encapsulation.
- Limited Access for Vibration: For applications with restricted access, concrete with a very low slump (50–75mm) is not recommended due to the risk of void formation behind the lining.
- Recommended Slump: A minimum slump of 100mm is recommended for installations where MasterShield AKS is fixed to formwork without external vibration, and where the height of the pour exceeds 1.0m.

Aggregate Size

- While concrete workability depends on the grading of aggregates, sand content, and cement quality, there are no special aggregate size requirements when using MasterShield AKS as a Concrete Protection Liner (CPL).
- The nominal aggregate size must be smaller than the narrowest flow path, such as the section thickness or the spacing of reinforcing steel.
- Proper aggregate selection will help produce a dense, void-free structure, avoiding “honeycombing.”

Concrete Strength

- The concrete mix should meet the structural requirements of the project.
- The advanced anchor design of MasterShield AKS ensures the system does not rely on high-strength concrete for effective "pull-off" resistance.
- MasterShield AKS achieves a pull-off resistance of approximately 1.0 MPa. Concrete with a compressive strength of at least 20.0 MPa (approximate tensile strength of 1.8 MPa) is sufficient to maximize the liner's performance.

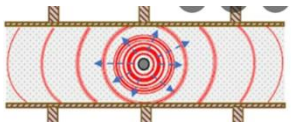
Height of Pour

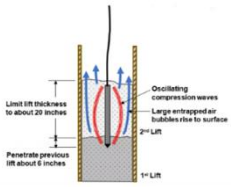
- The concrete mix workability and placement method must consider the height and thickness of the pour along with vibration access.
- For significant drop distances, a tremie pipe should be used to prevent free-fall and segregation of the concrete.

Note: Creating voids behind the MasterShield AKS must be avoided.

Vibration of Concrete

- The vibration energy required for proper compaction depends on concrete workability and vibrator placement.
- MasterShield AKS can be applied to steel formwork with external vibration, which has shown negligible damping effects from the liner.
  Trials should be conducted to determine the most effective vibration regime for the specific application.





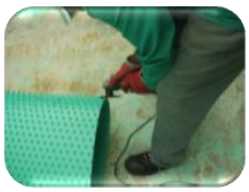
Curing

- Standard concrete curing processes can be followed when MasterShield AKS is installed.
- The lining acts as a moisture barrier, enhancing the curing process and improving overall concrete quality.
- For precast steam curing, temperature control is critical. Excessive temperatures may cause liner expansion and create ripples.
- Recommended temperature limit is 50°C, particularly at the top of vertical moulds or liner overlap areas where temperatures may peak.
- For temperatures exceeding this limit, consult Master Builders Solutions.

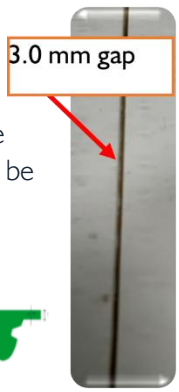
AKS Installation Process

Preliminary Preparation

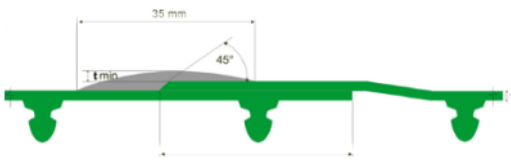
- The MasterShield AKS approved installer must either train form-workers in the correct processes or strictly supervise the fixing of lining to the formwork.
- MasterShield AKS is supplied in flat sheets or rolls in sizes as ordered by the installer.
- The installer should prepare a cutting schedule before finalising his required sheet sizes in order to minimise wastage and the number of joints to be welded on site.
- Full sheets should be used wherever possible. Master Builders Solutions will assist the installer as far as possible by supplying sheets to the required panel sizes.
- MasterShield AKS is stocked in Australia in 3.0m x 26m and 2.6m x 26m rolls. Should the required sizes be larger than the maximum sizes manufactured; lining sheets can be supplied which can be efficiently jointed.



- Refer to "Wedge Welding" or "Butt Welding" sections to reach the required panel sizes.
- Removal of knobs, heat bending and applying appropriate tension are key elements for successful installation.
- Careful attention must be paid to the sizes and accuracy of cutting to avoid excessive gaps between the panels. The maximum allowable gap at joints between sheets is 3.0mm, without use of a cover trip.



- Using the extrusion weld to bridge excessive gaps will lead to poor quality joints as the heat conducted by exposed concrete affects the proper preheating of the surfaces to be welded.
- The use of nominal 50mm overlaps in the sheets is recommended as it improves the alignment of the joints and eliminates leakage of concrete through the joints. Knobs are removed along the overlap edge of the sheets.



- Should a 200mm capping strip be applied, the gap between sheets can be up to 100mm. The sequencing of lining installation is important to ensure minimal damage to work completed.
- The sequence of lining would be to complete the walls first before installation of MasterShield AKS to the base slab via the grouting method.

Formwork

Cleaning of Forms

- Forms should be cleaned before securing MasterShield AKS to avoid scratches and unevenness on the lining surface.
- Form release oils should not be applied when MasterShield AKS is attached to forms. There is no need for form release oils as the smooth surface of the HDPE will enable easy release.
- The use of form release oils can cause problems with the welding of the joints in the liner, so forms containing oils should be thoroughly cleaned to prevent contamination of surfaces of MasterShield AKS, to be welded.

Planning

- Proper planning will greatly enhance the outcomes and the quality of the finished product.
- The MasterShield AKS sheet layouts should be planned through the development of layout sketches of each surface of the structure. Sheet layouts should avoid seams in locations that will have brackets or other metal structures attached later.
- The extrusion welds will be pronounced above the surface and will hinder the tightening of brackets and plates.

Impact of Temperature

- MasterShield AKS HDPE has the following properties that relate to dimensional change:
  - Thermal expansion and contraction – 1.4mm per metre for every 10°C change in temperature.
  - Elastic elongation – 13%. (Sheet can be stretched 130mm per metre and still return to the original length)
- Concrete pours should be planned to be undertaken early morning at generally lower ambient temperatures.
- HDPE membrane should be secured to forms at higher ambient temperatures, generally later in the day.
- Once fixed to the formwork at the higher temperature; then as temperature drops, the HDPE will contract and stretch within the elastic 13% and become taut and flat against the form.
- Watch out for:
  - Direct sunlight can heat the formwork from a 23oC day could be 35oC on the formwork AKS will move around.
  - Consider shading while applying AKS.
- If concrete is poured at the high temperature, the membrane could be loose on the form and the rising concrete pour will push the liner up and may leave wrinkles in the cast-in product.

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- The important temperature is the temperature of the HDPE material (MT). This temperature is best measured onsite with an infrared thermometer.
- Every site and project will have a different temperature cycle over 24 hours depending on the location and season; however, the base temperature (BT) is the ambient temperature expected early morning at the time of pouring the concrete against that section of form.
- The AKS HDPE sheet will expand or contract around 1.5mm per metre length of liner every 10 degrees change in temperature of the sheet. This means that the 3.0metre wide sheets will reduce 4.5mm in width when temperature of the material changes from 30 °C to 20 °C.
- It shouldn't make any difference as to the dimensions of the sheets – the dimensional change per metre of liner is always 0.015% of the length every 1.0 °C change in temperature.
- The recommended process is:
  - Lay out the HDPE liner on the horizontal forms in direct morning sunlight.
  - Check when the MT reaches 10°C to 20°C greater than expected BT. (Excess MT may overstress the liner at nails when cooler on the form)
  - Flatten the sheet on the form and secure with nails.
- The sheet will continue to expand and loosen on the form as MT increases further through the day but will contract tight against the form as MT falls towards BT.
  - Mark the liner with the MT at the time of securing the liner on the form.
- The liner should always be inspected in place before pouring concrete to ensure the material is taut and flat against the form, as planned.

Fixing AKS to Formwork

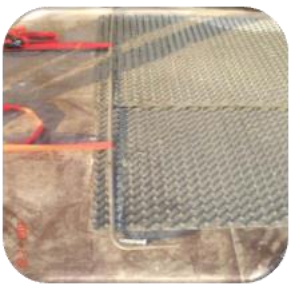
- The sheets must be well secured against the forms to avoid movement or displacement when the concrete is poured. Care must be taken to avoid damage to the lining, as any damage will need to be located and repaired.
- The use of nails to secure MasterShield AKS to the forms should be avoided where possible as the holes are extremely difficult to locate once the forms have been removed.
- If nails are necessary, they should only be located in areas that will be patched or welded subsequently.
- Wherever possible the lining should be secured to forms by tying it back by utilising the anchors.
- Inert ties are advisable to avoid creating a corrosion path. Where form ties are necessary these will hold the lining in place.
- The lining can be tensioned on forms in various ways. The photo shows two reinforcing bars locked in between the anchors on either side of a joint. A tensioning strap is then used to bring the two sides together. While in tension, the joint is speed-welded or laced closed with nylon line or steel binding before the tension force is released and the reinforcing bars are removed.

- MasterShield AKS can be tensioned on timber forms. In this case a bar fixed through the anchors is connected to two tensioning straps. The lining is secured along the top edge and tensioned. The lining is then fixed (in this case by nails along its edge which will be subsequently welded) before the straps are released.

Fixing to Circular Forms

- Membrane should be secured to circular forms by wrapping tightly around the form and tying it back to itself at the overlapping vertical joint with wire or strong fish line, utilising the anchors.
- The number of overlapping vertical joins will be governed by the lengths of membrane that can be practically handled into place around the circular form.
- Inert ties are advisable to avoid creating a corrosion path.
- A speed weld using a hot air gun and HDPE weld rod can also be used to further secure and seal the overlapping join.

- Where through bolts or Z bars are necessary these will also hold the lining in place.
- Following tensioning and securing of the lining at the joints external inert strapping may be tightened around the circumference for added security.
- A thin scrape coat or contact layer before building up to the required thickness, wet on wet, will improve the wet adhesion and cohesion of the mortar on a circular form the lining can be tensioned on itself before it is secured.
- Timber forms for a manhole chamber. Nails were used at the joints of the lining and only placed in positions where welds were subsequently executed.



- Following tensioning and nailing of the lining at the joints external strapping can be tightened around the circumference for added security.
- It is recommended that the MasterShield AKS approved applicator either install or at least strictly supervise the fixing of lining to formwork.

- If this job is left the other with no experience in lining works or no responsibility for the sealing of the lining, nailing and cutting of the lining will not be controlled and the chance of a failure will be significantly increased.

FormkTak

- A simple “peel and stick” adhesive strip is recommended to speed up the process of fixing the MasterShield AKS to the forms and to avoid damage which may be caused by other temporary fixing methods.

- Typically, the FormTak will be fitted to the perimeter of each panel of MasterShield AKS, with a strip positioned in the centre of each panel / diagonally across the centre, depending on the size of the panel, the thickness of the MasterShield AKS and the ambient temperature.

Z-Bar Ties

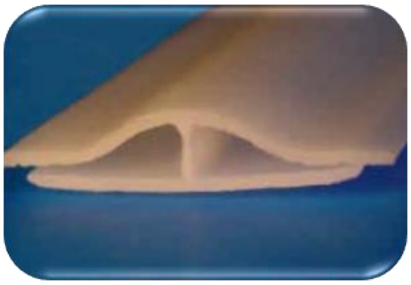
- MasterShield AKS should not be nailed or stapled to the timber formwork except where the nails are located:
    - Under future extrusion welds or cover strips at membrane joints.
    - In sacrificial membrane above the final pour level.
    - Below the lowest fluid level in the operational structure.
    - Around penetrations or tops of walls that will be covered later by HDPE fleece back.
- Around Z-bar tie rods that will be covered later by a circular patch.
- Use external bracing to avoid penetrations through the MasterShield AKS whenever possible.

- By maintaining tie bars positioned above the casting area no patching is required later. It is an important and recommended practice as it avoids making holes in the MasterShield AKS wherever possible.
- It is not always possible to avoid tie-rods through the forms and the lining. These will need to be patched following casting and form removal. The diameter of holes in the lining should be kept to a minimum.
- Even if the top row of tie-rods can be replaced by external clamping this will be of benefit in reducing the amount of patching required to the lining.
- Ensure the nailing around the Z -bar tie holes are only carried out when the membrane is taut on the forms (early morning).

- Galvanized nails of 50mm length with flat heads are recommended to be installed with a “framing” power nailing gun. Shorter flat head nails, if required can be applied by hand with a carpenter’s hammer.
- At formwork corners it is recommended to either nail the membrane against the edge of the forms within the future extrusion weld or tension the two faces of membrane at the corner by using rubber O-rings stretched around the corner onto the knobs at say 100mm centres.
- If the top row of ties can be replaced by external clamping this will be of benefit in reducing the amount of patching required to the lining. The diameter of holes in the lining should be kept to a minimum.

- Where diameter is maintained at 30mm or less, an extrusion patch is welded over the hole.
- When holes are greater than 30mm a circular patch repair of a minimum 200mm diameter will need to be welded over the hole. For the repair method refer to: “Closing of Tie Bars/Ferrules holes” section.
- The hole in the liner can be kept below 30mm by leaving the plastic cone formers in the concrete wall.
- Master Builders Solutions can also supply GRP tie bars that are cut flush on either side of the concrete wall and extrusion welded over. GRP tie bars provide an immediate watertight seal in water retaining structures. The tie rod aids in holding the lining on the forms, but the hole created requires patching.

H Profile for Temporary Joints



- To optimise the quality of extrusion welded joints the use of ALS H-profile is recommended as a temporary method for keeping the MasterShield AKS properly aligned.
- It also ensures that no concrete or fines can run between the edges of the panels and settle between the forms and the MasterShield AKS.
- Please note that this profile is a temporary method of holding the sheet together and is not intended to be used as a permanent joint under any circumstances.
- To fit the H profile, one or two rows of anchors may need to be removed from each edge of the MasterShield AKS panels.
- The smooth edges of the sheets are pushed into the profile so that they fit snugly against the Centre dividing rib.
- The H profile stays in place until the forms are removed.
- At this stage, the front strip is removed by starting a cut at the end of the strip and tearing it away from the joint.
- A further benefit provided by this profile is that the edges of the MasterShield AKS are kept clean where they are to be welded.

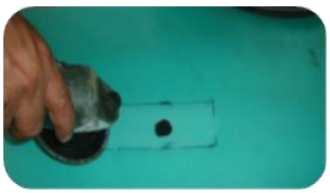
Fabricated Corners

- As MasterShield AKS can be very effectively shaped to corners by warming the surface with a hot air blower.
- This is a preferred method of fitting MasterShield AKS into rectangular shaped structures as it enables welding to be carried out away from the awkward corners.
- The exact position of the bend should be marked on the MasterShield AKS and appropriate rows of anchors removed if they interfere with the position of the bend.
- To create a neat bend, it is best to use cover strips of plastic or timber to shield the adjacent area from the hot air and enable the sheet to be neatly bent.
- Performing this type of detail is a skill which needs to be practised to ensure that the MasterShield AKS is warmed to the correct temperature.
- Trials should be carried out on offcuts of MasterShield AKS to determine the ideal temperature and heating time required, bearing in mind that this will also vary according to sheet thickness, colour and ambient temperature. These preformed corners should be prepared under workshop conditions to ensure uniformity of quality and shape.

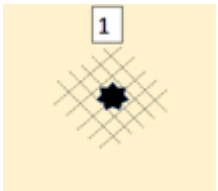
Removal of Forms

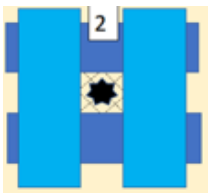
- When removing forms, take care not to damage the lining and only remove forms after the concrete has reached adequate strength.
- MasterShield AKS will greatly assist in curing of concrete after forms have been removed leading to improved concrete quality. The use of curing compounds is unnecessary.
- The timber forms will pull away from any nails used to secure the membrane before the pour.
- The protruding nails must be cut flush with the membrane before extrusion welding, taking care not to damage the membrane.
- Should any damage occur to the lining, ensure that these are clearly marked for repair later.

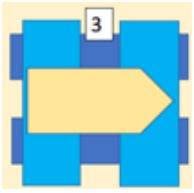
Closing of Tie/Ferrules Holes



- Prepare the surface around the damaged area by grinding or scraping to remove the oxidised material on the surface of the liner.
- Prepare a cover strip or circular patch of smooth MasterShield AKS sheet to cover the damage or Ferrule.
- Tack weld sacrificial loose lining at the edges of welding zone. It is recommended that the extrusion weld commences and ends on a sacrificial piece of smooth HDPE liner which is removed immediately after the repair is carried out.
- These sacrificial pieces are to be positioned at least 50mm away from the damage at both ends of the weld. This procedure ensures that the extrusion welding machine runs at correct speed and that pre-heating of the MasterShield AKS is consistent throughout the short repair.
- Deposit three extrusion weld beads within the marked area. Each weld bead should have a thickness equal to the thickness of MasterShield AKS being welded.
- The material should be allowed to cool for 5 minutes and the surface lightly grinded. The third welding run should then be completed over the centre of the hole.
- The temporary lining can then be removed.







- The repair method for holes greater than 30mm in diameter is as follows:

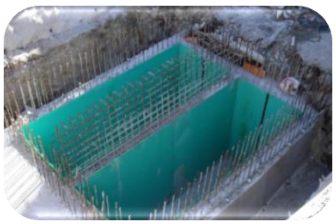
Closing of Tie Bars/Ferrules Holes with a Patch

- Prepare a cover strip or circular patch of smooth HDPE sheet compatible with MasterShield AKS liner to cover the damage. Circular patches must be at least 300mm diameter with 150mm radius ends and strips must be at least 200mm wide.
- No square or rectangular patches are to be used as 90° corners can lead to pin holes where extrusion welds intersect.
- Tack weld the patches over the damages, using a hot air blower and flat nozzle.
- The patches must overlap the damages by at least 25mm at any point. Patch edges must be chamfered at 45°.
- Prepare the surface to be welded by grinding or scraping to remove the oxidised material on the surface of the liner and patch.

AKS Installation to Vertical Walls

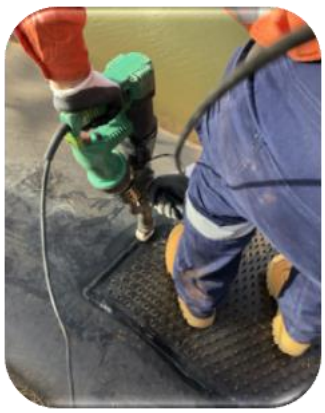
- Prepare the MasterShield AKS sheets to the required sizes per the cutting schedule.
- Pre-fit the sheets to the forms, with the smooth side fixed to the inner face of the formwork, prior to pouring the concrete.
- To ensure that the sheets do not move during casting and that no concrete is deposited between the formwork and the sheet, the following procedure should be followed:
- Secure the sheets to the face of the formwork.
- Nails will not be used to secure the liner to the forms.
- Large sheets may, in addition, be clamped to the formwork along their top edge, above the level of the concrete being poured. Nylon fishing line can also be used to hold the AKS in position by lacing it around the top row of knobs along the edge of the sheets and tensioning it onto the form.
- Position the forms and use external bracing to avoid penetrations through the MasterShield AKS as far as possible.

- If the concrete is reinforced, the MasterShield AKS will be kept firmly pressed against the inner face of the formwork by the reinforcement spacer blocks or disks. If small enough spacer blocks are not available to fit in the spaces between knobs, a minimal number of anchor knobs may be trimmed for clearance, or smaller spacers must be used. Thermoform corners in advance to avoid corner welds where possible. Refer to Fabricated Corners section for details.

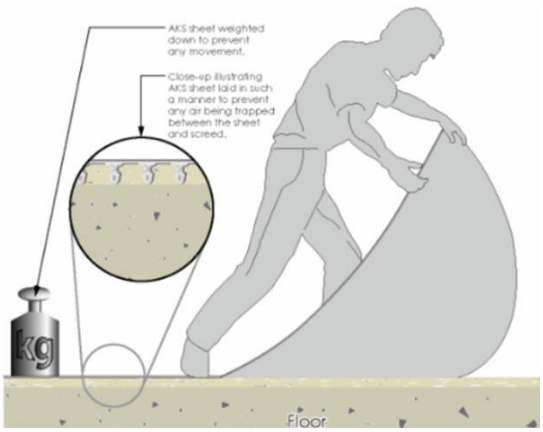


AKS Installation to Internal Slabs

- To achieve level and even floors, the concrete must be cast and set, 12mm plus the sheet thickness below the final desired floor level.
- A method of pressing the membrane into the wet concrete is not suitable as it creates the risk of inadequate embedment of the anchors and uneven surfaces. This is caused by the coarse aggregates in the concrete resisting penetration of the anchors.
- The process of installing MasterShield AKS to floors is as follows:
- Pour concrete surface bed to a finished level which allows for the addition of the MasterShield AKS. The anchors will rest on the surface of the concrete, so the added thickness is only the length of the knobs (12mm) plus the thickness of the sheet. Allow to set.
- Clean surface of concrete and remove laitance. High pressure water jetting is one method of preparation. Ideally there should be exposed concrete aggregate with 5mm depth to act as a key.
- Install a timber perimeter (12mm high) around the area to be lined.
- Brush MasterCrete PRI 5000 or 157 as bonding agent onto the floor surface to enhance adhesion of the grout to the existing concrete. Allow the primer to start to dry (become tacky).



- If a primer is not used ensure the base surface is SSD.
- Grout should be mixed to a plastic consistency and spread on the floor covering the surface area of each panel.
- Place pre-cut panel of MasterShield AKS into the grout by positioning one corner first and lowering the panel diagonally to avoid air being trapped under the MasterShield AKS.
- Weigh down the MasterShield AKS panels to prevent them from “floating” in the grout.
- Ensure that the ballast is evenly placed to ensure a smooth finished surface.
- Wipe away any surplus grout which has spilled over the timber strips.
- Allow the grout to reach initial set before moving the ballast and then repeat the procedure on the adjacent panel, using the previous panel of installed MasterShield AKS to restrain the grout on one edge.
- Ensure that gaps between the panels are kept to a minimum (not exceeding 3mm).



AKS Installation to External Slabs

- The process of installing MasterShield AKS to the underside of base slabs is as follows:
- Prepare the MasterShield AKS sheets to the required sizes per the cutting schedule and turn up edges by thermoforming.
- Clean surface of blinding ensuring the surface is clear of sharp objects and place the lining smooth side down.
- Use sandbags to hold the lining in position then weld and test all joints.
- Place slab reinforcement and concrete.

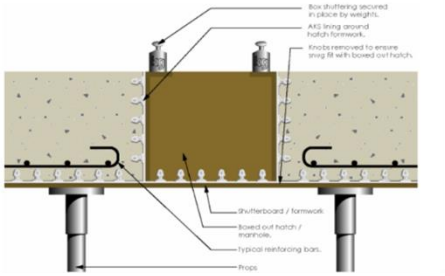
AKS Installation to Soffit Slabs

The process of installing MasterShield AKS to slab soffits is as follows:

- Prepare the MasterShield AKS sheets accurately to the required sizes as per the cutting schedule.
- Place the sheets on top of the forms, with the smooth side lying on the upper face of the formwork, prior to pouring the concrete.
- Use short nails at sacrificial lining beneath the overlap joint of each panel to keep them temporarily secured in position.
- Where possible, it is recommended that the MasterShield AKS sheets / panels are welding together before placing of the concrete.
- Prepare for any hatches, manholes or other penetrations of the slab, by positioning forms, placed and secured in the correct positions to "box out" the concrete in that area. The vertical sides of the penetrations should also be lined with MasterShield AKS by placing strips against the upstand forms and securing them in position.
- The weld area is then prepared as per "Extrusion"Welding section of this document and an extrusion weld is performed.

- This detail can be prepared and welded off-site or in-situ by extrusion welding using a 900 internal corner welding shoe and supporting the upstand strip during this process.
- Approximately 4 rows of anchor knobs will need to be removed from the MasterShield AKS where the extrusion weld is to be positioned. Thereafter the opening can be supported with pre-cut foam.
- All joints in the MasterShield AKS should be sealed by welding or the use of suitable tape before the concrete is poured. This will avoid fines flowing between the MasterShield AKS and the formwork.
- When MasterShield AKS is installed onto the Soffit, there are various Pipes; Structures and/or Penetrations around which the AKS needs to be sealed.
- Refer to "Detailing" section for more details.

MasterShield AKS lining the soffit of a slab with a box-out included:



- MasterShield AKS wrapped around formwork to create the walls of a sewerage pump station.
- Once these walls have been cast the sofit of the roof slab required MasterShield AKS lining.
- Walls have been cast with an overlap strip of MasterShield AKS material extending past the formwork by a minimum of 50mm.
- The MasterShield AKS material extending past the formwork has been heated and turned over onto the sofit formwork (thermoforming).
- The slab soffit MasterShield AKS is then overlapped onto the wall lining and tack welded.

AKS Installation to Roof Slabs

- Prepare the MasterShield AKS sheets accurately to the required sizes as per the cutting schedule.
- Place the sheets on top of the forms, with the smooth side lying on the upper face of the formwork, prior to pouring the concrete.
- Where possible, it is recommended that the MasterShield AKS sheets / panels are welding together before placing of the concrete.
- Prepare for any hatches, manholes or other penetrations of the slab, by positioning forms, placed and secured in the correct positions to "box out" the concrete in that area. The vertical sides of the penetrations should also be lined with MasterShield AKS by placing strips against the upstand forms and securing them in position.

- This detail can be prepared and welded off-site or in-situ by extrusion welding using a 90-degree internal corner welding shoe and supporting the upstand strip during this process. Approximately 4 rows of anchor knobs will need to be removed from the MasterShield AKS where the extrusion weld is to be positioned. Thereafter the opening can be supported with pre-cut foam.

- Alternatively, the access points can be prefabricated out of solid HDPE sheet and act both as permanent formwork and a corrosion protection layer.
- All joints in the MasterShield AKS should be sealed by welding or the use of suitable tape before the concrete is poured. This will avoid fines flowing between the MasterShield AKS and the formwork.

AKS LINED PRECAST CONCRETE

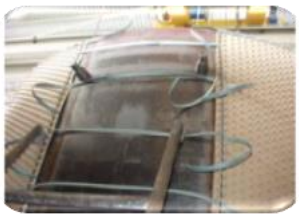
Vertical Cast Pipes

The following procedures cover the internal lining of pipes produced by the "vertical casting" method (both "wet-casting" and "dry-casting"). Some aspects of the casting processes are considered proprietary to the concrete pipe manufacturers and cannot be covered in detail without the specific permission of the concrete pipe manufacturers.

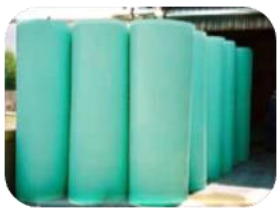
- Small diameter pipes, typically less than 900mm internal diameter, do not allow man access and the joints need to be created by forming a spigot on one end of each pipe and sockets on the opposite end so that they can be fitted together.
- Larger diameter pipes will allow man-access, and the jointing of the CPL can be carried out in-situ by extrusion welding.
- These pipes are normally more critical as they are laid deeper in the ground and carry sewage for longer distances during which time it becomes septic, and more sulphides are released to feed the bacteria.
- For the two pipe production methods which are described hereafter, it is strongly advised that the MasterShield AKS sheets are coiled with the knobs facing outwards prior to insertion into the moulds. This ensures that the liner is already orientated in the correct cylindrical form and that it readily "hugs" the internal mould.

Vertical Wet Cast Pipe Method

- This method normally employs a collapsible inner mould onto which the prefabricated tube of MasterShield AKS is positioned, prior to pouring of the concrete.
- Once the concrete has reached "demoulding' strength (usually 10-15MPa), the inner mould is collapsed, and the complete pipe removed to continue its curing process.
- The use of MasterShield AKS is found to be very beneficial to the curing process as it helps to trap moisture in the concrete during curing and this leads to better quality concrete.
- MasterShield AKS can be wrapped 330 degrees around the circular steel inner form and held fast via strapping supported along the lining's edge by galvanised bar.
- The Inner form is collapsible allowing the pipe to be easily de-moulded.
- MasterShield AKS tubes are pre-manufactured to the exact internal diameter of the pipes – if they are to be lined to 3600.



- The tubes / pre-cut panels are positioned on the inner mould with the knobs facing outwards / into the concrete pipe wall.



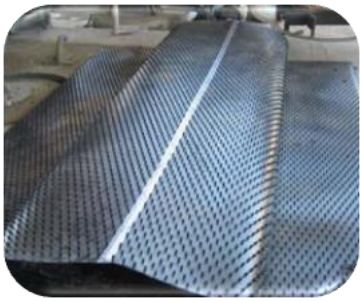

- If less than 3600 lining is being installed, the MasterShield AKS is cut to the accurate size required and the panels will need to be held onto the inner mould by "gently" securing the edges using very thin wire or nylon fishing line. The wire or fishing line is attached to the last row of knobs and lightly tensioned to avoid a gap between the MasterShield AKS and the form to prevent concrete flowing between the MasterShield AKS and the inner mould.

- The tubes are constructed with a male/female end. The male side projects approximately 50 mm beyond the end of the concrete so that it fits over the female end of the next pipe. Alternatvely, the tubes can end flush with both ends and the joint completed on site using a cover strip and two extrusion welds.


- The steel reinforcing cage (if required) is positioned around the MasterShield AKS lined inner mould and spacer blocks are used to keep it in the correct position.
- Once the reinforcing is in place, the outer formwork is positioned, and the concrete poured.
- After the concrete has reached initial set, the inner moulds can be collapsed, and the outer forms hinged open and removed.
- The pipes will now be placed in a water bath or "steam" tent for further curing. The temperature during "steam" curing must not exceed 500°C. Higher temperatures may cause buckling of the liner and affect the attachment of the knobs in the concrete before it gains adequate strength

- The typical curing period is 2 days for 50% of ultimate strength.
- When laying or installing the pipe, care must be taken not to damage the 50 mm long "male" projecting portion of the joint.
- This projection will slip over the female end and the joint it fully sealed by extrusion welding at the overlap.
- Welding and testing procedures are covered under a separate section.

Vertical Dry Cast Pipe Method



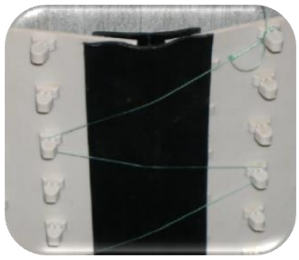
- This method is aimed to producing pipes faster than the "wet cast" method and using less equipment. By using a relatively dry concrete mix the newly poured pipe can be removed from the inner form (but still attached to the outer mould) within minutes of placement and compaction.
- Once positioned in its curing place, the outer mould is also removed, allowing many pipes to be cast each shift using the same moulds.
- A tube of MasterShield AKS can have tape applied to the joint and then laced up with nylon wire around the anchors.

- The top of the lining can be sealed with tape around the inner form to prevent concrete from getting between the lining and the mould.
- Another benefit of using MasterShield AKS in this type of pipe is that, although the "dry-cast" method is recognised as producing pipes which are more porous than "wet-cast" pipes, the use of MasterShield AKS renders the pipe walls waterproof.
- Apart from the points mentioned above regarding the rapid de-moulding of the pipe, the steps required to install MasterShield AKS are the same as are required for the "wetcast" process.
- The process of prefabricating MasterShield AKS to fit inner static mould is as follows.

- Prepare the MasterShield AKS sheet accurately to the required size: Measure the circumference of the mould at the top and bottom. Use the smallest diameter to cut the sheet to size (For example, if the bottom is 915mm and top is 912mm, use 912mm).
- Mark the MasterShield AKS sheet on the smooth side using measuring tape and chalk line.
- Cut the sheet by using a skill saw and straight edge.

- AKS Cutters can be used, but they only cut in between the anchors in two directions.
- The row of anchors being removed on the edge of the sheet by means of a wire fixing tool or making use of a wood chisel and hammer – do this on both edges to allow the H-Profile to slip over the sheet.

- After the anchors are removed, the H-Profile can be slipped between the two ends of the sheet. The H-Profile is kept in place by using builders line and tying it across the strip.
- The benefit of using this profile is that it ensures the welding surface is clean after the concrete has been cast where the joint is to be welded. Builders line is used to allow for flexibility around the mould.




- The MasterShield AKS sheet is then placed over the static mould. Duct tape was used to seal the MasterShield AKS at the top, preventing concrete from flowing between the mould and AKS.
- A plastic packing strip can also be used to keep the MasterShield AKS in place at the top of the mould.

- Please take note not to wet the mould, as it needs to be dry and dust free.
- The wire mesh is then lowered into the mould and the concrete is cast.
- Take care not to damage the MasterShield AKS when lowering the mesh onto the mould.

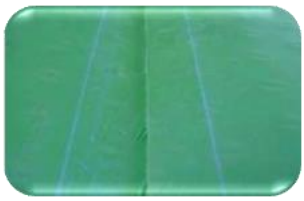
- After the concrete has been poured, the pipe is placed in the curing area and the outer formwork removed.
- The pipes are now complete and ready to be used.

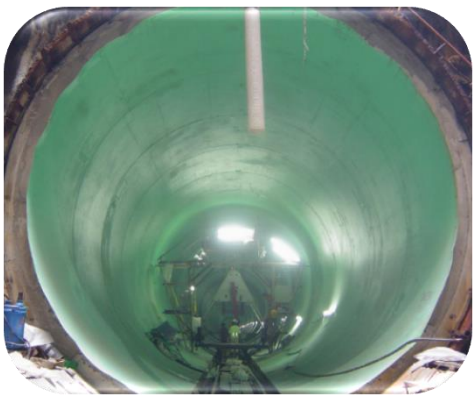


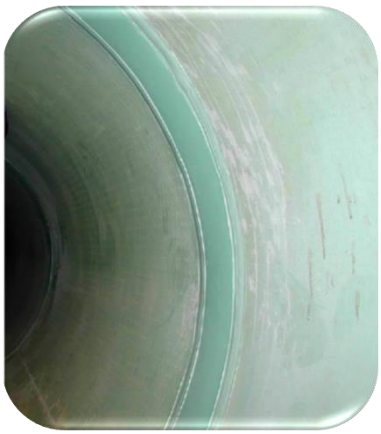
Installation of Capping Strips to Joints Inside the AKS Lined Concrete Pipe

- Two edges of MasterShield AKS are either 'butt' jointed or overlapped.
- For the installation of Capping Strips into MasterShield AKS lined concrete pipes, overlap joints will always be used.
- Capping Strip Joint: For overlap joint used, the Capping Strip is heat tacked to the inside of the MasterShield AKS lined pipe to prevent differential movement.

- Surface oxidation is removed by grinding/sanding the area to be welded.
- Welding rod manufactured of resin identical to the MasterShield AKS & Capping Strip is molten, and deposited over the weld zone, after preheating the surfaces to receive the extruded weld with the hot air in the front of the extrusion welder.
- Preheating is necessary to prevent thermal shock.
- The nominal width of this extruded bead of resin is minimum 30mm, after being finally shaped by a Teflon welding shoe.
- The weld area is clearly market.
- The markings to be at the width of the selected extrusion shoe – typically 35mm wide.
- The area is prepared with grinding/sanding or scraping.
- The extrusion welder applies the final extrudate over the overlap joint, while placing a conductive wire to allow for spark testing afterwards.







- The grout hole is clearly marked. The markings to be at the width of the selected extrusion shoe, typically 30 – 35mm wide.
- Refer to:" Closing of Tie Bars/Ferrules holes" section for closing of grout holes details.

Wet Spun Pipes

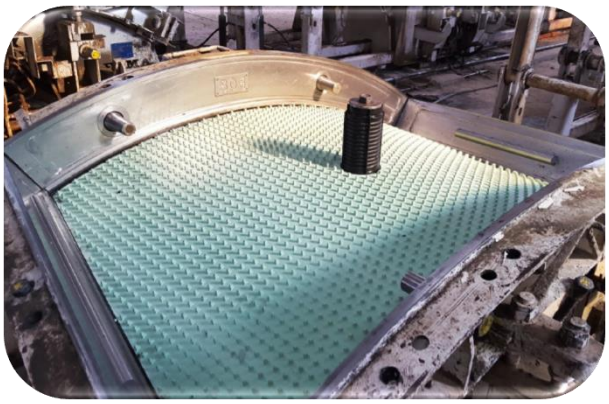
- The process of manufacturing wet spun concrete pipes involves a horizontal external mould within which the reinforcement cage is placed.
- The mould is rotated whilst low slump concrete is placed in the mould.
- A traveller runs along the length of the pipe on a spreader bar delivering concrete while the mould spins. This compacts the concrete by centrifugal force and forces some water from the mix reducing the water-cement ratio and increasing the strength of the pipe.
- An operator controls the traveller ensuring the wall thickness is even throughout the pipe.
- Lips on the edge of the mould are used as a guide for the thickness of the concrete pipe wall.

- MasterShield AKS can be installed immediately after the concrete has been placed.
- To ensure proper embedment of the anchors there are two main methods employed:
- The first is to use an expanding inner mould system to squeeze the MasterShield AKS into the concrete.

- Immediately after the expanding collars have been installed, the mould needs to be rotated again to ensure that the concrete fully encapsulates each anchor.

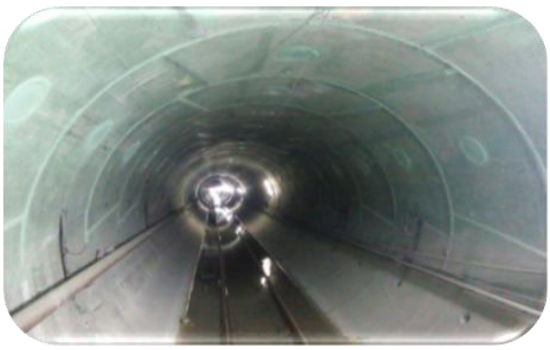
Other Precast Concrete Elements

- MasterShield AKS can be cast into any precast concrete element.
- Prefabrication of the lining on a “same shape” jig before placing in the precast mould is recommended.
- Vertical faces and horizontal surfaces within the mould are included in the prefabricated lining.
- Horizontal surfaces that are the open casting face of the element must have the lining formed either with MasterShield AKS grouted on after stripping the element or with HDPE smooth fleece back, epoxied onto the surface and welded to the cast-in MasterShield AKS.









CAGE Pile Applications in Aggressive Groundwater Conditions

Installing AKS onto Steel Cage

- For the prefabrication of the MasterShield AKS sheet to match the steel pile sleeve ID, is made up to the required pile length.
- If prefabrication of the MasterShield AKS is required to achieve larger circumference of a pile, it can be done either by Wedge or Extrusion Welding.
- The width of the spacer bar is determined by subtracting the OD of the reinforced steel cage from the ID of the steel pile sleeve (Considering the thickness of the MasterShield AKS).
- In addition, round plastic cover blocks are fixed onto the reinforced steel cage, which will allow for the MasterShield AKS not to hook onto the steel.

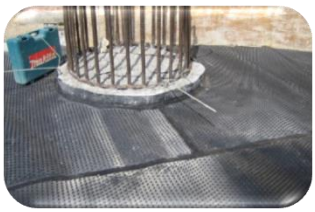



** Please note that the steel spacers and plastic spacer blocks are not structural, but merely used to keep the AKS in place around the reinforced steel cage and hold the weight of the reinforced steel cage while AKS is wrapped/fixed around.*

- Steel rings are then fixed onto the spacer bars (as determined above) onto which the MasterShield AKS is fastened – the shape of the anchors allows the AKS sheet to be firmly wired to the steel rings.
- At the top and bottom of the AKS sheet, additional rebar is extrusion welded onto the MasterShield AKS to assist with fixing the lining around the steel cage. The anchors on the one long edge are removed to allow for the overlap of the MasterShield AKS sheet once it has been wrapped around the reinforced steel cage. This is then extrusion welded together to form a complete tube.
- The steel cage is then placed centrally on the MasterShield AKS, where the sheet is then wrapped around as per the above and extrusion welded on the top.
- Additional nylon strapping which may be required on each end of the MasterShield AKS tube, to secure the edge of the sheet.




- Once the MasterShield AKS wrapped rebar has been placed inside the steel pile sleeve and the concrete is cast, the steel sleeve is removed during this process.
- As the steel sleeve is removed, the MasterShield AKS (being a flexible product) will allow for the slight expansion needed to fill the void.
- The non-structural rebar used to fix the MasterShield AKS to the steel cage is loosened, bent away and cut off.
- Depending on the final application, MasterShield AKS can also be used to protect the exterior of the pile.



Welding

- For the purposes of this application, only Extrusion Welding is considered.
- Two edges of MasterShield AKS are either 'butt' jointed or overlapped.
- For butt jointing, the edges of liner are held firmly together (Cable Ties) during the welding process.
- For overlap joint, the MasterShield AKS is heat tacked together to prevent differential movement.
- Surface oxidation is removed by grinding the area to be welded.
- Welding rod manufactured of resin identical to the MasterShield AKS is molten, and deposited over the weld zone, after preheating the surfaces to receive the extruded weld.
- Preheating is necessary to prevent thermal shock.
- The nominal width of this extruded bead of resin is min 30mm, after being finally shaped by a Teflon welding shoe.

APPLICATION- EXISTING STRUCTURE

MasterShield AKS may be installed to existing steel, concrete or brick structures where some surface degradation has already taken place or when the structure will be exposed to aggressive conditions. An important advantage over other lining and coating systems is that the underlying surface does not need to be dry before it can be lined. It must however be clean and sound.

Surface Preparation

Concrete

- Preparation of the concrete substrate for concrete repairs generally involves a couple of steps. Preparation will involve removal of the contaminated, cracked and affected concrete to create a suitable profile.
- For the best results, a CSP profile is required, please refer to each product specific TDS.
- The choice of technique will be determined by the size and depth of the patch. Suitable techniques include:
  - Abrasive blasting
  - Jack hammering
  - Ultra-high pressure water jetting

- Where steel reinforcement has been exposed the concrete must be cut back to a depth behind the reinforcement providing adequate access for the repair of the bars as necessary.
- Corrosion of steel reinforcement leads to reduced cross section of steel and notching due to pitting; both of which will affect the load bearing capacity of the structure. Methods of steel reinforcement treatment and repair are beyond the scope of this manual. Please consult Master Builders solutions for MasterCrete repair solutions or MasterShield CI protective sealers for protection of steel.

Saturated Surface Dry (SSD)

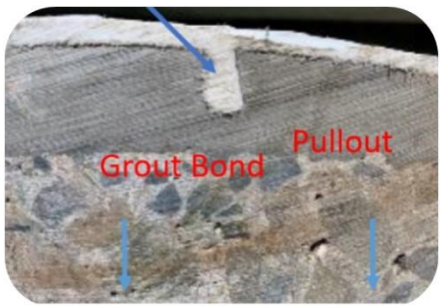
- The concrete substrate should be a saturated surface dry (SSD) substrate, to accept the grout, as a dry substrate will lead to surface cracking and poor bond to the substrate.
- Any localised incoming flow should be arrested by injection of PUR resins such as MasterFill PR 1400 or MasterFill PR 1450, in accordance with specific advice from Master Builders Solutions.
- If the surface is dry it is recommended to either flood the surface with water behind the formwork and completely drain just prior to grouting, or apply water diluted MasterCrete PRI 157 primer, where grouting can commence within 30 minutes of primer application.

Steel

- All loose material should be removed, and the reinforcing steel exposed to the point where there is no visible rust, and a grey surface colour is observed. This is to achieve good adhesive bond strength between the steel and the grouted MasterShield AKS.
- If the steel is corroded it will need to be prepared, and the most common method is via abrasive blasting. The method involves mechanical cleaning by continuous impact by abrasive particles at high velocities. Various methods and grades of cleanliness are presented in ISO 8501-1: 1988, (BS 7079, Part-A1 1989), "Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness". This standard essentially refers to the surface appearance of the steel after abrasive blast cleaning (dry blasting) and gives descriptions with pictorial references of the grades of cleanliness.
- The surface preparation will depend on the application but as the steel is to be lined with MasterShield AKS, Sa1-Sa2 should be sufficient.
- An epoxy primer such as MasterCrete PRI 2500 can then be applied to provide a key. Alternatively, a steel surface also provides the opportunity for welding a steel mesh to the surface which will provide a positive bond between the steel and the grouted MasterShield AKS.

Grout & Mortar

- Fill any deep damages with a suitable MasterCrete repair mortar, if necessary, prior to grouting.
- Grouts to be used to secure MasterShield AKS to existing structures are as outlined above for new floors:
  - MasterFlux 200 for walls and soffits
  - MasterFlux 880 or MasterFlux 200 for walls and floors where rapid set and fast cycle time is required.
- Mix and apply strictly in accordance with Master Builder Solutions application guides and product technical data sheets.
- Where grout encapsulates the MasterShield AKS, the anchors will provide a pull-out resistance from the grout of around 700KPa. The grout provides bond to the substrate. In underground structures, it is important to prove grout bond to the surface is at least a factor of safety above the expected external pressure exerted by groundwater. This can be done by applying grout test pads to the prepared substrate and coring/pull testing the grout.

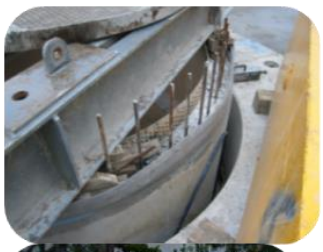


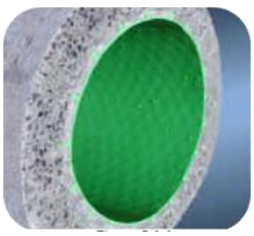
- Refer to Master Builders Solutions for advice on suitable mixing and pumping equipment for each of the recommended grouts.
- It is recommended to trial this equipment to check mixing, pumping and work time prior to undertaking the actual MasterShield AKS grouting.
- Prepare 50mm x 50mm x 50mm grout specimens in clean and properly assembled steel cube moulds for 24 hours and 28-day compressive strength testing to validate grout quality.
  Do not use polystyrene cube moulds.

Formwork

Formwork must be designed by an engineer for each specific application. The design will need to consider the following:

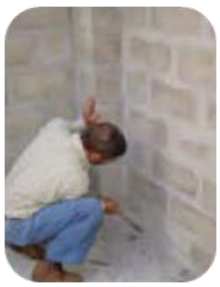
- Stripping: Careful design is required to ensure the forms can be easily removed after casting. The lining is beneficial here as the smooth surface makes striking easier and there is no need for form release oils.
- Grouting pressures and supports: This may be of particular concern in refurbishment works as floatation pressures may cause the form supports to exert loads on a weakened structure. Staged grouting can be undertaken if floatation is of concern. Where possible; supports should be placed outside the lining area to reduce repairs to the lining.
- Access: Access into and through the forms is generally necessary. Access will also be required through the forms for securing the lining.
- Tensioning of the lining prior to casting is important to prevent creases developing in the crown during casting.





AKS Installation to Vertical Surfaces

- The installation procedure below is detailed for walls only.
- Ensure that the surfaces are clean and free of any loose or degraded material and suitable preparation methods have been employed as detailed above.
- Saturated surface dry condition or prime the surfaces with MasterCrete PRI 157 to avoid the moisture being drawn from the grout when it is placed.
- Secure MasterShield AKS sheets to formwork as described previously for new works.



- A pre-bent horizontal to vertical corner piece should be placed around the perimeter of the floor with a gasket along the outer horizontal edge to retain the wet grout. This corner piece should project 300mm horizontally and 300mm vertically away from the floor to wall corner.
- Weigh down the horizontal strip to prevent displacement when the grout is poured and position a gasket to prevent grout leaking from the outer edge.

- The gasket should be retained by a temporary timber strip, secured to the floor. These strips should be removed when the grout has started to set and the gaskets may then be removed.
- Position H profile horizontally along the top edge of the perimeter strips.
- Position the bottom edges of the wall sheets into the H profile fitted to the perimeter strips.
- The anchor knobs should be pressing against the high points of the wall. Ensure that the MasterShield AKS is fully supported by forms to prevent buckling when the grout is pumped or poured.
- Allow for 50mm overlap of the sheet to adjacent sheets. Remove anchors at the overlap.
- Apply a compressed foam seal along vertical edges and the bottom of the form (either on the form or on the substrate).
- Erect properly designed formwork against the wall and prop to prevent movement during the grout pour.
- Ensure that the MasterShield AKS is fully supported by forms to prevent buckling when the grout is pumped or poured.

- Pour or pump MasterFlux 200 or 880 grout in the space created by the knobs against the wall. Tapping of the forms or external vibration will assist in ensuring that air bubbles are expelled from the mix.
- When grout has set, remove the forms, clean any spillage from surfaces to be welded and commence welding of seams.

AKS Installation to Horizontal Surfaces

Floor

- The procedure for the lining of existing floors is the same as for new floors.
- It is strongly recommended that the floor lining is installed once all overhead and vertical work has been completed to ensure that potential damage to the floor surface is minimised.

Soffit

- Drill and secure a galvanised or stainless-steel mesh to the underside of the soffit.
- Grout bond cannot be relied upon for this application as there is no way of understanding if there is complete interaction of the grout with the soffit surface. The grout is intended to encapsulate the MasterShield AKS anchors and the mesh, and the mesh transfers loads back to the concrete roof slab.
- Survey the underside of the soffit surface by measuring up from a level datum inside the structure.
- From the survey data, decide on a grouting sequence and grout entry locations (grout entry at lowest soffit level and air release and grout visual check at highest soffit level)
- Drill grouting holes from above through the roof slab at appropriate centres to allow full monitoring of grout entry and flow across the soffit.
- Erect formwork within the structure with MasterShield AKS sheet cut to size and placed on top of formwork with anchors up.
- Temporary weld seams and edges and add compressed foam seals as required to seal grout.
- Form up penetrations as required from fabricated rigid HDPE sheets or HDPE pipe where possible.
- Alternatively form penetrations with timber forms with MasterShield AKS attached to vertical surfaces.
- Mix and pump MasterFlux 200 grout through the grout holes and check for grout fill and air release. Alternatively pour the grout in through a raised filler pipe to create a static head to force the grout flow across the soffit.
- Strip formwork from inside of the structure and “sound” the MasterShield AKS smooth surface to ensure the absence of voids under the membrane and weld all seams and joins to the wall membrane.

REPAIRS & MAINTENANCE

Inspection

- Once all formwork has been removed and the area cleared, a detailed inspection must take place.
- The inspection is recorded with all defects marked with reference and accurately recorded by the HDPE Applicator.
- The defects are also clearly marked inside the tank/structure on the smooth surface of the liner. This must be done with a permanent marker, in a color easily visible against the color of the HDPE liner.
- Once a defect has been spotted and identified as one of the three types listed, the appropriate repair method will be applied. The repair methods are detailed below.

Type 1- Minor defects to HDPE liner

Minor defects to the HDPE liner encompass such defects as pinholes, tears, and faulty welding seams. Type 1 defect may also be considered where scratches on the surface of the HDPE liner may be deep and impact the liner integrity. Refer to welding procedure described in "Closing of Tie Bars/Ferrules holes" section.

Preparation of Working Area

- Once all defects have been identified a detailed repair plan must be agreed between the HDPE applicator's site manager and the welding team.
- This will include marking-up the extent of the welding area and preparation area. This must be done accurately using straight edge and templates for the extrusion shoe width.
- The marked area will determine the extent of preparation and the exact area in which the repair will take place.
- No grinding will be permitted outside this area.

Type 2- Damage to CPL concrete

Type 2 defects are identified as areas where the HDPE liner is unsupported due to insufficient grout, concrete or other supporting structure being present after the removal of formwork or shuttering. These will be classified as Category B1, B2, B3 and B4.
The defects are also clearly marked inside the tank/structure on the smooth surface of the liner.

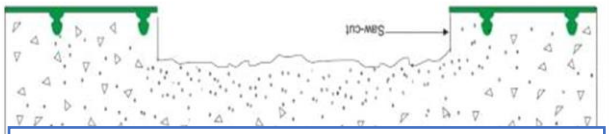
Preparation of Working Area

- Once all defects have been identified a detailed repair plan must be agreed between the HDPE applicator's site manager and the welding team.
- This will include marking-up the extent of the defect area and preparation area. This must be done accurately using straight edge and templates.
- The size of the area will be based on the extent of the unsupported liner. This can be determined by lightly tapping the liner to listen for any hollows.

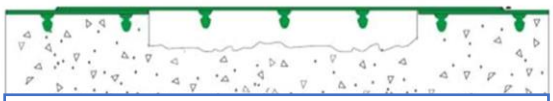
Preparation Stages and Procedure for Category B1

1. The Honeycomb area is identified and marked.

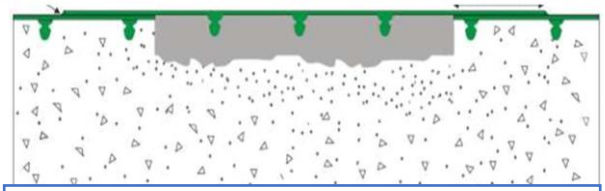
2. The unsupported liner is cut and removed.



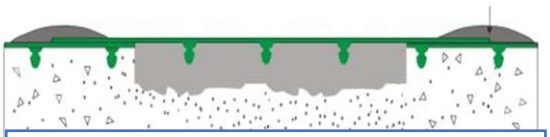
3. The area is cut back neatly to give straight firm edges.



4. A new HDPE sheet is cut to the exact dimensions and inserted. This is Tack welded and speed welded in place

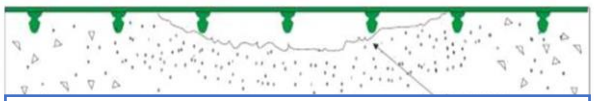


5. HDPE patch is installed over the affected area. Press the pre-cut patch of HDPE liner into the mortar. Remove and clean any excess mortar that squeeze out.



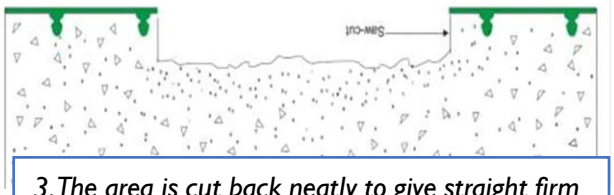
6. Then heat tack and temporary speed weld the overlap. Support the patch if required with ballast or formwork. The overlap should be min 30mm wide around the patch. Extrusion weld the patch to ensure a watertight seal.

Preparation Stages and Procedure for Category B2&3

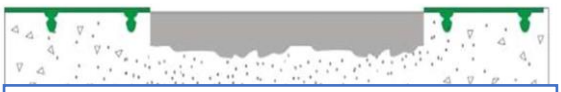


1. The Honeycomb area is identified and marked.

2. The unsupported liner is cut and removed.

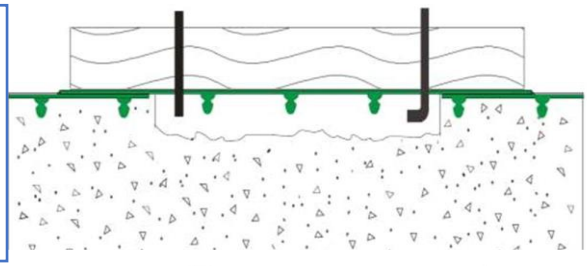


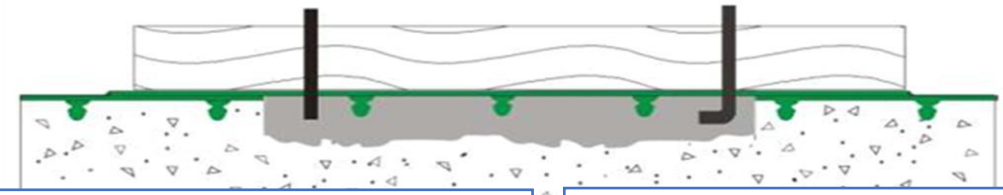
3. The area is cut back neatly to give straight firm edges.



4. Apply MasterCrete PRI 5000 and MasterCrete/MasterFlux repair mortar/grout as Master Builders Solutions' instructions and agreed by the Design Engineer

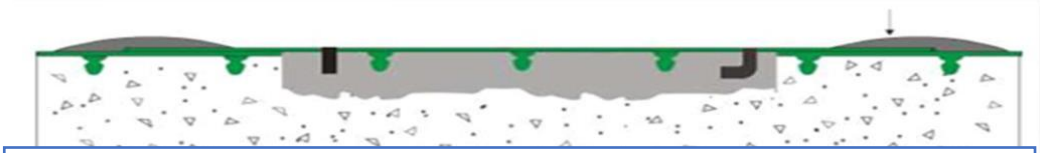
5. Grout inlet and breather pipe are inserted through the HDPE liner. These are relatively small diameter pipes, with min diameter to allow grout to flow. The Patch area is then fully supported using a flexible form in order to maintain the tunnel curvature.





6. B2:
The flowable cement grout MasterFlux 200 is then pumped into the cavity until it flows from the breather pipe. Ensure the breather pipe is at the highest end of the working area, to ensure the void is 100% full.

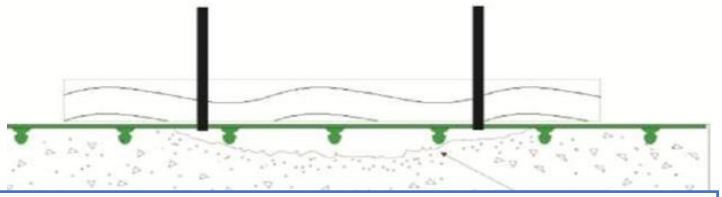
6. B3:
The flowable Epoxy grout MasterFlux ER into the cavity until it flows from the breather pipe. Ensure the breather pipe is at the highest end of the working area, to ensure the void is 100% full.



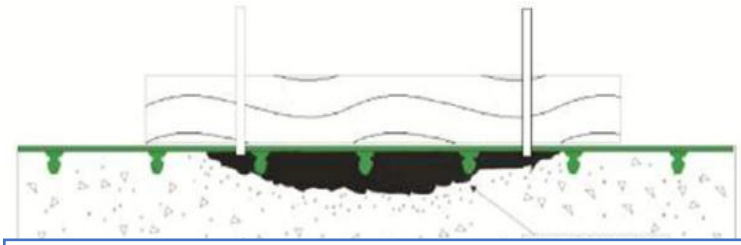
7. Once the grout has set, the support structure is removed, and the edges are extrusion welded. The grout pipes are also cut off flush with the surface and covered with an extrusion weld.

Preparation Stages and Procedure for Category B4

1. The Honeycomb area is identified and marked.



2. Grout pipes are place as needed to ensure even flow into all cavities. Ballast is placed on the honeycomb area to ensure no uplift during grout pumping.



3. Suitable grout is pumped until full and is visible from all grout pipes.

4. On completion, the ballast is removed; the grout pipes cut flush with the surface and covered with an extrusion weld.

Type 3- Indentations/bulges in CPL concrete/HDPE Liner

Type 3 defects identified as areas where the liner is deformed due to misalignment of formwork, movement during pouring, creases due to insufficient tension of the sheet or any other aspect that may cause the finished HDPE to be creased or folded, after the removal of formwork or shuttering.
It is not possible to set up easy criteria for the size of minor/major indentations. The evaluation will have to be made on a case by case basis, based on the appearance and potential stress on the AKS in the relevant location.
This defect is easily visible and will be seen as a depression or tight bulge in the HDPE liner. Light tapping of the area will easily differentiate between a Type 2 defects, as there will be no hollow sound.
The determination on whether to repair or not, requires the additional input from the Designer, as there may be structural implication for this type of defect.
The assessment of a category C1 and C2 defect will require additional input from the Designer. This is not a simple visual inspection, although visual inspection will be used to highlight the potential defect, and it will require additional input from various parties.
It is important to note that the HDPE liner has high elongation properties and can bend and flex substantially without serious impact on the overall performance of the product. Therefore, although the defect may appear serious, in many cases the performance and integrity of the liner is not in jeopardy.
The inspection and identification process needs to address two major aspects namely:

➢ Is the liner under stress/ strain that may cause it to fail or be damaged?

➢ Is the structural integrity of the structure in any way compromised due to insufficient cover or excessive miss alignment?

In these cases, the Designer in coordination with the HDPE Applicator will determine the remedial measures to be implemented and an NCR will be raised to cover these repairs.
The proposed repairs will then be defined in an update of the relevant NCR and the Designer and the Engineer's approval obtained prior to repairs being carried out. The NCR will be closed once the repairs have been carried out and verified by the QCE and the Engineer.

Preparation of Working Area

- Once all defects have been identified a detailed repair plan must be agreed between the HDPE applicator's site manager and the welding team to determine if a Category C1 or C2 repair should be done.
- This will include marking-up the extent of the defect area and preparation area. This must be done accurately using straight edge and templates.
- The marked area will determine the extent of preparation and the exact area in which the repair will take place.

Procedure and Finishing

- The preparation and repair of Type 3 defects is almost identical to that of Type 2.
- With the only difference being that the concrete has to be cut away, for cases where it is bulging, prior to the HDPE patch being installed.

QUALITY ASSURANCE & TESTING PROCEDURES

MasterShield AKS has been manufactured and successfully installed since 1993. AKS Lining Systems manufactures and supplies concrete protection lining material to the highest available standards. To achieve this, state-of-the-art resins and masterbatch are used to manufacture AKS. This creates the opportunity for clients to receive the best lining solutions available, provided the installers perform to equally high standards.

Quality Assurance Standards

Installer Functions

- Master Builders Solutions recommends that only MasterShield AKS Approved Installers complete MasterShield AKS installations. They need to work to the standards outlined in this guide.
- Master Builders Solutions is available to assist with training and evaluation in accordance with this manual.
- MasterShield AKS Approved Installers must have welding technicians who are trained and certified in the operation and maintenance of the welding equipment that they will operate. They should use well maintained and suitable equipment. The technicians should also be trained to evaluate test data and report results of inspection and testing.
- The MasterShield AKS approved Installer will appoint a Quality Assurance Representative (QAR) for each project. The QAR should have the following role:
    - Prepare QA plan for each project.
    - Produce site specific documentation.
    - Ensure all independent form-workers are trained in securing membrane to forms.
    - Evaluate/calibrate test equipment.
    - Observe all non-destructive testing.
    - Record location, date, test unit number, operator, and outcome of all testing.
    - Log and inform the Site Manager of any required repairs.
- Once the necessary repairs have been completed the QAR will:
    - Observe the re-testing of the repair.
    - Mark on the area of AKS that the repair has been completed and tested; and
    - Document the results.

Incoming Material Inspections

- All MasterShield AKS material must be inspected for damage prior to installation.
- MasterShield AKS is a very robust material, and it is rare for significant damage to occur to the material during transit, however, certain damage if not detected could affect the function of the lining system.
- MasterShield AKS should be inspected on both sides to ensure anchors have not been damaged and will perform properly.
- If MasterShield AKS is to be stored on the ground, a protective sheet should be laid down to protect the lining from excessive scratching or contamination.
- Rolls should not be stacked more than two high to avoid deformation and forming oval rolls.
- Provision of a dispensing frame with a central pin is recommended on sites where large numbers of rolls are to be laid out for cutting on site.

- Pale coloured AKS is used in underground applications to enhance light reflection within the tunnel/tank/structure and hence improve the working environment.
- A lighter working environment assists the Quality Assurance activities by making defects easy to locate. As these pale coloured materials will not be exposed to the sun's UV radiation long-term, they do not require full UV stabilisation.
- To protect the lining during production and installation, the light membrane is UV stabilised to protect the lining for up to 24 months of UV exposure. It is therefore recommended that this material is stored out of the sun and kept covered.
- Black AKS material contains carbon black and is UV stable for at least 30 years.

Site Inspection & Testing

- Destructive and non-destructive test methods are used to ensure that an installed MasterShield AKS lining solution is secure.
- Non-destructive tests are used to monitor and confirm the integrity of all jointing works completed on an installation.
- The destructive test methods determine the actual strength values of welds completed on test samples using the same equipment under the same conditions as the welding to the actual MasterShield AKS in-situ.
- Avoid destructive testing of samples removed from the works as the removal will cause damage to the lining and influences the results and their repair creates new risks.

Testing Equipment Calibration

- Equipment used in the testing process such as field tensiometers, pressure gauges and pyrometers should be calibrated regularly according to the manufacturers' recommendations.

Records

- Records must be kept of all site inspection and testing activities. The following are recommended minimum requirements:
    - Trial weld Report
    - Production weld report
    - Installation record
- The installer will write the details of each non-destructive test on the installed MasterShield AKS.
- For air pressure tests this will include: the initials of the tester, the date, start time and pressure, end time and pressure, and pass or fail result.
- For vacuum testing this will include: the initials of the tester, the date, and pass or fail result.
- For spark testing this will include: the initials of the tester, the date, voltage setting, and pass or fail result.
- When a test fails, the details of the appropriate repair will also be recorded on the MasterShield AKS and in the inspection and test report.

Non-Destructive Testing

- The table below contains a summary of the methods for non-destructive testing and their recommended frequency. The procedures for each method are described further below.

Method	Recommended Frequency
Sounding test	100% of the cast in MasterShield AKS surface
Visual test	100% of all work
Impact test	100% of extrusion welds
Vacuum testing	All extrusion welds where the method can be practically employed and only as a check on spark tests
Spark testing	All extrusion welds

Sounding

- Tapping of the cast-in MasterShield AKS lining surface will detect any voids beneath the surface and potential poor anchor encapsulation by the concrete, usually as a result of an inadequate mix design or substandard placement and compaction of the concrete.

Visual Inspection

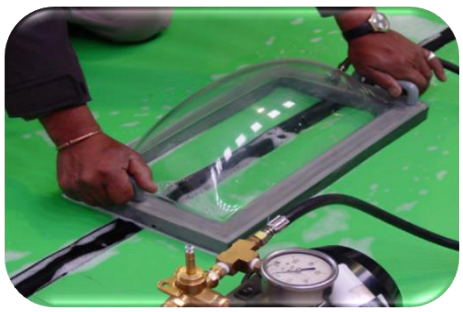
- Visual inspection is the first form of non-destructive testing. The surface of the lining should be checked to ensure it has not been damaged by transport or construction activities and weld seams should be visually inspected for:
    - Excessive squeeze-out
    - Weld shape conformance.
    - Footprint/width
    - Colour
    - Evidence of air bubbles/change of surface texture
    - Extensive heat deformation
    - Folds
    - Foreign matter
    - General appearance
- All suspect areas should be marked and repaired.

Impact Test

- All extrusion welds should be subjected to point stressing along the interface between the weld and the lining using a blunt instrument to ensure continuity of bond (pick at weld edge with screwdriver).
- The welding technician should complete this test progressively after each weld is complete as the first step in ensuring weld integrity.
- If the extrusion bead shows a tendency to peel the source of the problem needs to be investigated.

- Possible sources include:
  - Insufficient grinding
  - Inadequate preheating or extrudate temperature
  - Dirty or wet welding rod
  - Dirt or oil at the joint
- The area should be marked and repaired once the source of the problem has been identified and rectified.

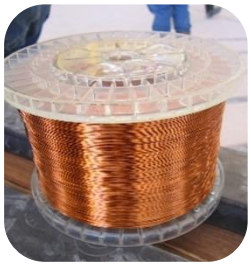
Vacuum Box Test (ASTM D5641)

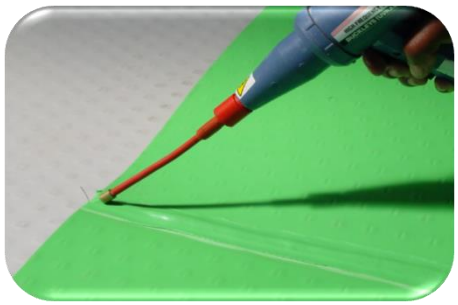


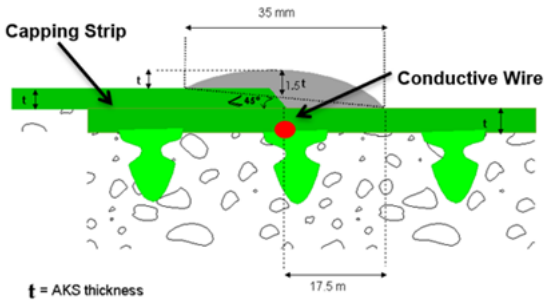
- Vacuum boxes are a very robust test for testing extrusion welds as they impart a load (albeit small) to the joint to ensure it is fully sealed.
- Vacuum box testing is not always practical especially in structures with short lengths of weld in tight spaces. The test is very slow and labour intensive. It is only recommended where spark test results need to be validated. Spark testing is adequate in most applications.
- Vacuum boxes can be made up to test a variety of shapes including internal/external corners, flat and curved sections. Vacuum boxes are constructed with transparent plastic covers and equipped with a soft, closed-cell gasket along the base edge where it contacts the liner.
- A vacuum pump is connected to the vacuum box by a hose. And a vacuum gauge is included in the system.
- The length of welded seam to be tested is painted with a soapy solution, the vacuum box is placed over the weld, pressed firmly onto the liner and the vacuum pump is started.
- The bleed valve is closed, and a partial vacuum is drawn to approximately minus 35 kPa (below atmospheric) gauge pressure and ensuring a leak-tight seal is created. For a minimum of 5 seconds, the HDPE seam will be examined through the viewing window for the presence of bubbles (large bubbles or fine froth) within the soapy solution.
- If no bubbles appear during the observation period, the vacuum will be released by opening the bleed valve and switching off the pump. The vacuum box should then be moved over the next adjoining area with a minimum 50mm overlap and the process repeated until the entire length of the seam has been tested.
- Any area where soap bubbles appear (or a complete drop in vacuum is observed) shall be marked, recorded, repaired and retested until the result is satisfactory. The results of this test should be recorded in the installation inspection and test report. The soapy solution should be rinsed from the area.

Spark Test (ASTM D6365)

- Spark testing is the quickest test for use on extrusion welds.
- During the extrusion welding process, a fine copper wire can be inserted into the joint prior to the extrudate being fused with the sheet.
- The spark testing equipment produces a high voltage current over the weld.
- Should there be a defect in the weld a circuit will be made to the wire, and an alarm will sound on the testing equipment.
- In many instances a copper wire is not necessary, as the underlying concrete will be moist and will create a suitable circuit through defects.







Set-up and Calibration of Spark Tester

- Prior to testing, a trial calibration seam must be made to confirm the minimum voltage required to discharge across a hole in the seam between the probe and the copper wire.
- Perform a trial weld using the extrusion machine and shoe profile required for all extrusion welding that day. The copper wire can be placed under the centreline of the extruded weld bead, prior to welding.
- A specific electric potential (not a current) of several thousand volts is applied between the probe and the copper wire.
- The distance between the tip of the probe and the copper wire is typically not the thickness of the AKS or the welded bead, but the distance from the edge of the extrusion bead to the copper wire. The exact distance needs to be determined with the trial weld.
- This is done by turning the output adjustment knob anti-clockwise at the start (least Voltage) and gradually increasing clockwise to adjust the voltage higher.
- Hold the tip of the probe on the edge of the welded seam (where the wire is exposed) at one end to determine the setting. Ensure that a clean spark is visible jumping to the copper wire.
- The potential is set so that a spark discharge (current) will not occur through the insulating polymer material of the AKS or Welded bead, but it will occur if there is a hole (lower resistance passageway) through the weld bead.
- Typical distance settings for various liner thicknesses are given below:
  (ASTM D6365 - Typical example of required voltage settings)

- The spark tester must therefore be set to generate a spark that will travel the distance of air, including the leak passageway, between the probe tip and the copper wire. The thickness of the spark is directly related to the voltage, (the thicker the spark, the higher the voltage)
  NB. Take care not to set the voltage to high, as it can possibly burn a hole through the Weld Bead you are testing.
- Once the desired Voltage is set on the Spark Tester, this should not be adjusted until such time as a different extruder or shoe profile is used. The set-up procedure should be done as a minimum once a day.

TEST VOLTAGE FOR VARIOUS EXPECTED DISTANCES

Distance (mm)	Test Voltage (V)
6	20000
10	25000
13	28000
16	31000
19	35000

Testing Procedure

*Caution: Care must be taken of the following:

- Spark testing must not be performed when the liner is wet.
- Do not have your hands or exposed skin on the probe side of the Spark Tester.
- Do not use this equipment if you have a pacemaker or other electronic medical devices fitted.
- By using the calibrated (set to the required voltage) Spark Tester, pass it along both edges of the extrusion weld seam at the distance obtained from the set-up procedure.
- For assured effective coverage, pass it along the centre of the welded extrusion seam as well.
- Monitor for audible and/or visible spark discharges that are indicative of a defect.
- A defect (pinhole, crack, or similar type flaw) can be detected by observing a bright concentrated spark (accompanied by a crackling sound) jumping from the electrode to the copper wire below the lining.
- Clearly mark the area where the spark is observed with a marker to be repaired.
- Care should be exercised not to stop and concentrate on any one area, and always remember to keep the spark testing equipment moving constantly, as it could burn through the lining and cause leaks if left in one place.

Note:

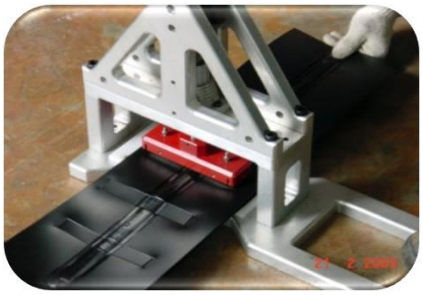
- A general white or blue luminous corona of current may be observed - this is not an indication of a leak.
- By using a single tip survey probe, it is possible to pass it along one side of an extrusion weld seam and not get a signal from a hole on the opposite side of the weld. It will however give a signal during a return pass along the opposite side This does not mean the hole was not there the first time or that the equipment is not functioning properly.
- The lack of a spark (no signal) indicates a good seam.
- Ensure that the spark tester is calibrated as per above procedure.
- ALWAYS READ THE SPARK TESTER'S MANUFACTURING INSTRUCTIONS AND FAMILIARISE YOURSELF WITH THE EQUIPMENT. THERE ARE MANY DIFFERENT TYPES OF EQUIPMENT AND THE SET-UP OF THESE MAY DIFFER FROM THE DESCRIPTION ABOVE.
- A spark test is not an indication of the bonding quality of the extrusion weld. It only validates continuity of the weld.

Destructive Testing

- Destructive tests are to be carried out on trial samples prepared under the same conditions as the in-situ welding work. These should be performed on site to confirm the welding equipment settings are correct by using a field tensiometer.
- Alternatively, samples can also be sent to an independent laboratory for analysis. The table below contains destructive testing methods and recommended frequency.

Method	Recommended Frequency
Site trial welds	Prior to each welding period on every installation
Independent lab testing	During trials for major works

Peel and Shear Test



- HDPE is a "notch sensitive" material which means that stress concentrations occur where there is a localised thinning of or change of thickness of the lining. This has a significant influence on test results of samples with anchors tested in peel and shear when compared to samples of smooth sheet composed of the same resins.
- This notch sensitivity does not affect the function of a cast-in AKS system as the lining is so frequently anchored to the concrete and cannot be stressed to near its yield point without catastrophic failure of the concrete behind the lining.
- Weld strengths are defined in various guides used by the Geosynthetic Industry, but all of these are aimed at testing the welds carried out on smooth loose sheet.
- The GRI Standards for sheer and tensile tests of welds, carried out on smooth sheet, are as follows:
- Shear – 90% minimum of liner strength Peel – 60% minimum of liner strength. The AKS anchors will interfere with the values unless you are able to isolate test coupons to be free of anchors. This is not possible across a weld, so the values are adjusted. To allow for the effect of the anchors, the following values are applicable to extrusion welds, carried out on AKS liner:
- Shear - 70% minimum of liner strength Peel – 50% minimum of liner strength
- In the absence of a calibrated tensiometer, site tests can only be tested to the limit of the strength of the parent material on which the welds have been carried out. In this case the test is considered a pass if the material fails in the parent material, not within the weld bead or between the bead and the surface of the liner. Peel separation (or incursion) for extrusion welds cannot exceed 25% of the joint's bonded area. If the weld breaks along the edge of the upper sheet it may be because the sheet was not correctly chamfered, or the thickness of the bead was not adequate. In the absence of a strength value, this weld must be considered a failure.
- The procedure for peel and shear testing of samples is as follows:
    - Cut sample with sample cutter
    - Allow sample to cool to ambient temperature before testing.
    - Confirm sample width and place in the jaws of the tensiometer in either peel or shear orientation depending on test
    - Set test rate to 50mm/minute
    - Start machine and monitor failure load
    - Remove sample and confirm failure mode

Field Trial Welds

- There are a number of variable ambient conditions which can affect the welding process. These include wind, humidity, sunlight/shade, air temperature, lining temperature. The welding technician needs to adjust the preheating temperature and extrudate temperature of the welding equipment to produce a quality weld under prevailing conditions. This can be regularly checked by measuring temperature of the extrudate and the preheat using a Pyrometer. Poor weld quality is also easily detected immediately by the Impact test as described above.

- Trial welds can also be undertaken to confirm that the setting selection is producing welds of passing quality. They also confirm that the equipment is working correctly prior to the commencement of production welds.

- Trial welds can be performed before starting site production and are recommended to be undertaken on a weekly basis if welding on the one site for extended periods.
- The trial weld procedure is as follows:
    - The trial weld will be made by joining two (2) pieces of MasterShield AKS, each piece at least 150mm in width, approximately 1m in length.
    - The seam should be visually inspected for squeeze out, footprint and general appearance.
    - An impact test should be performed on the weld following completion (by picking at edge with blunt object)
    - Three 25mm wide x 150mm long specimens should be cut, one from the middle of the seam and one each 300mm from each end of the test seam using a 25mm sample cutter. Any areas which look visually suspect should also be tested. The specimens will then be tested in peel using a field tensiometer.
- The failure must occur in the parent material (usually next to the weld seam area) and not in the weld itself.

Field Testing: Production Welds

- It is not practical to conduct destructive field testing of production welds of cast-in MasterShield AKS. This practice is also not recommended as the patch repair of samples cut in-situ will include T-intersections and the lining will be subjected to additional heat treatment. Therefore, by cutting a sample, one destroys a good weld and repairs it with a slightly inferior weld and creates a new risk.

Pull Testing

- Pull testing of installed MasterShield AKS may be carried out on the first concrete pour, or on a trial pour, in a project to validate the concrete mix and that the concrete is fully encapsulating the knobs. Further pull testing on installed MasterShield AKS is not recommended, as it often creates a penetration in perfectly good membrane which necessitates repair.
- In any casting process, full encapsulation of the anchors can be quickly validated by sounding of the membrane surface, after casting and stripping forms. Sounding is through repeated tapping to detect any hollow sounds which indicate voids behind the lining and less than 100% encapsulation. In the rare instance that voids are detected, they can be easily remediated by injection of high strength fluid cement grout (such as MasterFlux 200) behind the membrane.

Laboratory Testing

- Samples of approved applicators welding technicians' welds may be evaluated off-site by Master Builders Solutions as part of the Installer approval process.

Overview

AKS Approved Applicator requirements

- International Code DVS2227
- Manufacturer Installation Manuals
- Sheet layout plans for each structure
- Technician Session:
    - Brief introduction to the product
    - Typical applications
    - The tools we will use
    - Preparation before welding
    - Welding criteria
    - Testing – vacuum box
    - Testing - pressure
    - Testing – spark
    - Installation details

Installation equipment / tools required

AKS sheet cutting tool

Stanley knives and blades

Silicone roller

Knob cutting pliers

80 grit grinding disks

Hand grinders

Hot air blower

Speed weld attachment
Correct hot air blower nozzle

4mm / 5mm Extrusion welder

inside corner welding shoes

flat welding shoe

outside corner welding shoes

Welding rod

Copper wire

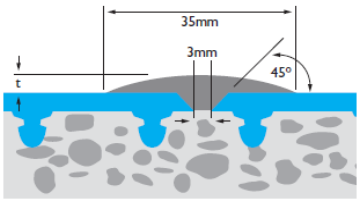
Tensiometer / Peel tester

Spark Tester

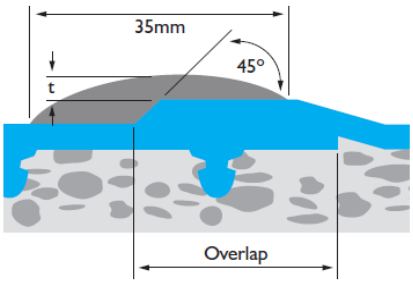
Pyrometer

Detailing

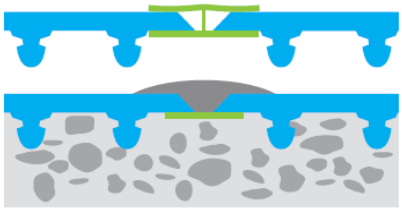
Flat Extrusion Butt Weld



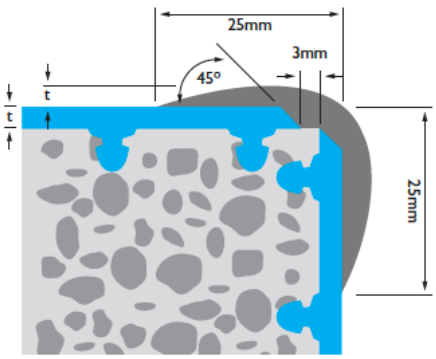
Flat Extrusion Overlap Weld



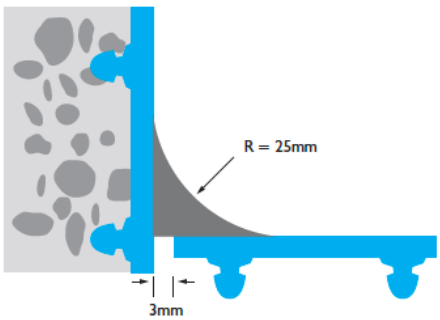
Butt Joint with ALS H- Profile



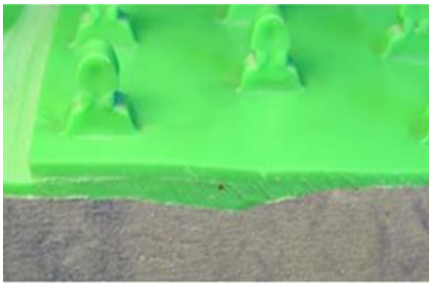
Outside Corner Weld



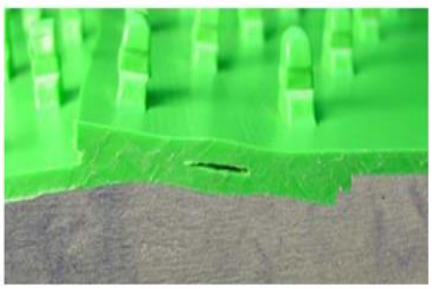
Inside Corner Weld



Extrusion Welding

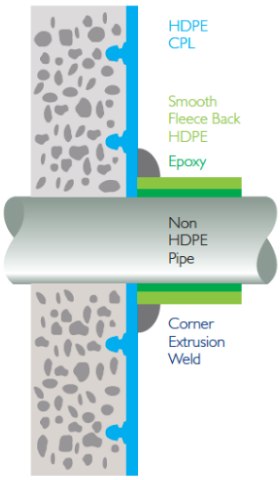


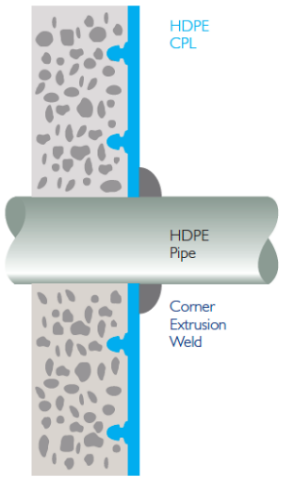
Double Hot Wedge Welding



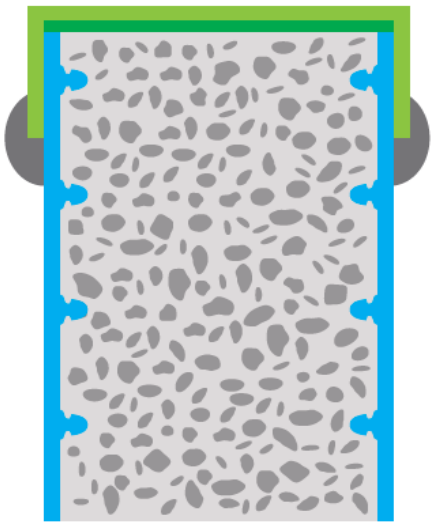
Butt Welding

Pipe Penetrations



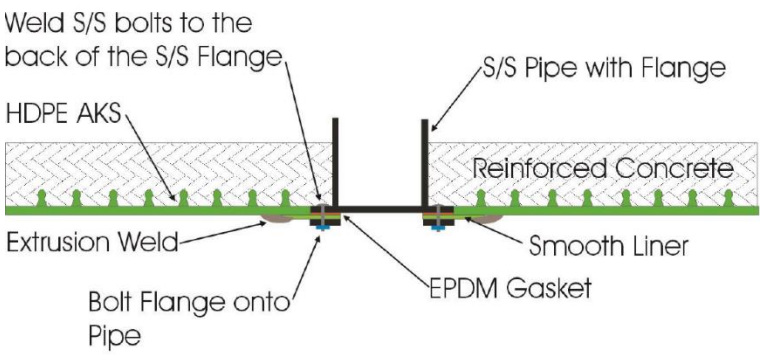


Top of Wall Details



Pipes, Structures and/or Penetrations in Soffit Applications

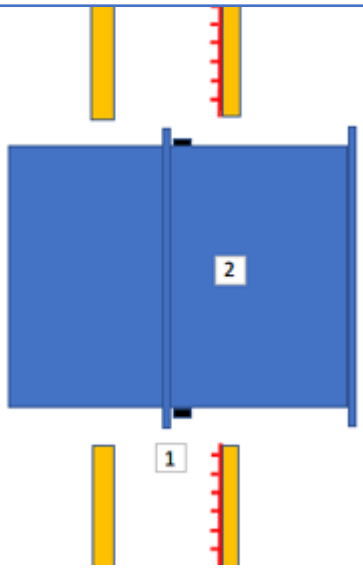
Flanged Pipe Penetrations in Soffit Applications



Pipe Penetration Detail using HDPE Fleeceback Sheet to Epoxy Seal to Non-HDPE Pipes

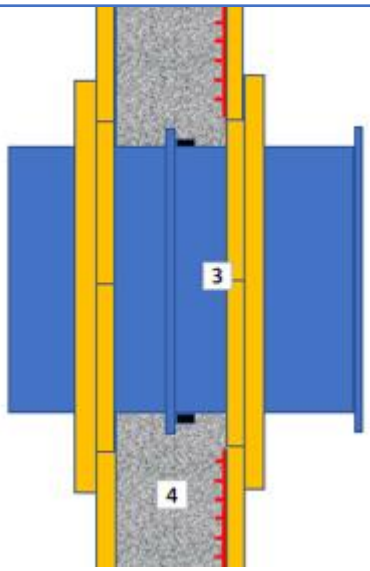
STEP 1

1. Attach MShield AKS to inner form and remove membrane and form locally at pipe penetration.
2. Pass flanged end pipe with puddle flange and hydrophilic strip through formwork



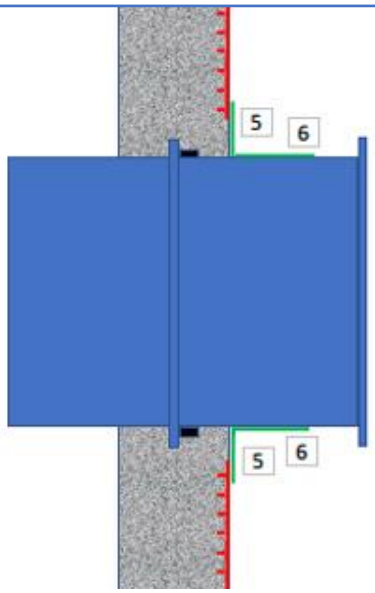
STEP 2

3. Cut out two donut halves from form material and secure/seal around pipe at inner and outer form
2. Pour concrete wall



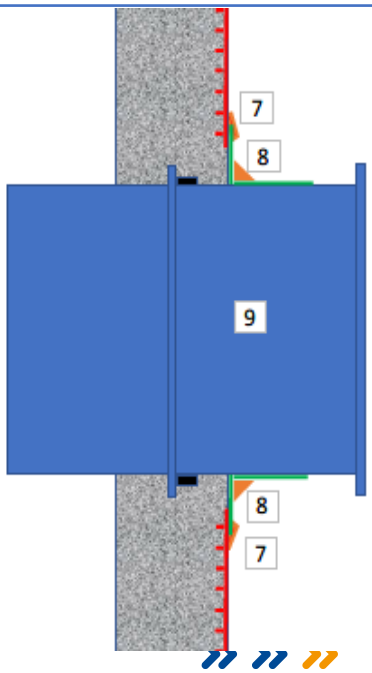
STEP 3

5. After form removal, cut out four donut quadrants from fleece-back HDPE sheet and epoxy fleece side to roughened exposed concrete, overlapping 15mm onto AKS HDPE. Use MasterStrength 2525.
6. Cut out rectangular strip from Fleece-back HDPE sheet and epoxy fleece side to clean pipe all around



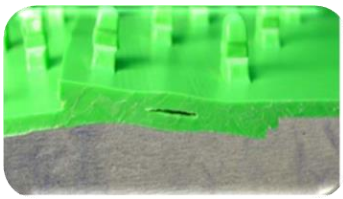
STEP 4

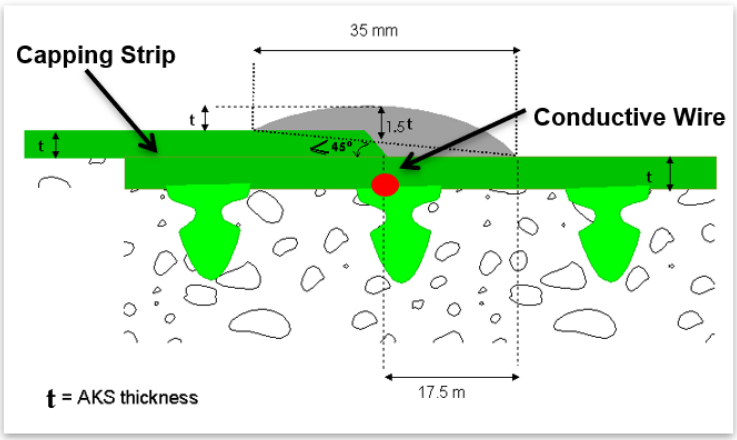
7. Extrusion weld HDPE side of fleece-back to AKS membrane all around.
8. Extrusion weld (internal corner weld) HDPE side of fleece-back pieces all around.
9. Extrusion weld all joins in fleece-back



Copper Wire Testing

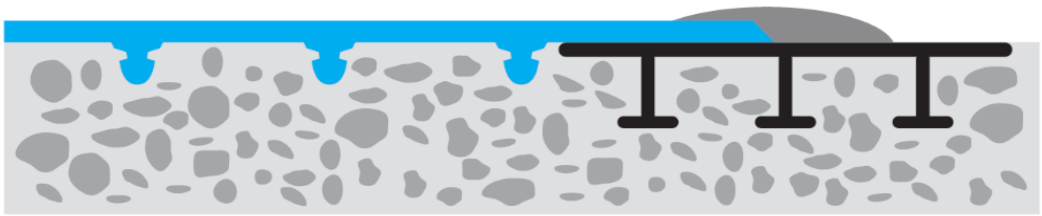
The extrusion welder applies the final extrudate over the overlap joint, while placing a conductive wire to allow for spark testing afterwards.





A single extrusion bead is laid over the overlap as can be seen in the above schematic.

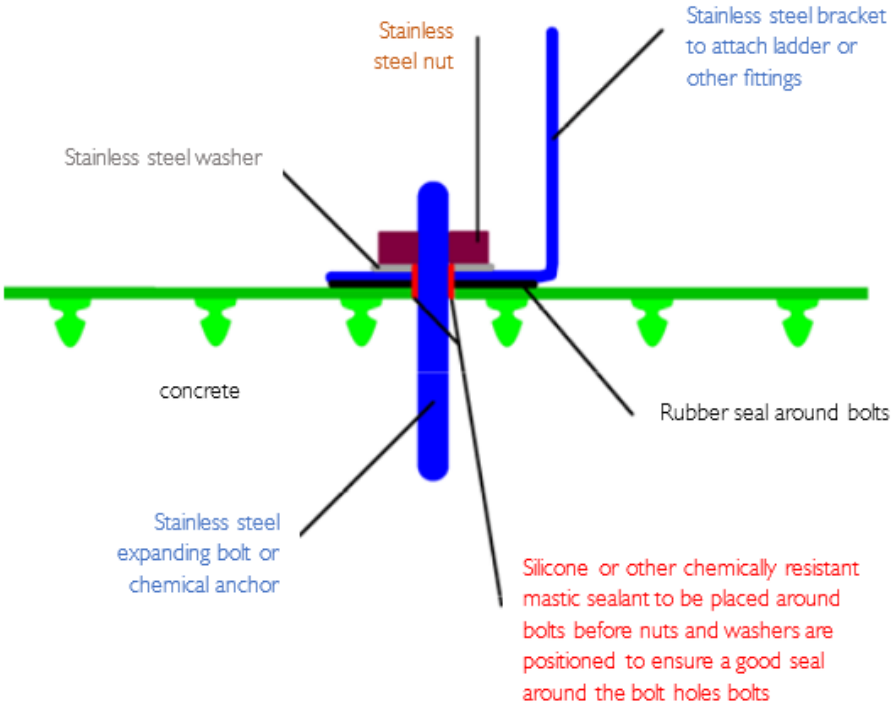
Sealing of Perimeter of HDPE CPL to Water Bar



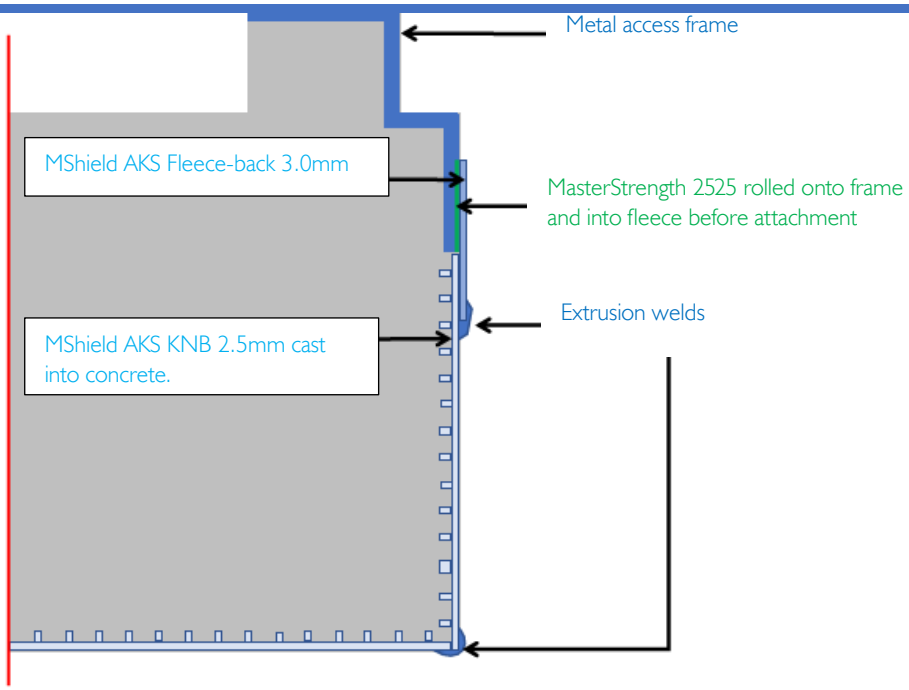
Expansion Joint

Joint filler (foam) HDPE slip piece Smooth HDPE capping strip

Sealing of Brackets and Fittings Attached to HDPE CPL Lined Structures



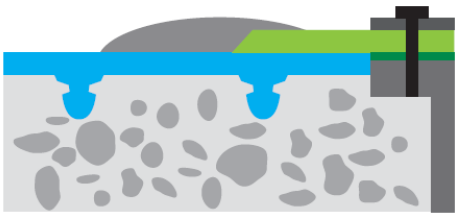
Detail for Connection and Sealing Against Metal Access Opening Frames



Interior of Sump

Gasket of closed cell foam or suitable soft rubber

Stainless steel pipe with flanged end. To be cast into the concrete.



Smooth HDPE sheet clamped in flange and welded

Stub flange

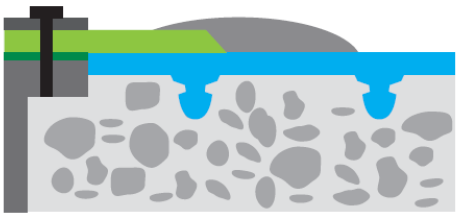
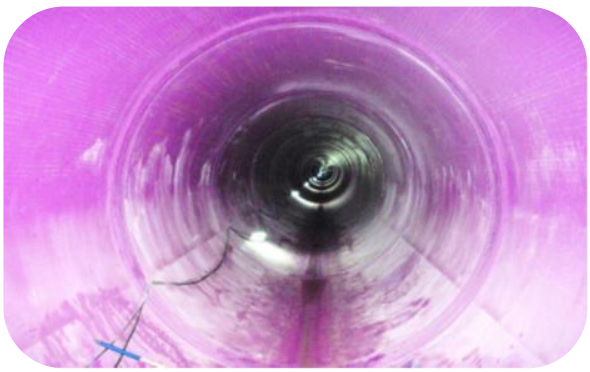
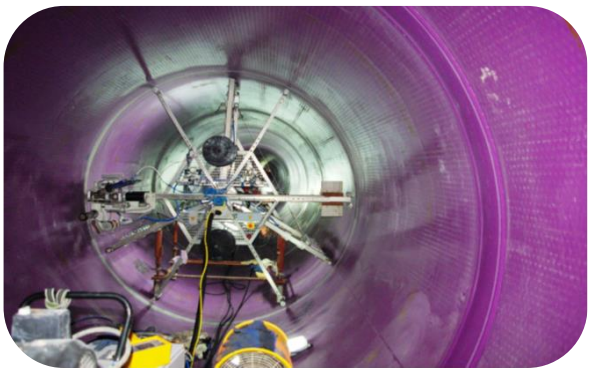


Photo Gallery

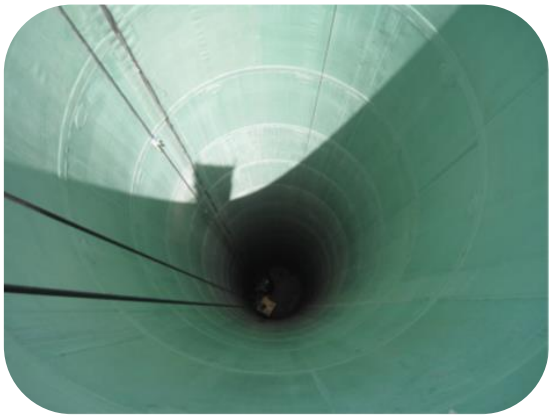
Sewer Pipelines & Outfalls





SHAFTS: Drop Shafts, Access Shafts

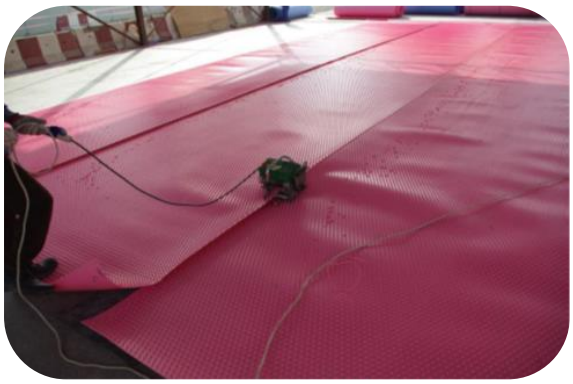
Depth 40-90m



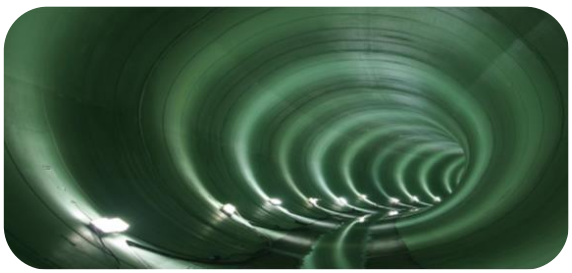
Large Sewer Tunnels

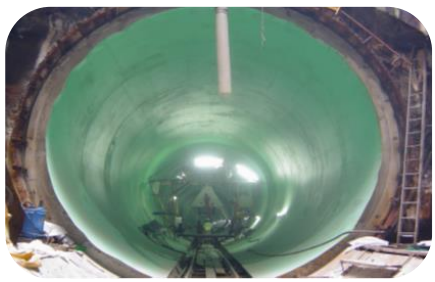
Large Sheets of AKS Prefabrication. These sheets will be 12 m in length and widths to match the tunnel circumference

As secondary process, large collapsible forms (12m length) with AKS pulled tightly around outer perimeter.

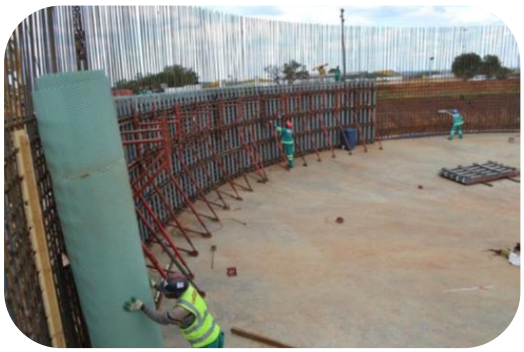


Formwork locked in place, with AKS cast/ grouted onto inner face of tunnel





Wastewater Treatment Works



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