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Selective Soldering

Vitronics Soltec

Design Rules for Selective Soldering Assemblies

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TOOLING AND APPLICATION

Recommendations for a robust selective soldering process

ZEVA platform

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Table of contents

1.0 General

This document describes general guidelines and attention points for PCB design regarding selective soldering. The guidelines can be applied for the different selective processes for both SnPb and lead-free solders.

When a PCB is designed according these guidelines, a stable and robust solder process can be guaranteed.

In case the guidelines seem to restrict your specific application please contact the Vitronics Soltec Tooling group (tooling.nl@itweae.com) to find the right solution for your application.

2.0 General PCB dimensions and specifications

2.1 Solderability

The solderability of the metal surfaces to be soldered must be in accordance with the general demands for (machine) soldering as defined in IPC/EIA J-STD-002. This standard prescribes test methods, defect definitions, acceptance criteria, and illustrations for assessing the solderability of electronic component leads, terminations, solid wires, stranded wires, lugs, and tabs.

2.2 Board dimensions

See machine specification. For ZEVAm GS-336 and ZEVAv GS-331.

2.3 Tolerances and board flatness

Although most of the boards are reflow soldered prior to selective soldering the flatness should be granted. Bow and twist should not exceed 1% as defined in the IPC-TM-650, 2.4.22. The maximum bow and twist is limited to 2 mm.

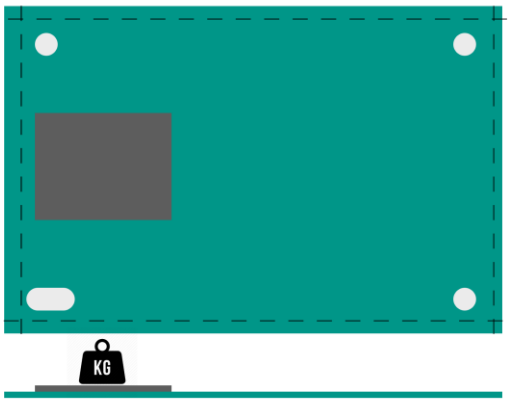
This is the maximum twist the conveyor can handle. For a robust process it is recommended to have a minimum twist since this will affect the contact time and cause a potential risk for open joints or bridging. For assemblies that are not flat a board warpage compensation by software is recommended.

2.4 Board weight

The maximum weight of the assembly is for the both machines (ZEVAm and ZEVAv) 10 kg (22 lb). This weight includes pallet and hold down unit if needed. The acceleration speed and maximum speed of the shuttle are defined in the machine specification of the ZEVAv GS-331.

2.5 Board weight distribution

On a board there might be one area where the weight exceeds the average weight expressed in mass/dm^2. The total weight however should not exceed the maximum weight as defined in chapter 2.4



The maximum weight concentration for a board area of 1 dm^2 on a larger board must be limited to approximately 0.5 – 1.0 kg/dm^2 (1.1 – 2.2 lbs/dm^2).

Figure 1: Board weight distribution

2.6 Edge clearance

2.6.1 Edge clearance for PCB

The edge clearance on top and bottom of PCB must be ≥ 3.0 mm (0.118 inch). This clearance is necessary for supporting the assembly on the chain or disk conveyor with clamping unit. Edge components, like pin connectors, can be applied if there is enough space left for support. Dedicated pallets may be an alternative.

The clamping in the shuttle or on the solder conveyor requires 3 mm free space over the whole width. Eventually these clamping systems can be modified for dedicated assemblies. For conveyors with a roller chain the edge clearance on front and rear side (of the pallet) should be ≥ 6.0 mm (0.236 inch). The leading edge of the board or pallet should have space for a stopper.

2.6.2 Board position holes in PCB

Preferable one round hole and one slotted on the fixed rail side of the PCB, diameter holes 3 mm (0.118 inch) according to IPC-2221.

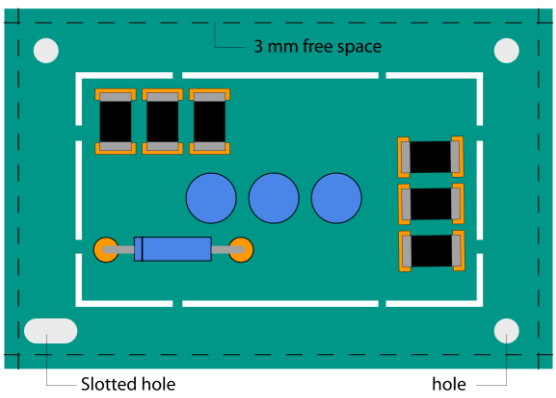


Figure 2: holes in PCB for positioning

The ZEVA shuttle doesn't require these positioning holes, but in case of PCB multi wave dipping these holes are ideal for position the PCB on the nozzle plate.

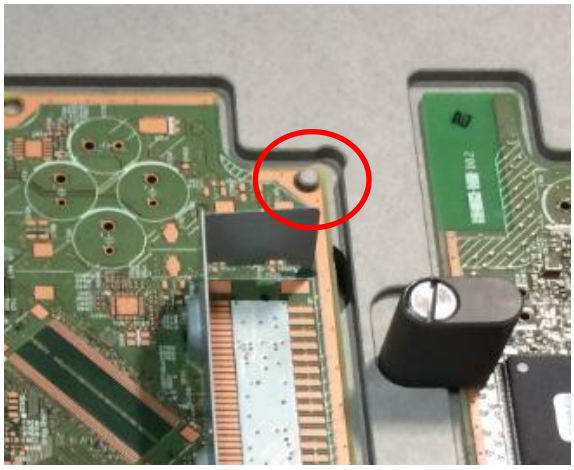


Figure 3: Hole used for positioning the PCB in the pallet.

3.0 PCB joint and component layout

3.1 Component height on top and bottom side

The general specification of component height on the topside of the PCB is 120 mm (4.72 inch) in both select and multi wave soldering. Hold down units may affect the maximum height.

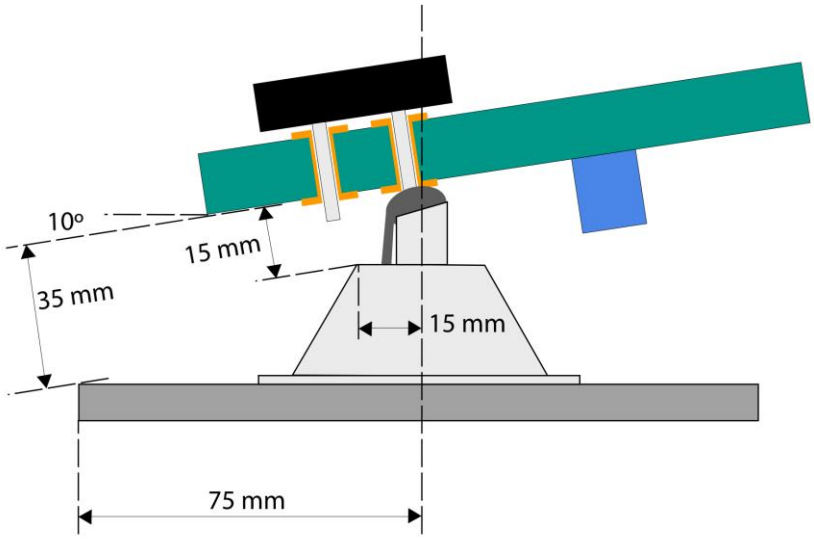


Figure 4: Required free space for selective drag soldering with tilt.

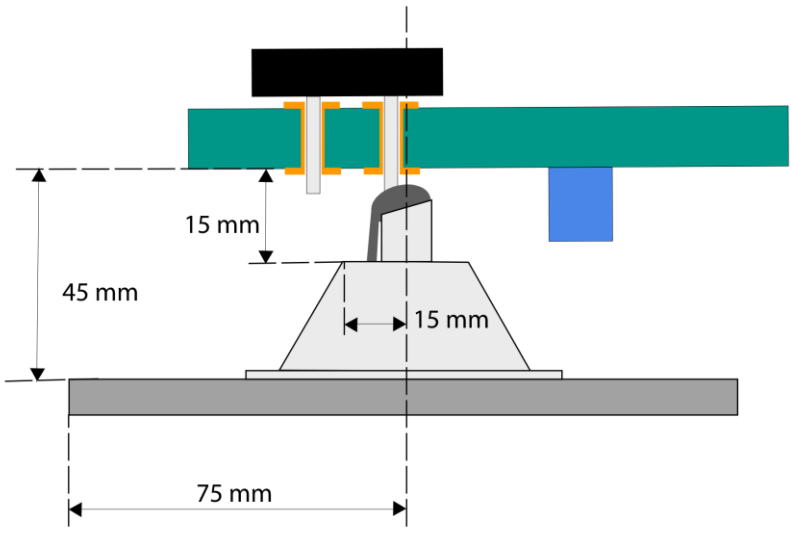


Figure 5: Required free space for selective soldering with PCB flat.

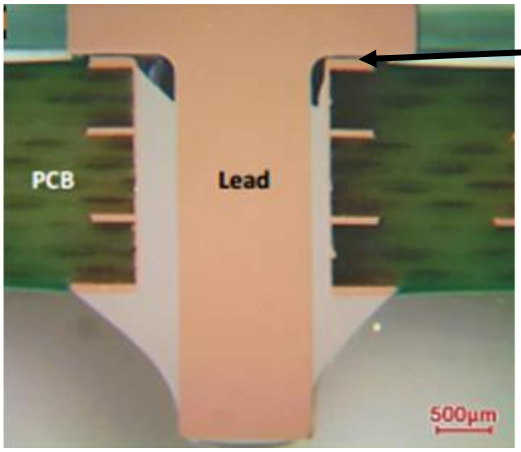
The maximum component height on the bottom (solder) side of the PCB is specified at 25 mm (1 inch) select wave and 16 mm (0.63 inch) for multi wave dip soldering.

The height restriction around the nitrogen cone for select wave nozzles is about 10 mm (0.39 inch). The conveyor limits the maximum component height on the bottom to 25 mm (1 inch).

3.2 Joint design

3.2.1 Clearance between component and PCB

Parts and components should be mounted such that there is no obstruction in the solder flow to the solder destination side. Enough gap between top side board and component should guarantee a good hole fill. The flux should have the ability to outgas on top side.



No gap, hole obstruction. Not possible for solder to flow to topside (gas confinement).

Figure 6: Cross section of joint with no space for outgassing.

3.2.2 Joint dimensions and lead protrusion length

The general minimum lead protruding length is defined in the IPC-A-610 chapter Through-Hole Technology. For double sided boards (supported holes) the end should be discernible in the solder. For single sided boards (unsupported holes) the end should be discernible in the solder additional for class 3 assemblies it should be sufficient to clinch.

For supported holes class 2 the maximum is 2.5 mm (0.1 inch) and for class 3 it is 1.5 mm (0.06 inch). Exempted are leads >1.3 mm (0.05 inch) diameter provided they don't violate minimum electrical clearance.

The maximum protrusion length for single sided boards is not defined, as long as there is no danger for shorts or violation of minimum electrical clearance.

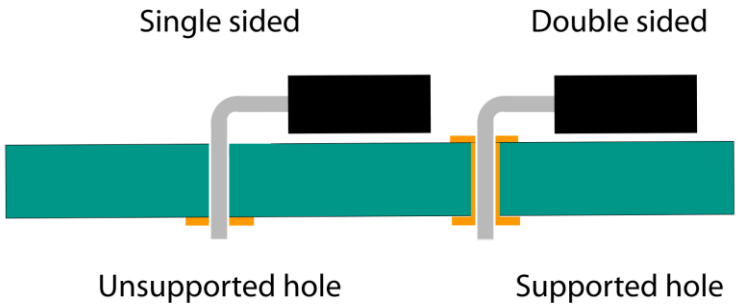


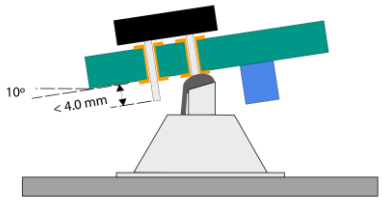
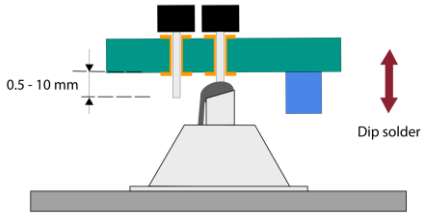
Figure 7: Protrusion length unsupported and supported holes

Select wave: to minimize risk for bridging short protrusion lengths are preferred. Recommendation for fine pitch lead length between 0.5 and 0.8 mm (0.02 and 0.03 inch). For dipping a longer lead brings more heat into the assembly, better hole filling.

Multi wave: longer leads have a better solder drainage and improve the wetting, hole filling.

3.2.3 Protrusion length limitation

For dip soldering in both, Select-Wave or Multi-Wave process, leads may have a length of 10 mm (0.39 inch). For drag soldering on a select wave the lead length is limited to 4.0 mm (0.16 inch). In general, shorter leads will give less risk for bridging but longer leads have a better heat transfer to achieve good hole filling.

Select Wave Drag soldering < 4.0 mm (<0.16 inch)	
Select Wave Dip soldering 0.5 – 10.0 mm (0.02 – 0.39 inch)	

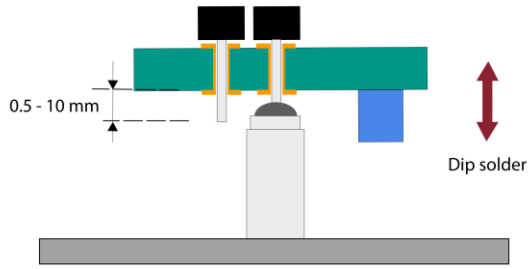
Multi Wave Dip soldering 0.5 – 10.0 mm (0.02 – 0.39 inch)	

Figure 8: Lead protrusion length limitations.

A straight protruding length of more than 1 mm will in general not collect more solder in the joint in machine soldering and therefore will not add more strength to the joint, but longer leads improve heat transfer.

3.3 Restrictions for SMD components inside the solder area

In general, inside the area to be soldered by the Multi Wave, no SMD components can be allowed, unless the SMD's are glued and already soldered and can withstand the selective soldering process without interfering with the leads of the solder joint.

To reduce solder bridging between SMD components and/or leads, the PCB design guidelines for dip soldering should be applied.

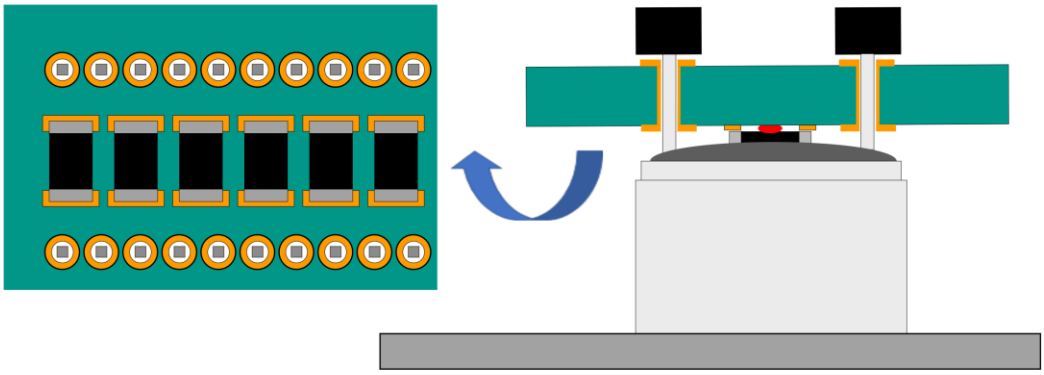


Figure 9: Restricted area for SMD components. SMD components are not recommended in the soldering area.

4.0 Free space requirements for multi wave

4.1 General non-wettable nozzles

Free space around a selective solder point is necessary for having free access of the nozzle to the joint and reduce thermal load to surrounding components during soldering. Additional free space might be required to address product tolerances. In general, a robust process is guaranteed for multi wave processes when there is a free space of 1.0 mm or more from the edge of the nozzle to a surrounded component or SMD pad.

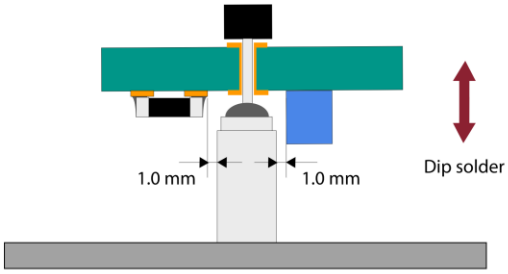


Figure 10: Minimum free spacing for non-wettable multi wave nozzles.

4.2 Dimensions available nozzles

A multi wave dip process can have different shape type of nozzles. For a stable wave height and soldering process, a minimum outside dimension of 6.0 mm (0.24 inch) is required.

Multi wave nozzles have patented tuning holes to keep the solder temperature at set-point in the solder area. The solder flows out of these holes during soldering. These side flow holes are 3.0 mm (0.12 inch) and located 10.0 mm (0.39 inch) to the rim of the nozzle. All nozzles have a fixed height of 36 mm (1.42 inch).

Figure 11: showing the tuning holes of the nozzles.

4.3 Free space requirements multi wave

Due to the spherical shape of the solder surface on the static wave in a stainless steel multi wave nozzle the 'net area' that can be used for soldering is reduced.

The inside nozzle dimension must be 1.5 mm (0.06 inch) more than the solder area in all directions (due to meniscus of solder and nozzle rim). There must be a clearance of 1.0 mm (0.04 inch) between the outside edge of the nozzle and surrounded components and the pads of SMDs (See figure 12).

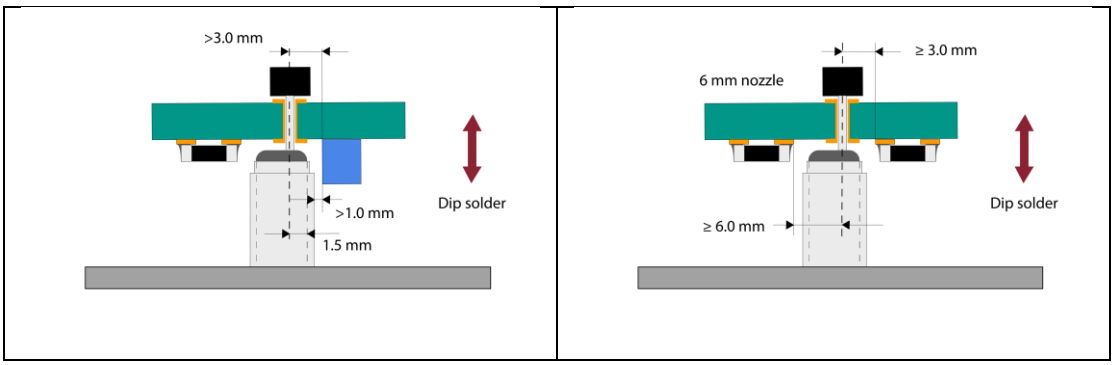


Figure 12: Free space for smallest nozzle 6 mm.

4.4 Distance multi wave nozzle to PCB

Multi wave nozzle plates are provided with 'stand-off' pins. The pins are made to keep the gap between the topside of the nozzle fixed at 0.3 mm (0.012 inch) from the bottom side of the board during soldering. 0.3 mm (0.012 inch) is the standard gap; optional are 0 and 1.5 mm (0.06 inch).

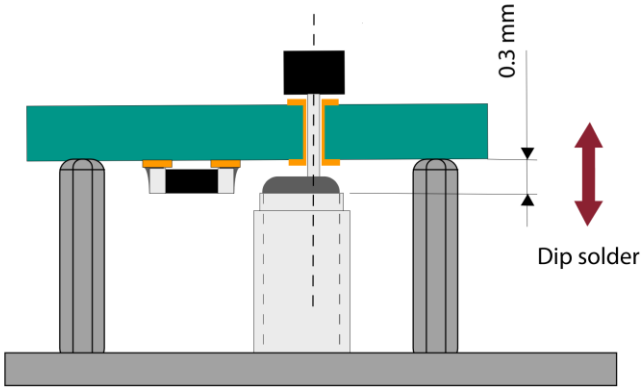


Figure 13: Distance topside nozzle to bottom side board.

The pins keep the board flat during soldering and avoid oxides to stick on the solder mask by creating a small gap between nozzle and board.

5.0 Free space requirements select wave

5.1 General requirements select wave nozzles

For select wave soldering there are two different type nozzles available. Wettable and non-wettable. The wettable nozzles are made of cold rolled steel and can be tinned. Non-wettable nozzles are made of stainless steel or titanium; materials that can't be tinned. Standard nozzles can be divided into three categories:

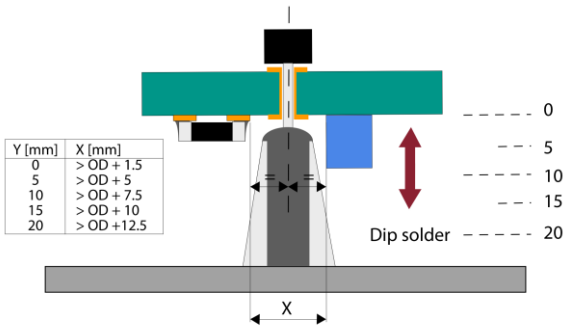
		
Standard wettable nozzle shape. Nozzle has a solderable finish and the solder flows around the trunk of the nozzle.	**Conical shape wettable nozzle.** The nozzle has a solderable finish and has more mass to maintain the solder temperature.	**Standard non-wettable nozzle** Surface can't be tinned and solder flows to one side (in picture to the left).

Figure 14: Different standard nozzles for select wave.

Different shape nozzles for dedicated applications can be designed. Contact the Vitronics Soltec Tooling group (tooling.nl@itweae.com).

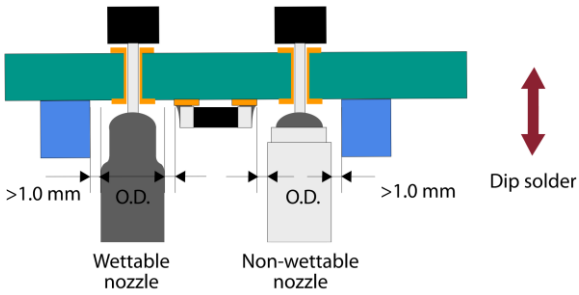
Two different solder techniques can be applied with these nozzles: dip and drag soldering. Both can be done horizontal or tilted under a 10 ° angle.

For both processes the minimum standard outside diameter is 4.0 mm (0.16 inch) for a wettable nozzle. The nozzle rim is typical 0.5 mm (0.02 inch) thick.



Conical wettable nozzle requires more taboo zone, but has better heat transfer.

Figure 15: Taboo zone conical nozzle for dipping



The taboo zone for standard wettable and non-wettable nozzles is the outer diameter + minimal 1.0 mm (

Figure 16: Taboo zone dipping

5.2 Taboo zone before and after drag without SDC unit – Flat soldering

Available (inner) diameters for non-wettable nozzles for the ZEVA m are: 4, 6, 8, 10, and 12 mm. The non-wettable nozzles can be used in combination with SDC (solder drainage conditioner) for de-bridging.

Definition keep out area:

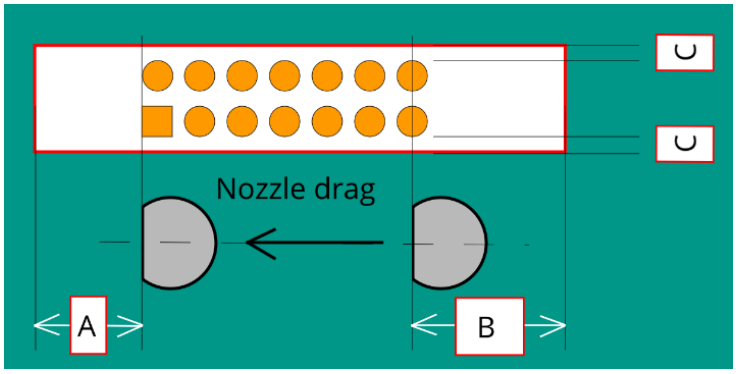


Figure 17: Definition taboo zones.

A = Free distance after drag/dip; from end of the Cu-pad or solder thief to the next component/Cu metallization.

B = Free distance before drag/dip: from end of Cu metallization or component to the center of the first pad to be soldered.

C = Free distance parallel to solder direction; distance from end of Cu-pad/thief to first Cu metallization or component.

For soldering with **non-wettable** nozzles without SDC unit the keep out areas are defined for both flat and tilted:

Keep out distance [mm]	A	B	C
Non-Wettable 4 mm	5.0	5.0	1.0
Non-Wettable 6 mm	6.5	7.0	1.0
Non-Wettable 8 mm	8.0	9.0	1.0
Non-Wettable 10 mm	9.5	11.0	1.0
Non-Wettable 12 mm	11.0	13.0	1.0
Non-Wettable 14 mm	12.5	15.0	1.0

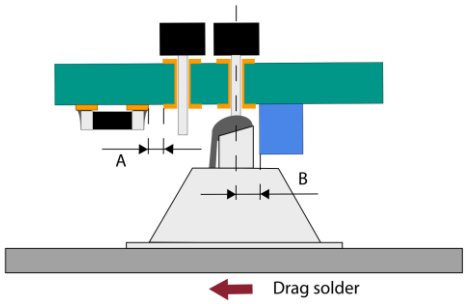


Figure 18: Required free space on print for drag soldering with non-wettable nozzle.

Wettable nozzles for ZEVA m are standard available in diameters: 3, 4, 6, and 8 mm. Typical the wettable nozzles are used without SDC since the tinned nozzles will drain the solder by itself.

Keep out distance [mm]	A		B		C
	H = 5 mm	H = 12 mm	H = 5 mm	H = 12 mm	
Wettable 3 mm	3.0	4.0	3.0	4.0	1.0
Wettable 4 mm	3.5	4.5	3.5	4.5	1.0
Wettable 6 mm	4.5	5.5	4.5	5.5	1.0
Wettable 8 mm	5.5	6.5	5.5	6.5	1.0

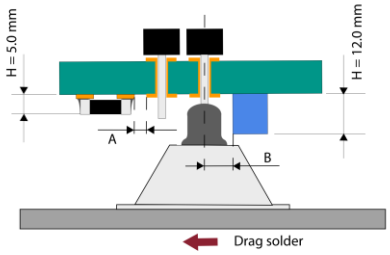


Figure 19: Required free space on the print for drag soldering standard wettable nozzle.

The conical wettable nozzles are 4, and 6 mm. Also, the conical wettable nozzles are typically not used in combination with SDC.

Keep out distance [mm]	A		B		C
	H = 5 mm	H = 12 mm	H = 5 mm	H = 12 mm	
Wettable 4 mm	5.0	6.0	5.0	6.0	1.0
Wettable 6 mm	6.0	7.0	6.0	7.0	1.0

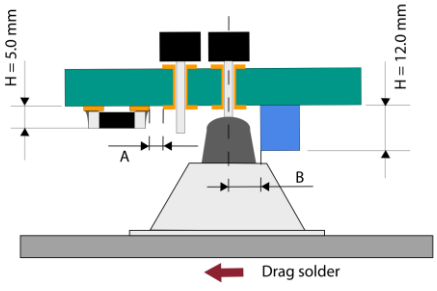
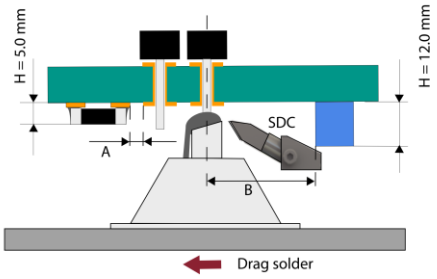


Figure 20: Required free space on the print for drag soldering conical wettable nozzle.

5.3 Taboo zone before and after drag with SDC – Flat soldering

Typical only non-wettable nozzles are used with SDC. This unit requires more space. The solder in non-wettable nozzles always flow to the front. The SDC is at solder exit to de-bridge. The tilting affects the keep out area therefore there is a table for tilt and flat. For flat soldering:



Keep out distance [mm]	A		B		C
	H = 5 mm	H = 12 mm	H = 5 mm	H = 12 mm	
Non-Wettable 4 mm	7.0	8.0	10.0	20.0	1.0
Non-Wettable 6 mm	7.0	8.0	12.0	22.0	1.0
Non-Wettable 8 mm	7.5	8.5	14.0	24.0	1.0
Non-Wettable 10 mm	7.5	8.5	16.0	26.0	1.0
Non-Wettable 12 mm	8.0	9.0	18.0	28.0	1.0
Non-Wettable 14 mm	8.0	9.0	20.0	30.0	1.0

Figure 21: The non-wettable nozzle with SDC requires relatively more free space at the before soldering position.

5.4 Taboo zone before and after drag soldering with tilted conveyor

The tilting of the conveyor makes it possible to come closer to components and the angle supports de-bridging. For non-wettable nozzles there is no significant difference in keep out areas when tilted.

For wettable nozzles the keep out area before soldering is smaller, but after soldering some more space is required.

Keep out distance [mm]	A		B		C
	H = 5 mm	H = 12 mm	H = 5 mm	H = 12 mm	
Wettable 3 mm	4.0	5.0	3.0	3.0	1.0
Wettable 4 mm	4.5	5.5	3.5	3.5	1.0
Wettable 6 mm	5.5	6.5	4.5	4.5	1.0
Wettable 8 mm	6.5	7.5	5.5	5.5	1.0

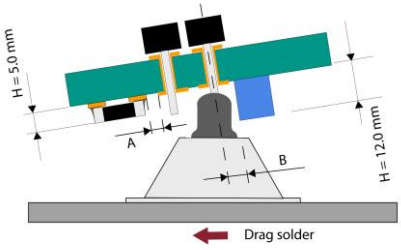


Figure 22: For standard wettable nozzle the taboo zone when the conveyor is tilted.

Similar for the conical wettable nozzle.

Keep out distance [mm]	A		B		C
	H = 5 mm	H = 12 mm	H = 5 mm	H = 12 mm	
Wettable 4 mm	5.0	6.0	5.0	5.0	1.0
Wettable 6 mm	6.0	7.0	6.0	6.0	1.0

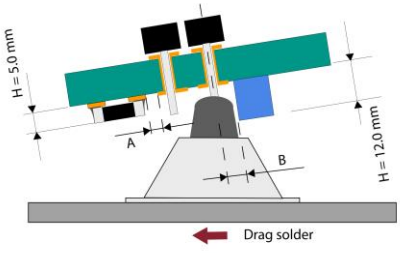
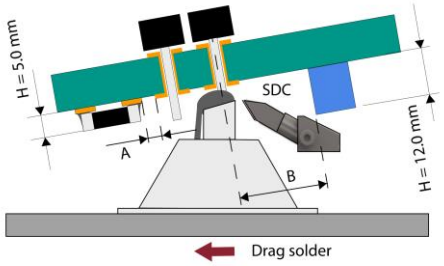


Figure 23: Similar for conical wettable nozzle.

5.5 Taboo zone before and after drag soldering with tilted conveyor and SDC

Soldering under an angle affects the keep out area. Special with SDC the tilt is beneficial. For the non-wettable nozzles the taboo zones for tilting are defined:



Keep out distance [mm]	A		B		C
	H = 5 mm	H = 12 mm	H = 5 mm	H = 12 mm	
Non-Wettable 4 mm	7.0	8.0	10.0	20.0	1.0
Non-Wettable 6 mm	7.0	8.0	12.0	22.0	1.0
Non-Wettable 8 mm	7.5	8.5	14.0	24.0	1.0
Non-Wettable 10 mm	7.5	8.5	16.0	26.0	1.0
Non-Wettable 12 mm	8.0	9.0	18.0	28.0	1.0
Non-Wettable 14 mm	8.0	9.0	20.0	30.0	1.0

Figure 24: Non-wettable nozzle with SDC. The distance before soldering reduced to the tilt of the conveyor.

5.6 Required free space pin chain

The ZEVA m can have a pin chain conveyor at the soldering station. Most common processes with pin chain conveyor have pallets to allow through hole components close to the edge of the board. PCB's can also be soldered without pallets. Since there is a double pin chain the best method to solder pin connectors at the conveyor side is using a long small wettable nozzle. This is a special nozzle and the reduced nitrogen shield height may affect the nitrogen performance at the solder area. The closest distance of board edge is 5 mm when using this configuration.

For PCB's with components close to the edge of the board a disk conveyor is preferred.

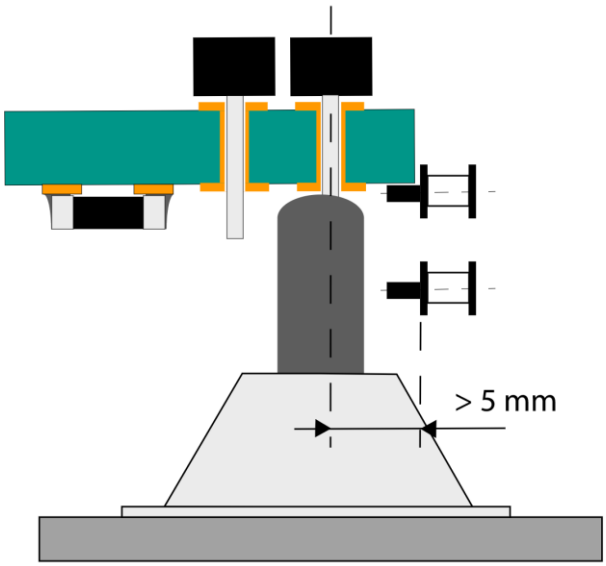
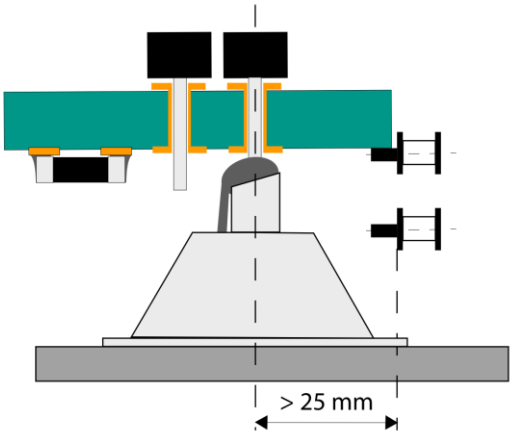


Figure 25: Long wettable nozzle is an alternative to solder THT close to the edge.



For a non-wettable nozzle with pin chain conveyor more space is required for soldering through hole components at PCB edge.

Figure 26: The SDC requires significant more space. A disk conveyor is a better option.

5.7 Required free space disk conveyor

The disk conveyor allows to run PCB's without pallets. Through hole components close to the edge of the board can be soldered with the different nozzle types without limitations.

With standard wettable nozzles it is feasible to solder THT pin connectors at edge of the board.

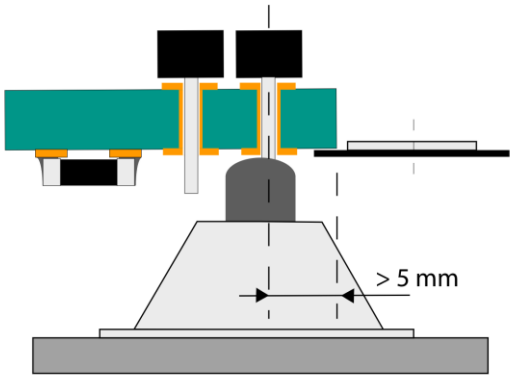


Figure 27: Wettable nozzle with disk conveyor.

Also, with the standard non-wettable nozzle and SDC unit to de-bridge the disk conveyor allows through hole pins be close to the edge.

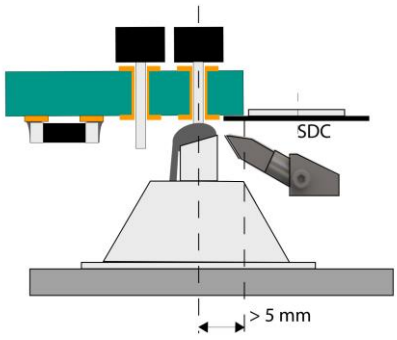


Figure 28: Non-wettable nozzle with SDC soldering THT close to edge.

6.0 Different pitch and recommended nozzles

The table shows the recommended nozzle diameters for fine and standard pitch sizes of through hole components. The nozzle diameters are recommendations and may differ depending on design and components used.

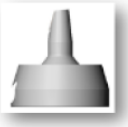
Component pitch [mm]	 Non-Wettable Nozzle	 Standard Wettable Nozzle	 Wettable Cone Nozzle
1.00 mm	4.0	3.0/4.0	4.0
1.27 mm	4.0/6.0	3.0/4.0	4.0
1.50 mm	4.0/6.0	4.0/6.0	4.0/6.0
2.00 mm	4.0/6.0	4.0/6.0	4.0/6.0
2.54 mm	4.0/8.0	4.0/8.0	4.0/6.0

Figure 29: different through hole pitch dimensions and recommended nozzle diameters.

For pitch equal or smaller than 1.50 mm the SDC (solder drainage conditioner) is recommended to eliminate bridging.

When SDC unit is used the lead protrusion length is not significant.

Smaller lead protrusion length will reduce the bridging risk. It is recommended to follow the IPC-A-610 standard for supported through holes.