Fundamentals of Press-Fit Technology

Introduction

As early as the 1970s, the telecommunications industry recognized the advantages of press-fit technology. Thanks to its reliability in harsh environments, it has also been gaining traction in the automotive industry since the 1980s. Especially in “rugged applications”—that is, environments subject to shock, vibration, moisture, dust, and dirt—press-fit technology stands out for its reliability. Many press-fit zones with different designs are now available on the market. However, they all have one thing in common: the goal of creating a durable, mechanical, and electrically conductive connection between the printed circuit board and the connector.

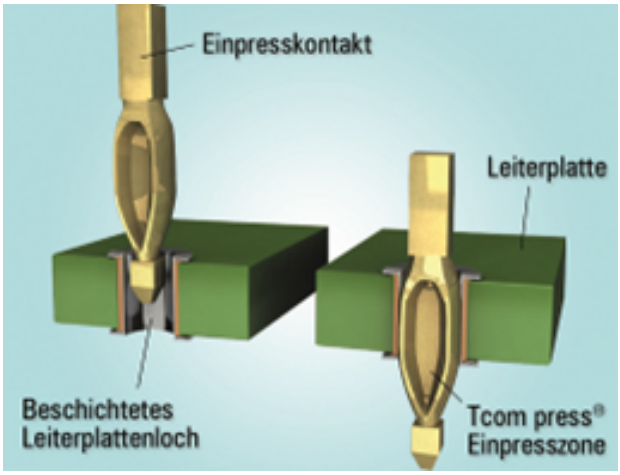

Fig. 1: Press-fitting process

To achieve this, the diagonal of the press-fit zone must be larger than the diameter of the metallized PCB hole. The contact is pressed into the hole with a defined force, creating a gas-tight, electrically conductive, and mechanically robust connection. The gas-tight zone also guarantees stable, age-resistant contact resistance.

A very important yet often overlooked factor in the mating process is the printed circuit board (PCB). The hole specifications, which are defined by the manufacturer of the mating zone, should be taken into account as early as the PCB design phase. While connector manufacturers generally strive to make their hole specifications similar, differences can be observed upon closer inspection. Elastic press-fit zones are necessary to compensate for the existing tolerances of the PCB holes. In the cross-section of the Tcom press® zone shown below, it can be seen that the elastic zone deforms, while the hole wall deforms only slightly. This is crucial for ensuring not only the functionality of the connection but also its reparability.

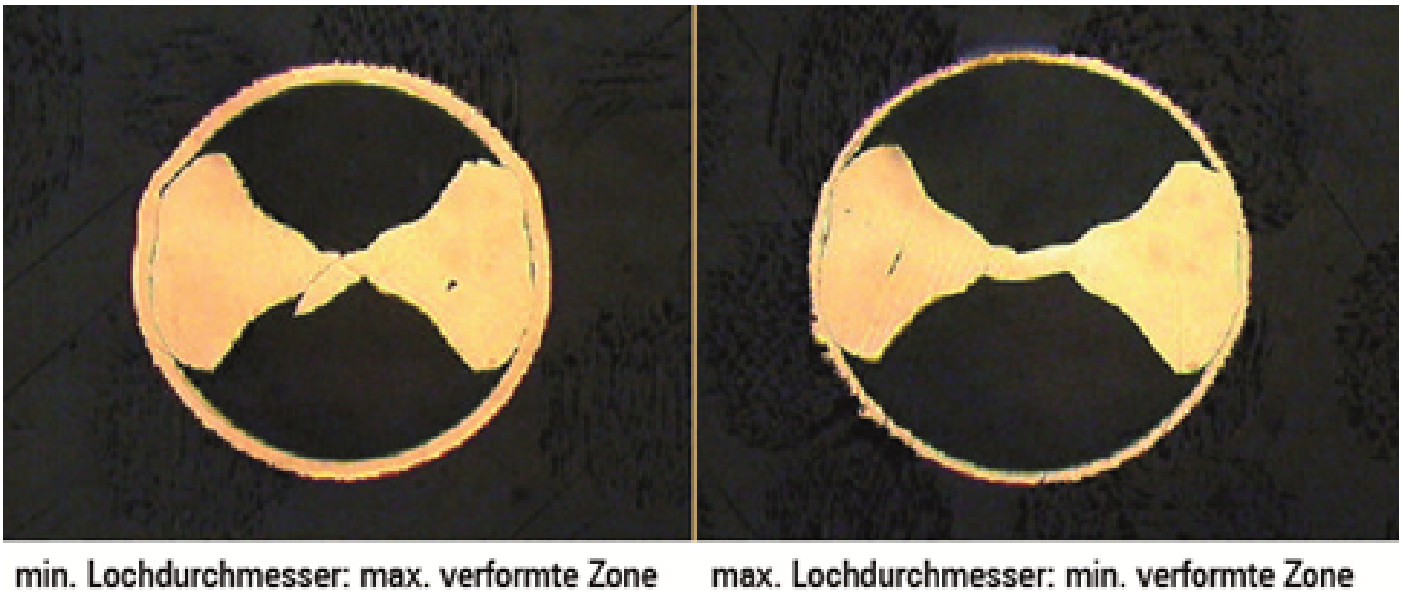

Fig. 2: Cross-section of the press-fit zone

Repairability

If a press-fit contact or connector has been improperly inserted, it can be removed using the appropriate tools. If a high-quality press-fit zone is used, the contact or connector can be reinserted into the through-hole on the printed circuit board. In this case, it is necessary to use a new contact or connector.

Printed circuit board surfaces

Right from the start, the user must decide which PCB surface offers the most benefits for their application. The most common surfaces currently include chemical tin, HAL tin (lead-free), copper OSP, nickel/gold, and silver.

With regard to press-fit connections, the hole coatings differ, among other things, in their retention force and insertion force. Insertion force is the force required to press the contact into the PCB hole. Retention force is the force required to push the contact back out of the PCB. The quality of the connection is measured, among other things, by the retention force.

Example: ept Ø 1 mm	Press-fit force	Retention force
Chem. Sn	max. 150 N	min. 30 N
Cu OSP	max. 130 N	min. 20N

Table 1: Comparison of PCB surfaces

Hole structure

To ensure a high-quality press-fit connection during PCB manufacturing, special attention must be paid to the drill hole diameter, the finished hole diameter, the copper sleeve thickness, and the PCB surface.

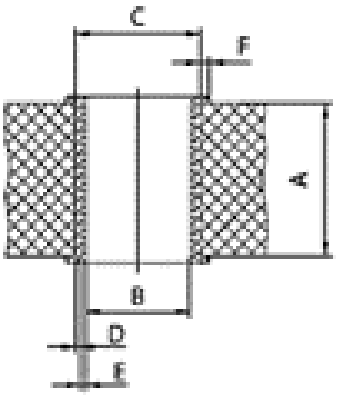

Fig. 3: ept hole specification, Ø 1 mm

	LP material	FR4
	Nominal hole	Ø 1.0 mm
A	PCB thickness	min. 1.44 mm
B	End hole	Ø 1.0 +0.09 / -0.06 mm
C	Base bore	1.15 ±0.025 mm
D	Cu layer	min. 25 µm
E	Surface	Chemical Sn layer, 0.5–1.5 µm
F	Residual ring	min. 0.1 mm

The most attention should be paid to the base hole, because a through-hole with a diameter of 1 mm is not necessarily the same as another through-hole with a diameter of 1 mm. The structure plays a decisive role here! “If the specification for press-fit holes is limited solely to the finished dimension—that is, the metallized hole—different drill bits may be used depending on the PCB manufacturer, and different metallization thicknesses may be supplied. This would result in completely different press-fit behavior, which must be rejected for reasons of quality assurance and the long-term performance of the joint.”

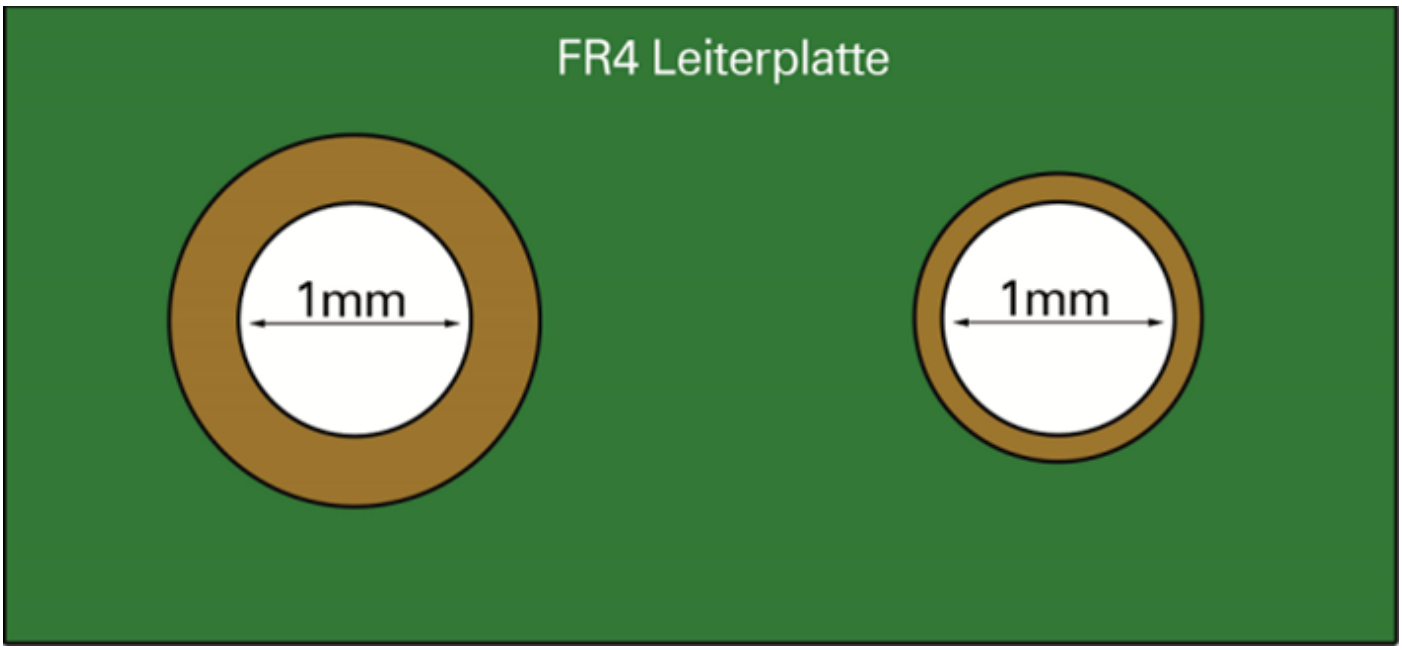

Fig. 4: Schematic representation of a 1-mm end hole with different drill hole diameters

Surface coating of the contacts and the press-fit zone

In addition to the PCB via, the contact itself is also plated. Thanks to innovative electroplating processes, the contact surfaces and the press-fit zone can be coated with different finishes. Ideally, the through-hole and the press-fit zone have the same surface finish.

PCB Design: Minimum Clearance and Trace Routing

When designing the printed circuit board (PCB), two factors must be taken into account: first, the minimum clearance between the connector and other components, and second, the routing of the traces. Due to the forces exerted on the PCB during insertion, a minimum clearance from electronic components must be maintained. This clearance also provides a support surface for the insertion tools. The trace routing should not lie in the direction of the force applied during insertion to prevent the traces from tearing.

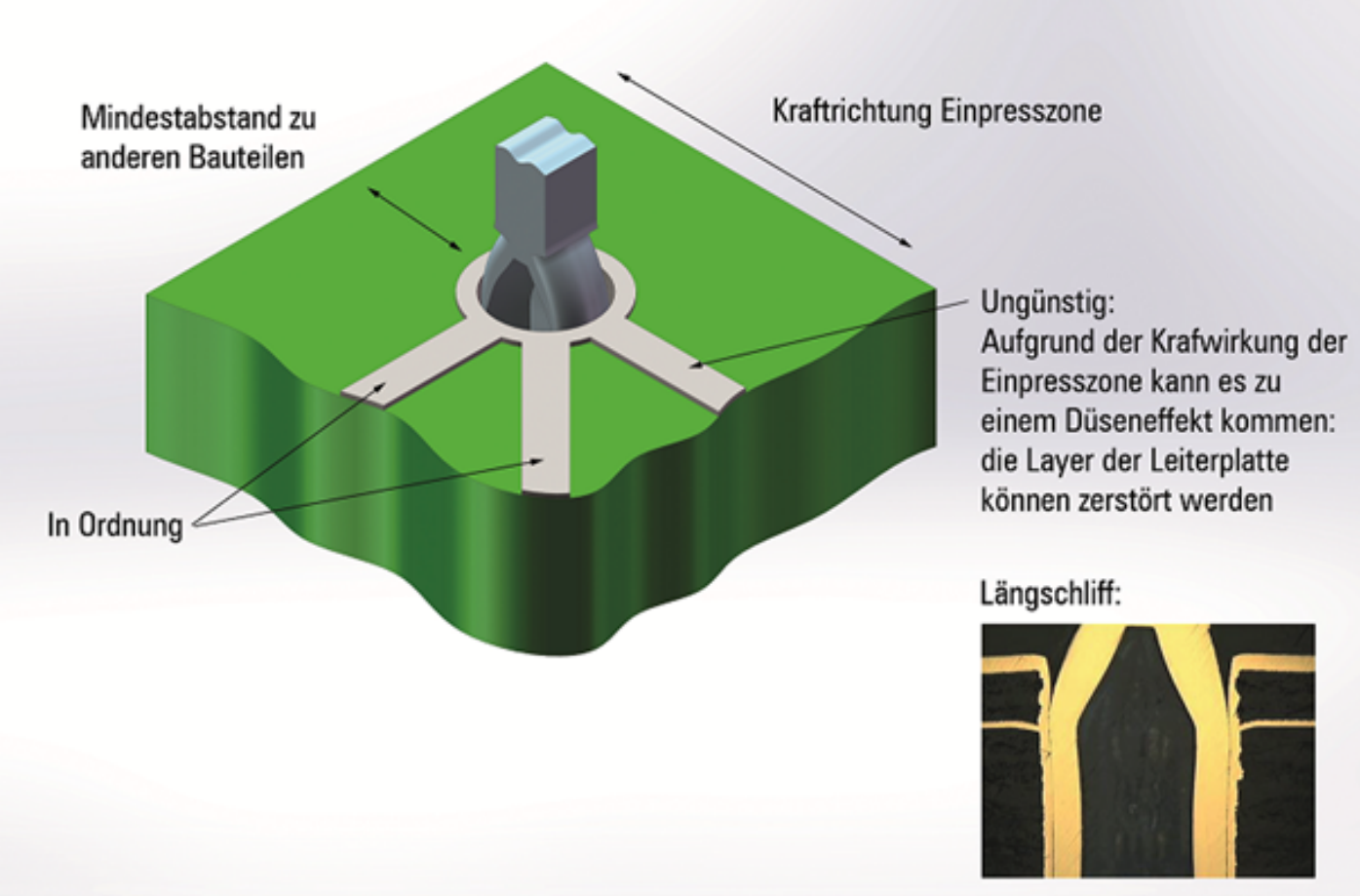

Fig. 5: Design Guide

Press-fit zone

To achieve a durable, mechanically strong, and electrically conductive connection between the printed circuit board and the connector, the press-fit process must be followed. The use of an upper and a lower die is absolutely essential. The upper tool transfers the press force to the contact, while the lower tool supports the PCB and shields it from material stress. Depending on the connector design, either a flat-plate tool or a comb tool can be used as the upper tool.

In the case of flat-panel tools, the force is transmitted directly through the connector's insulating body, and the contacts are embedded in the plastic with shoulders. In the case of comb tools, the upper tool presses directly against the shoulder of the press-fit contact. A lower tool

must be used to prevent the printed circuit board from bending.

Fig. 7: Sub-tool: Universal counterholder with a pitch of 2.54 mm (DIN 41612 products)

If the tools are not perfectly aligned, forces and stresses are applied to the circuit board, which can damage existing components. The insertion force should be absorbed by the lower tool. Circuit boards with inserted connectors should not be heated above 125°C.

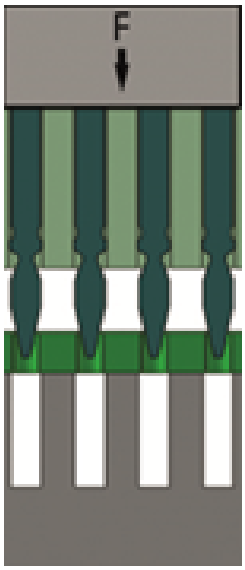

Fig. 8: Schematic representation of the lower die

Presses

The choice of press depends on the specific application. The number of connectors to be inserted and the number of contacts they have are key factors in this decision. The market offers a range of options, from manual and pneumatically assisted hand-lever presses to fully automatic insertion machines.

Fig. 9: 16 kN manual lever press

While single units and small batches can still be processed using very inexpensive hand-operated presses, mass production relies on fully automatic machines equipped with automatic feeders, tool changers, and insertion force monitoring. The monitoring of insertion force serves as a quality control measure and indicates whether each individual contact has been inserted in accordance with specifications.

Fig. 10: Fully automatic 80 kN machine

Reliability of press-fit technology

Press-fit connections are up to 10 times more reliable than automated soldered connections. This makes press-fit technology the decisive factor for its use, especially in safety-critical applications and particularly under vibration loads.

Connection type	Failure rate
Hand soldering	0.5 FIT
Automated soldering	0.03 FIT
Press-fit technology	0.005 FIT

Table 2: Failure rates of various contact technologies

Examples of Use

From high speed to high current

In general, there are few limitations to the press-fit technology. Depending on the contact material, material thickness, hole diameter, and coating, a press-fit contact can meet a wide range of requirements. With a hole diameter of 0.55 mm, data transfer rates of up to 20 Gbit/s can be achieved. In the high-current range, however, hole diameters of 1.45 mm can transmit up to 45 A. Studies show that the press-fit connection is not the limiting factor in current transmission.

Examples of Applications for Shock and Vibration Resistance

One of the greatest advantages of press-fit technology is its high resistance to shock and vibration. For example, the “flexilink” PCB connector allows PCBs to be firmly connected to one another without spacers or additional screw fasteners. With a holding force of at least 30 N per contact, a 2x5-pin connector provides a total holding force of at least 300 N. These flexilink connectors are already being successfully used in applications with shock loads of up to 200 G, while the current-carrying capacity is 8 A per contact. Due to their gas-tight connection, press-fit contacts are also successfully used in applications with potting compounds.

Fig. 11: Doppel-Tcom flexilink 2x6-pin

Conclusion

In conclusion, the advantages of the press-fit technique can be summarized as follows:

- High reliability of the connection
- No "cold" solder joints, no solder bridges
- Simple and cost-effective processing
- Can be used as a mechanical connection
- No thermal stress on the PCB and components
- Repairability
- Environmentally friendly