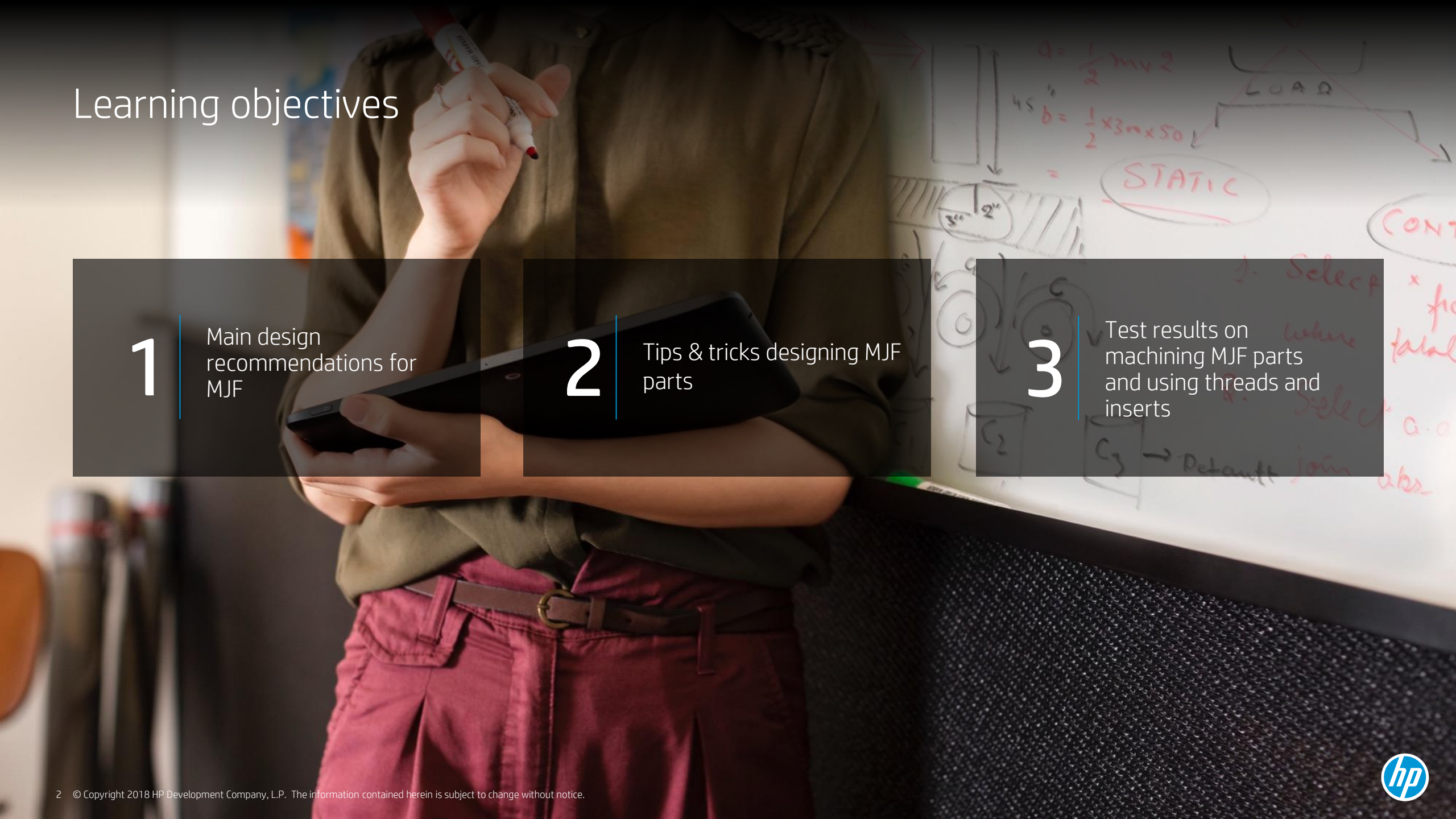
DESIGN FOR MJF PARTS

Learning objectives

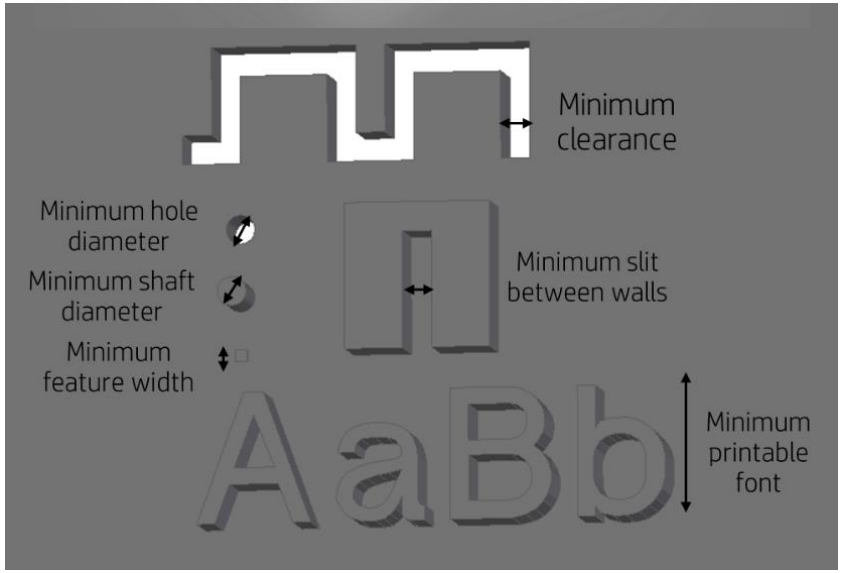


1. Main design recommendations for MJF
2. Tips & tricks designing MJF parts
3. Test results on machining MJF parts and using threads and inserts

Dimensional accuracy

The dimensional accuracy that can be achieved by HP Multi Jet Fusion 3D is ± 0.2 mm up to 100 mm and 0.2% above that value, measured after sand blasting.

Printable features	Minimum values
Through hole diameter at 1mm thickness	0.5 mm
Shaft diameter at 10 mm height	0.5 mm
Printable **font size**	6 pt
Printable **features or details**	0.1 mm width
Clearance at 1 mm thickness	0.5 mm
Slit between walls / emboss	0.5 mm



During print preparation it is not necessary to add a contraction coefficient. This is compensated automatically by the printer.

Wall thickness

The minimum wall thickness depends on the orientation of the part.

Minimum wall thickness	mm
Short walls orientated in the XY plane	0.3 mm
Short walls orientated in the Z planes	0.5 mm

However, it is recommended to **increase thickness** so that it is higher than this value or add ribs or fillets in order to reinforce the parts.

Minimum Wall thickness: 0.3 mm

Minimum Wall thickness: 0.5 mm

Wall thickness

Smaller thickness can be printed but could be easily damaged:

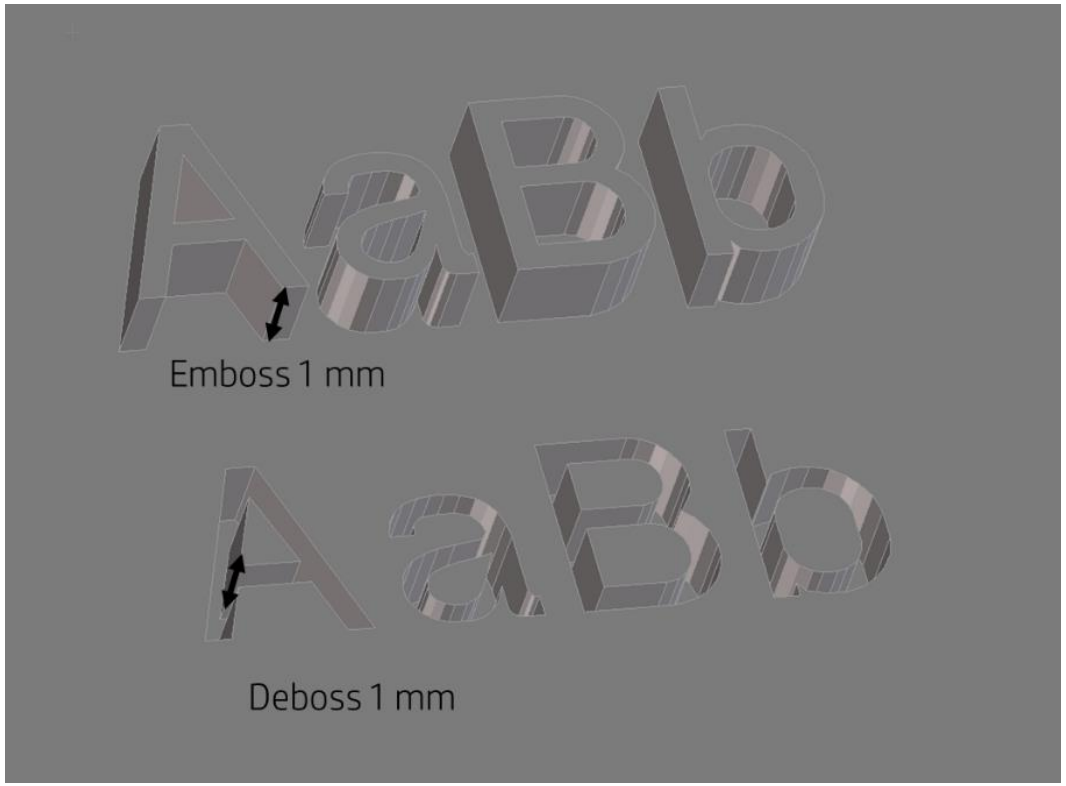
MJF part printed at 45° with a minimum thickness of 0.08mm

Engraving

- Multi Jet Fusion technology allows for printing letters, and a number of drawings with a very high resolution and definition.

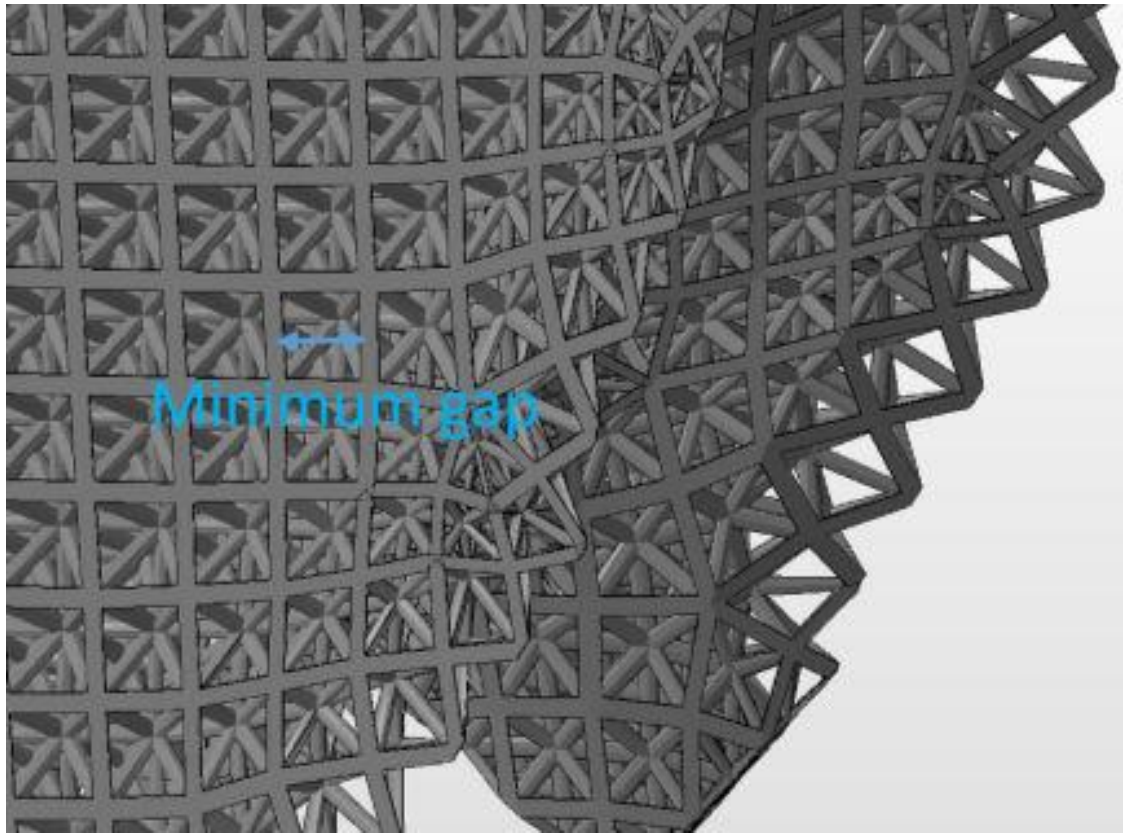
Any text, number or drawing included in a part is recommended to have at least 1 mm of depth and to be oriented in the XY plane.

- For parts with high thickness, the depth or protrusion should be higher than 1 mm.
- Embossings → better oriented face up
- Debossings → better oriented face up



Solid part or structural fill

- Multi Jet Fusion allows you to print:
  - topology-optimized, generative designs, or
  - even small lattice structures
- These kind of designs help **reduce**:
  - the **weight** of the part and the quantity of material used.
  - the **operating cost** in applications which are very weight sensitive.
- The **minimum gap recommended** in a lattice structure to ensure that all the powder inside the part can be removed is **5 mm.**

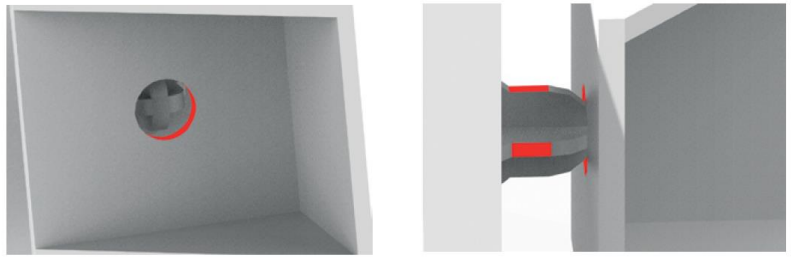


Tip:
Make your part as hollow as possible. It saves agent and powder. Also, sink marks are reduced.

Minimum spacing

Between parts to be assembled after printing

- Sometimes a pair of printed parts need to fit together due to their final application.
- In these cases, it is recommended to have **gaps of at least 0.4 mm** (+/-0.2 mm of tolerance of each part) in the interface areas that should fit together, in order to ensure correct assembly.

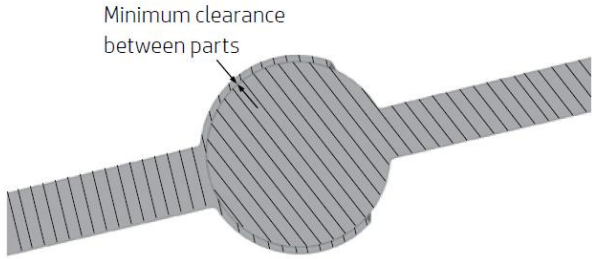


Between parts placed in the print chamber

- For optimal stability, it is recommended to use a distance of **3 mm between parts.**
- In some cases this can be reduced to 2 mm if the parts have a low volume (~1 cm^3).

Between parts printed as assemblies

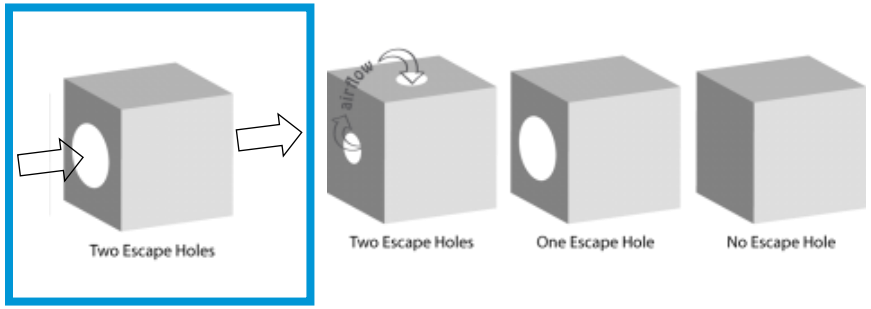
- Parts to be assembled that are **printed together** should have a **minimum clearance** between them of 0.5 mm. due to “caked” powder removal.
- Parts with very thick walls above 30 mm should have a **higher gap** in order to ensure proper performance.



Postprocessing considerations

Hollow closed geometries

- Multi Jet Fusion is a process where the parts are built by **selectively fusing** the desired areas of powder-based layers.
- If the parts that are printed are hollow, in order to remove the powder, **drain holes** need to be added to the design. The minimum recommended diameter of the holes is 5 mm.
- The recommendation is to include at least 2 holes:



Recommended:
two aligned Escape Holes

Ducts

- To remove the powder from inside ducts a **chain** through the duct can be design and printed.
- When the parts are printed, the chain can be removed by **pulling it**, and it will allow the sand blaster beads to enter the duct and **remove the remaining powder.**

Include strip or chain inside the 3D model to print it

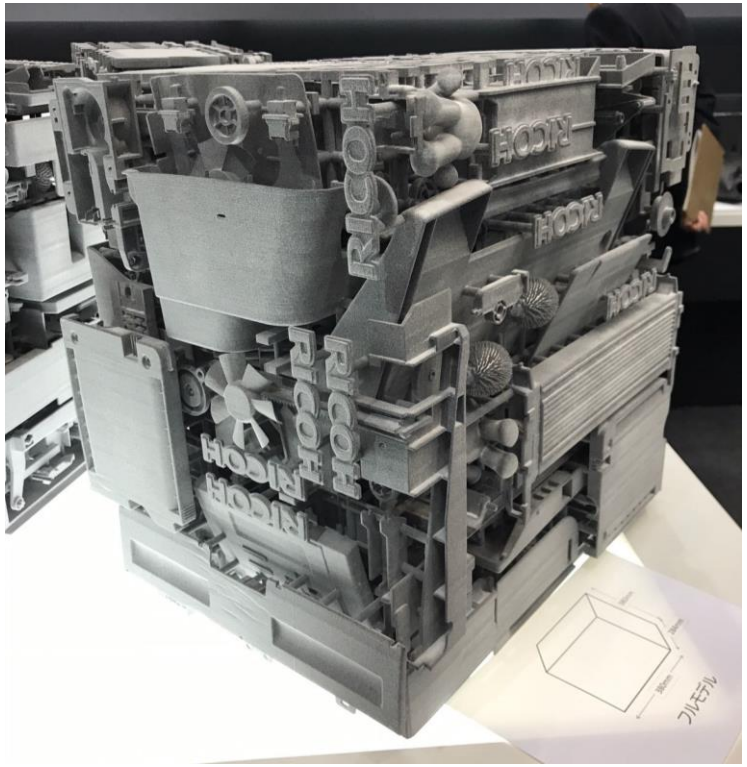
Assembly of big parts

- Parts **bigger** than the largest supported build size can be printed with Multi Jet fusion **by splitting** them up into different parts.
- Options available to ensure proper jointing between them:
  - Glue the parts
  - Weld the parts
  - Use mechanical joints
- Recommended geometries for gluing parts:

- To obtain a good outcome, the design should consider **0.1- 0.2 mm of clearance in addition to the minimum spacing (0.4 mm)** recommended between parts for the gluing to maintain the dimensional properties.

Effective building volume:

- HP Jet Fusion 3D 4200 series:
  - 380 x 284 x 380 mm (15 x 11.2 x 15 in)



Machining MJF parts

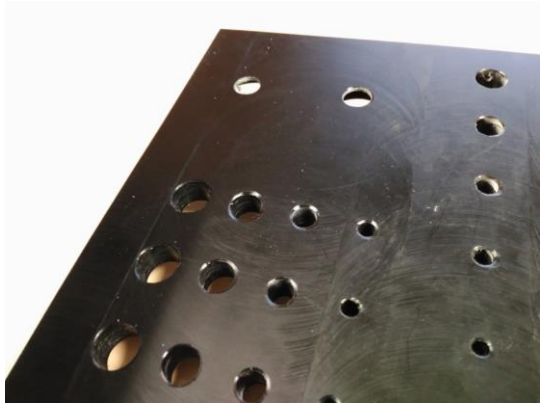
- Multi Jet Fusion parts **can be machined** and the parameters required are similar to other technical plastics (ABS, PA66 with GF,...).
- **Results** achieved with MJF parts:
  - **± 0.05 mm for dimensional** tolerances.
  - **0.30 µm Ra** in surface finishing (typical surface roughness with sand blasted MJF parts is 8 -12 µm Ra) -> It's recommended to have an **overmaterial of at least, 0.5mm** for face grinding.
- Recommended **tools** for machining Multi Jet Fusion parts are the same as other **technical plastics** and tools for machining **metals** like steel or aluminum may also be used.
- **Small threads** or fine embossing can be post machined ensuring good results.

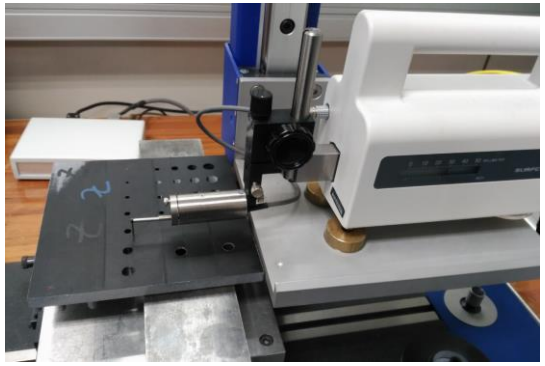
Milling parameters:

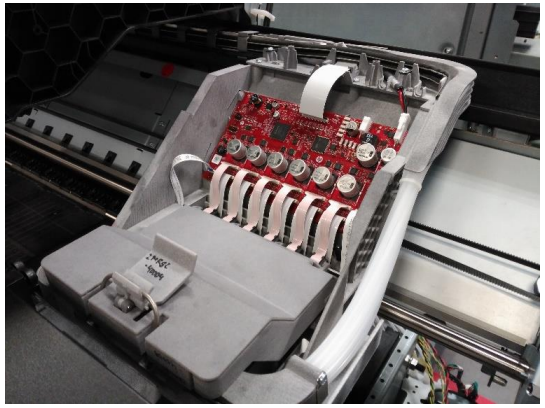
Operation	Through holes (direct diameter)	Through holes (large diameter)	Face grinding	Turret heights
Tool recommended	Drill of required diameter	Drill of Ø12	End mill of Ø63 with interchangeable inserts	End mill of Ø8
RPM recommended	4000	10000	6000	6000
Cutting speed recommended	200 mm/min	2000 mm/min	1000 mm/min	1000 mm/min
Depth of cut recommended	1mm	1mm	0.25mm	0.25mm
Other comments		Helical interpolation		Helical interpolation

Turning parameters:

Operation	Facing	Cylindrical facing	Boring	Reaming
Tool recommended	Cutting tool*	Cutting tool*	Drill of required diameter	Reamer of required diameter
RPM recommended	650	650	500	150
Cutting speed recommended	50-100 mm/min	50-100 mm/min	200 mm/min	200 mm/min
Depth of cut recommended	0.5mm	0.5mm	NA	NA







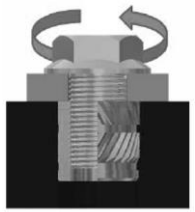
Printhead carriage lead time reduced from 15 to 5 days.

Threaded Inserts for MJF

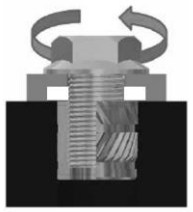
- Types of threaded inserts tested:
  - Press-in inserts
    - Flanged screw to expand - **M4 & M6**
    - Steel twist resistant Hex-Shaped - **M4 & M6**
  - Heat staking - **M4 & M6**
- Technical specifications:

Pullout

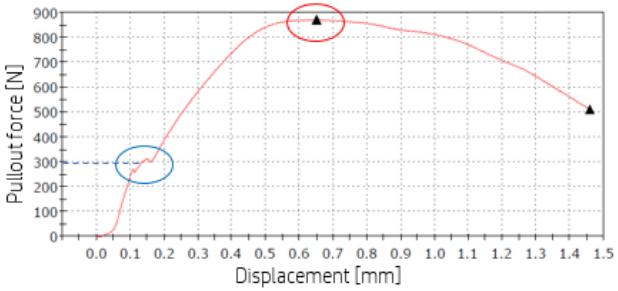
Torque-out



Clamp load torque



Jack-out torque



Electronic torque wrench

Common plastic inserts

Screw to expand

Flanged screw to expand

Screw to expand inserts for through hole

Steel twist resistant Hex-Shaped

Heat staking / ultrasonic inserts

Other suitable custom designs

Pullout and torque out tests:
3x types of inserts
M4 and M6
Print orientation: 0º, 45º and 90º

Recommended for final/production parts

Inserts for MJF: Tests results

Inserts with good performance:

Heat-staking:

- Torque-out and pullout force are **not very dependent on hole size** because the material is melted around the insert.
- **Good results in pullout force.** In addition, the force required to completely remove the insert from the hole is 3x to 4x higher than the minimum force to start moving the insert inside the hole.
- **Very good results in torque-out tests.**

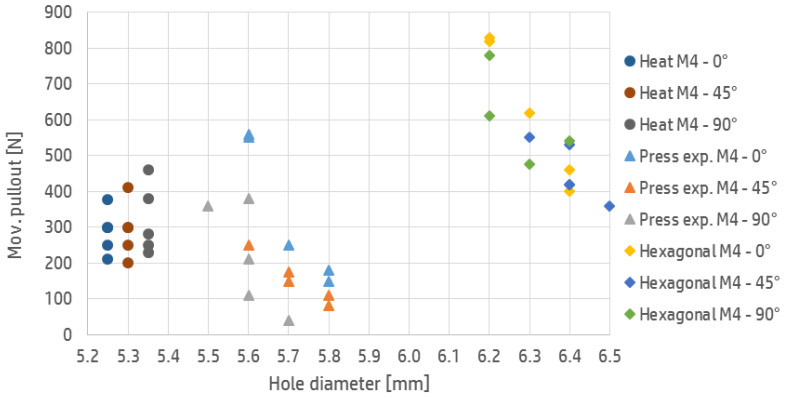
Press-in hexagonal-shaped screw:

- Torque-out and pullout force are dependent on hole size.
- Very good results in pullout tests.
- The torque-out achieved is low, the use of this type of insert could be **acceptable if the hole is designed in a hexagonal shape or if low torque is allowed.**

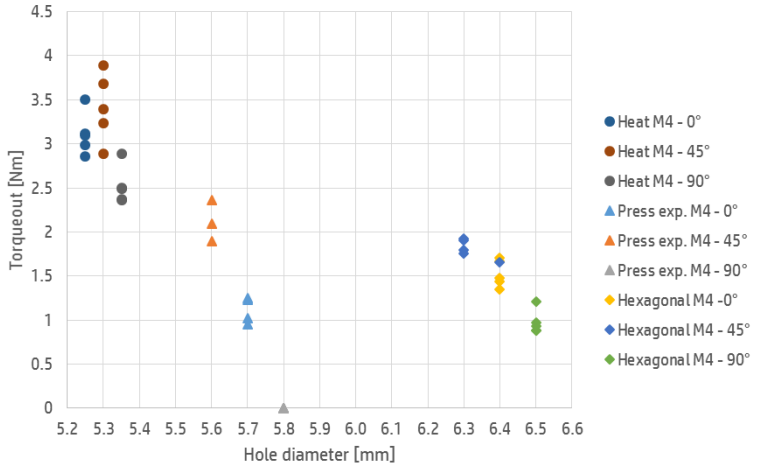
Inserts with low performance:

Press-in screw-to-expand:

- Torque-out and pullout force are very dependent on hole size.
- The average torque-out and pullout forces are very low. The pullout force achieved with M6 screw sizes was lower than with M4 sizes.



Pullout M4



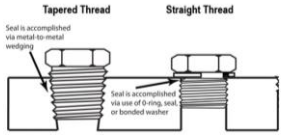
Torque-out M4

- Summary table:

			Torque-out	Pullout	Max. pullout
Type	Insert	Metric size	Nm	N	N
1	Press-in Screw-to-expand	M4	1.08	237	283
2		M6	1.8	109	134
3	Press-in Hexagonal-shaped	M4	1.44	558	822
4		M6	2.81	627	1020
5	Heat-staking	M4	3.02	300	1197
6		M6	8.16	374	1212

Printed Threads with MJF

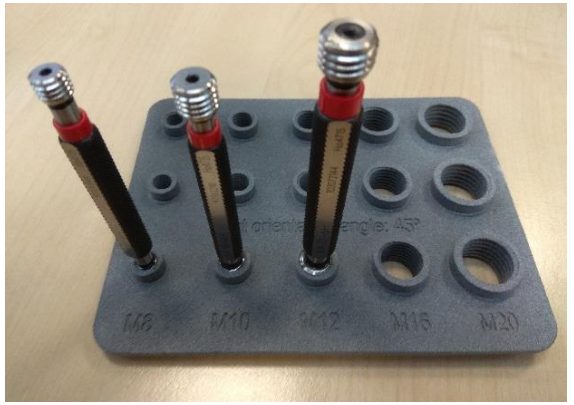
- It's possible to print **M8 or larger** threads in 0°, 45° and 90° (smaller threads have not been tested yet). For **small threads** it's recommended to use **self tapping screws**, inserts or machine the thread.
- Standard thread CAD's can't be used to print MJF threads -> use LLT of ISO 965-2 or let a **minimum gap in the thread of 0.2 to 0.4 mm** depending on material and printmode.
- It's recommended to design **tapered threads for improved tightness (sealed threads)** -> investigation pending.
- If better tolerances are required it's recommended to **use taps and dies as a post-processing operation.**



Milling parameters:

		Internal threads – 6H					External threads – 6g					
		ØD	Pitch $ØD_2$		Minor $ØD_1$		Major Ød		Pitch $Ød_2$		Minor $Ød_3$	
Thread	Pitch	min.	min.	**max.**	min.	**max.**	max.	**min.**	max.	**min.**	max.	**min.**
M8	1.25	8	7.188	**7.348**	6.647	**6.912**	7.972	**7.760**	7.160	**7.042**	6.438	**6.272**
M10	1.5	10	9.026	**9.206**	8.376	**8.676**	9.968	**9.732**	8.994	**8.862**	8.128	**7.938**
M12	1.75	12	10.863	**11.063**	10.106	**10.441**	11.966	**11.701**	10.829	**10.679**	9.819	**9.602**
M16	2	16	14.701	**14.913**	13.835	**14.210**	15.962	**15.682**	14.663	**14.503**	13.508	**13.271**
M20	2.5	20	18.376	**18.600**	17.294	**17.744**	19.958	**19.623**	18.334	**18.164**	16.891	**16.625**

Samples tested with Go/ No go (6H/6g) gauges:



LLT + 0.10mm offset

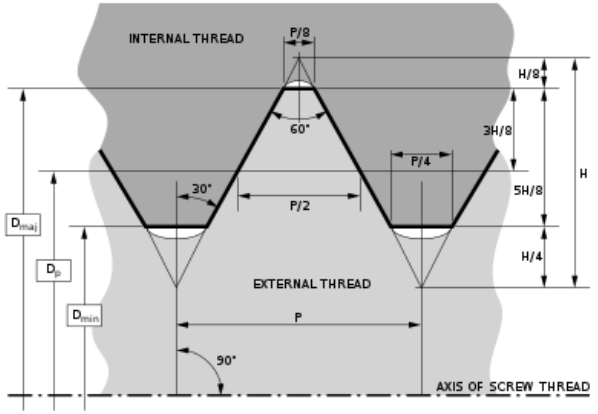
LLT + 0.05mm offset

LLT (Lower Limit Tolerance)

LLT + 0.10mm offset

LLT + 0.05mm offset

LLT (Lower Limit Tolerance)



Thank you!