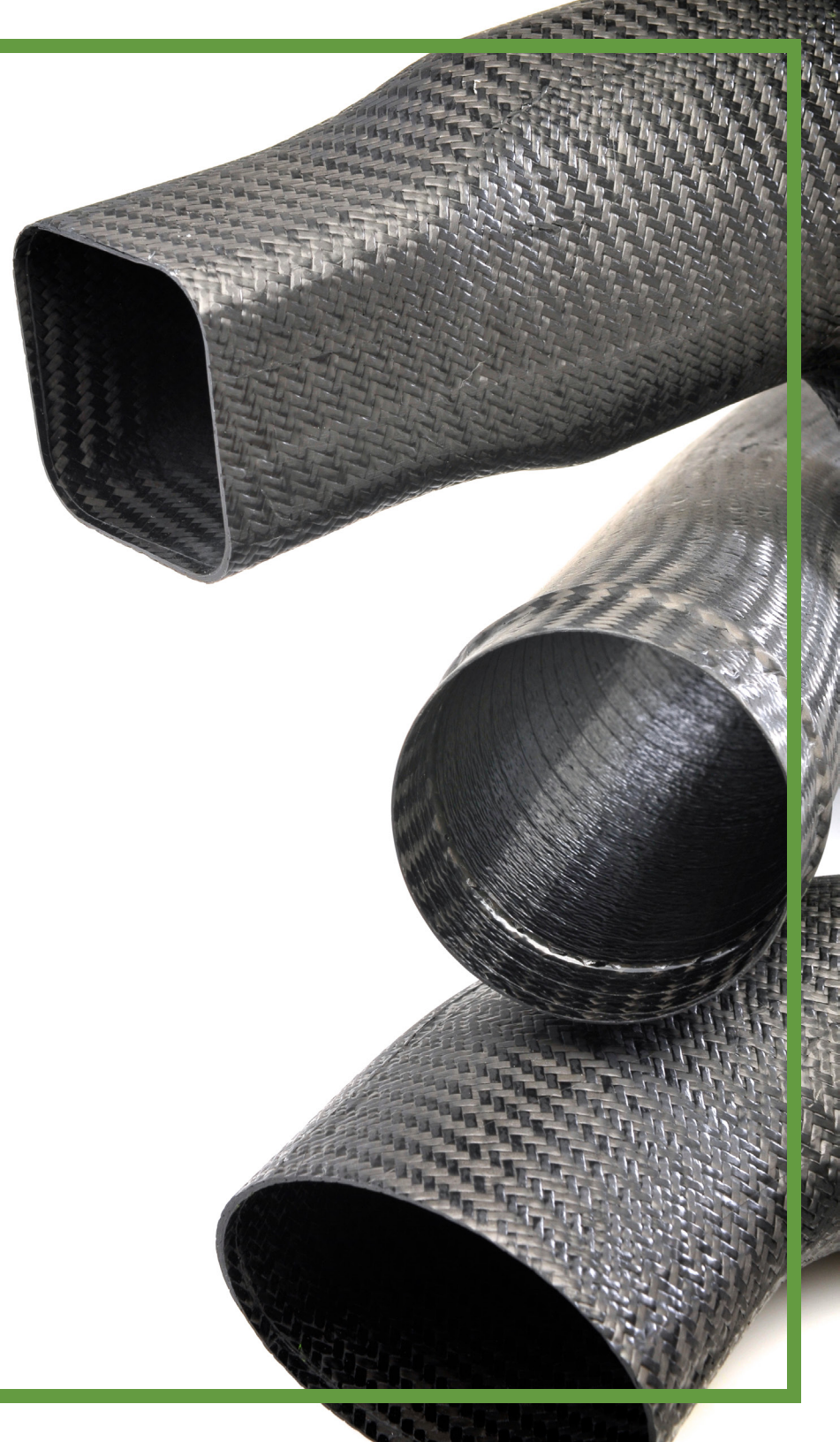


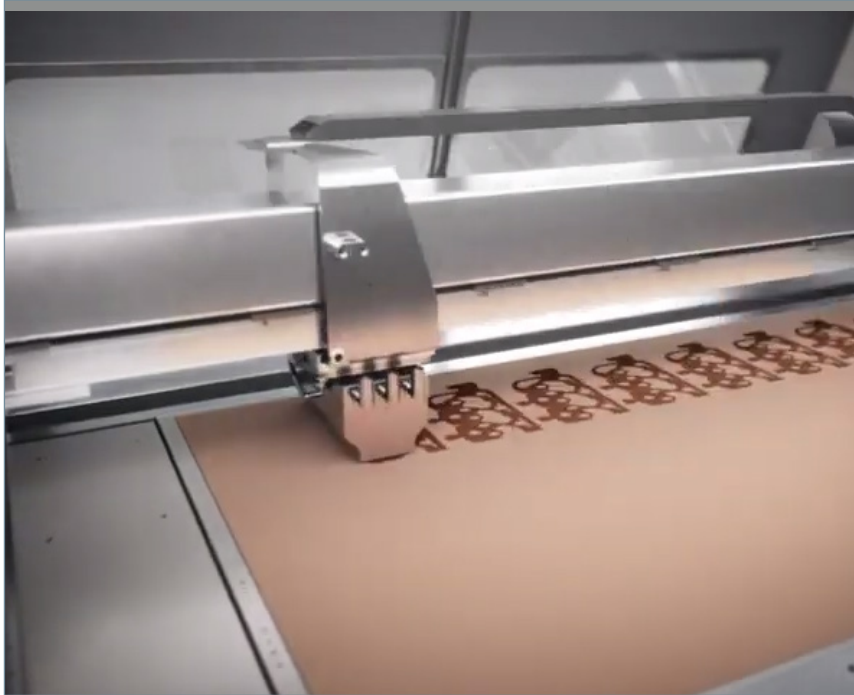


**ExOne™**

Collaborate. Innovate. Accelerate.

**INNOVATIVE  
3D PRINTED  
TOOLING  
SOLUTIONS**





## ABOUT US

# The ExOne Company

ExOne is the pioneer and global leader in binder jet 3D printing technology.

Since 1995, we've been on a mission to deliver powerful 3D printers that solve the toughest problems and enable world-changing innovations.

Our industrial 3D printing systems quickly transform powder materials – including metals, sand, ceramics, or composites – into precision parts, metalcasting molds and cores, as well as innovative tooling solutions.

Industrial customers use our technology to:

- save time and money,
- reduce waste,
- improve manufacturing flexibility, and
- deliver designs and products that were once impossible.

As home to the world's leading team of binder jetting experts, ExOne also provides specialized 3D printing services, including on-demand production of mission-critical parts, as well as engineering and design consulting.



## What is Binder Jetting?

Binder jetting is a method of 3D printing in which an industrial printhead quickly deposits a liquid bonding agent onto a thin layer of powdered particles, either metal, sand, ceramics or composites.

The process is repeated, layer by layer, using a map from a digital design file, until the object is complete.

Initially developed at the Massachusetts Institute of Technology in the early 1990s, ExOne obtained the exclusive license to this inkjet-in-powder-bed method of 3D printing in 1996.

Two years later, ExOne launched the market's first commercial binder jet 3D printer for metals, the RTS-300. In 2002, ExOne launched its first sand 3D printer, the S15.

ExOne 3D printers have been used by industrial customers ever since.



# BINDER JET 3D PRINTING – IDEAL FOR CUSTOM, SUSTAINABLE TOOLMAKING

**W**ith its ability to precisely bind powdered materials together quickly across large surface areas, binder jet 3D printing is known for high volumetric output at quick speeds. But that's just one of the reasons the technology is ideal for toolmaking.

Binder jetting can also be scaled up to produce very large parts with intricate and complex designs – without losing dimensional accuracy.

Currently, ExOne sand machines can print in a build envelope up to 1800 x 1000 x 700 mm (70.9 x 39.4 x 27.6 in).

But one of the most compelling reasons for binder jetted tooling is that large forms can be created in a broad range of cheap raw materials that can be infiltrated with substances to deliver desired tooling properties.

## Washout Sacrificial Tooling

For example, with ExOne's washout tooling, ExOne can 3D print the form in silica sand or ceramic sand with a binder that remains water soluble up to 180° Celsius or 356° Fahrenheit throughout the process.

Each of those sand media has its own coefficient of thermal expansion. The CTE for silica sand is 20 ppm/°C (11 ppm/°F), which works for certain materials. If a lower CTE is desired, ceramic sand delivers a CTE of 3 ppm/°C (2 ppm/°F).

Additionally, the expansion is driven by the media, not the binder, which makes the expansion isotropic (XYZ), resulting in controllable, high-quality results.

After the sand tool shape is created, the part is coated with a surface to prevent resin migration into the porous

tool form during composite layup. The chosen coating also can deliver desired temperature or surface quality characteristics.

ExOne offers two forms of proprietary spray coatings for its 3D printed tooling,



## WHY BINDER JETTING?

in addition to Teflon tape wrapping. Our blue coating remains water soluble up to 180° Celsius or 356° Fahrenheit while our green coating remains water soluble up to 132° Celsius or 270° Fahrenheit.

After autoclaving, removal of the tool is as simple as it sounds: it's simply washed out with tap water. No chemicals, breakout, break-down or deflating is necessary.

Even better: All the sand can be reclaimed and recycled for sustainable reuse.

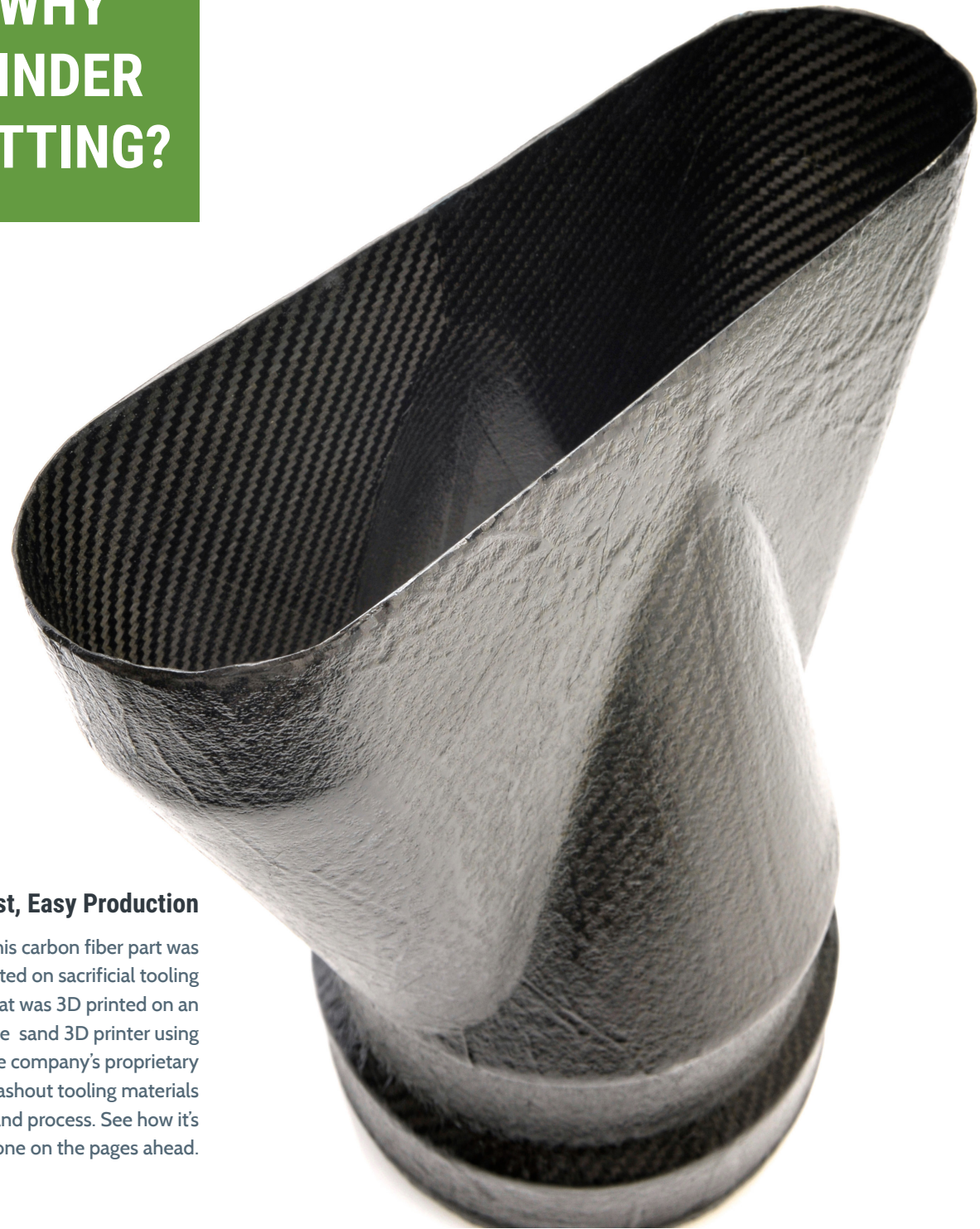
### **Vacuum- and Hydro-form Tooling**

Using this same approach, ExOne creates large tools that are now being used for vacuum- and hydro-forming. The porous sand part is infiltrated with resins that make the form incredibly durable and capable of withstanding high temperatures, pressures and other conditions.

At ExOne, we even use this tooling to build body panels on some of our industrial printers.

### **Fast, Easy Production**

This carbon fiber part was created on sacrificial tooling that was 3D printed on an ExOne sand 3D printer using the company's proprietary washout tooling materials and process. See how it's done on the pages ahead.



# GO DIGITAL

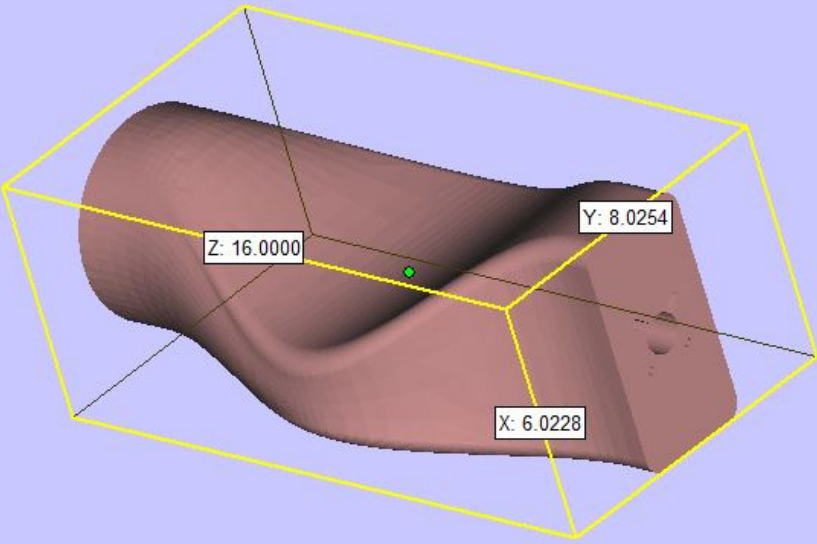
Washout tooling is a simple process that starts with a digital design file.

ExOne will:

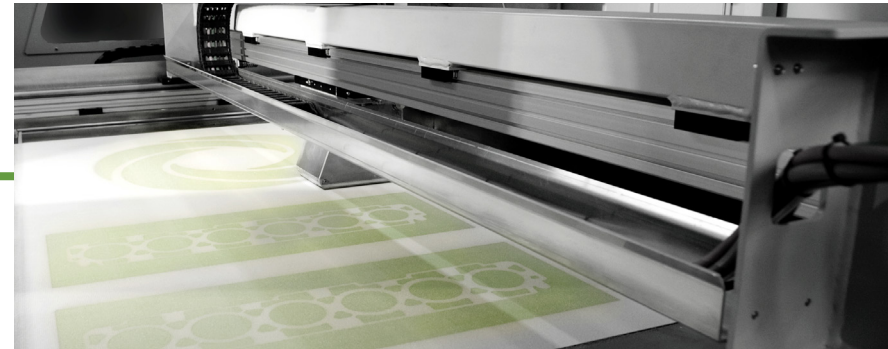
- 3D print your form in the desired powdered media
- Coat your tool to meet your manufacturing requirements, and
- Verify the dimensional accuracy and other quality metrics of your tooling along the way.

After you receive your washout tooling, you can process composites on your tool as normal.

Once your composite part has been autoclaved, the tool simply washes away with water – and the sand can be reclaimed for sustainable reuse.



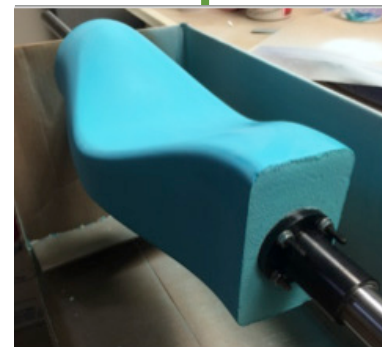
**1. Digitally Design Tool with Freedom**



**2. Binder Jet 3D Print the Sand Tool**



**3. Depowder and Clean the Tool Form**



**4. Coat Porous Tool for Layup**



**5. Inspect Final Tool, Pre-Layup**



#### 6. Process Composite on Tooling as usual

- Hand/wet layup
- Pre-preg layup
- Filament winding
- Tape or fiber



7. Washout Tool with Tap Water



8. Reclaim, Reuse Sand Media



9. Precision Final Part

FINISHED PRODUCT

## 3D PRINTING MEDIA

ExOne binder jet machines 3D print traditional silica sand or ceramic sand into a tool with a binder that remains water soluble up to 180° Celsius or 356° Fahrenheit throughout the process. Expansion is driven by the media, not the binder, and it's isotropic (XYZ), resulting in high-quality results.



Silica Sand  
CTE 20 ppm/°C (11 ppm/°F)



Ceramic Sand  
CTE 3 ppm/°C (2 ppm/°F)



3D Printed Form  
Before Coating



## COATING OPTIONS

ExOne offers two forms of proprietary spray coatings for its 3D printed tooling, blue and green, in addition to Teflon tape wrapping. Each remains water soluble to the temperatures noted below.



Proprietary Blue Coating  
Water soluble to 180° Celsius  
or 356° Fahrenheit

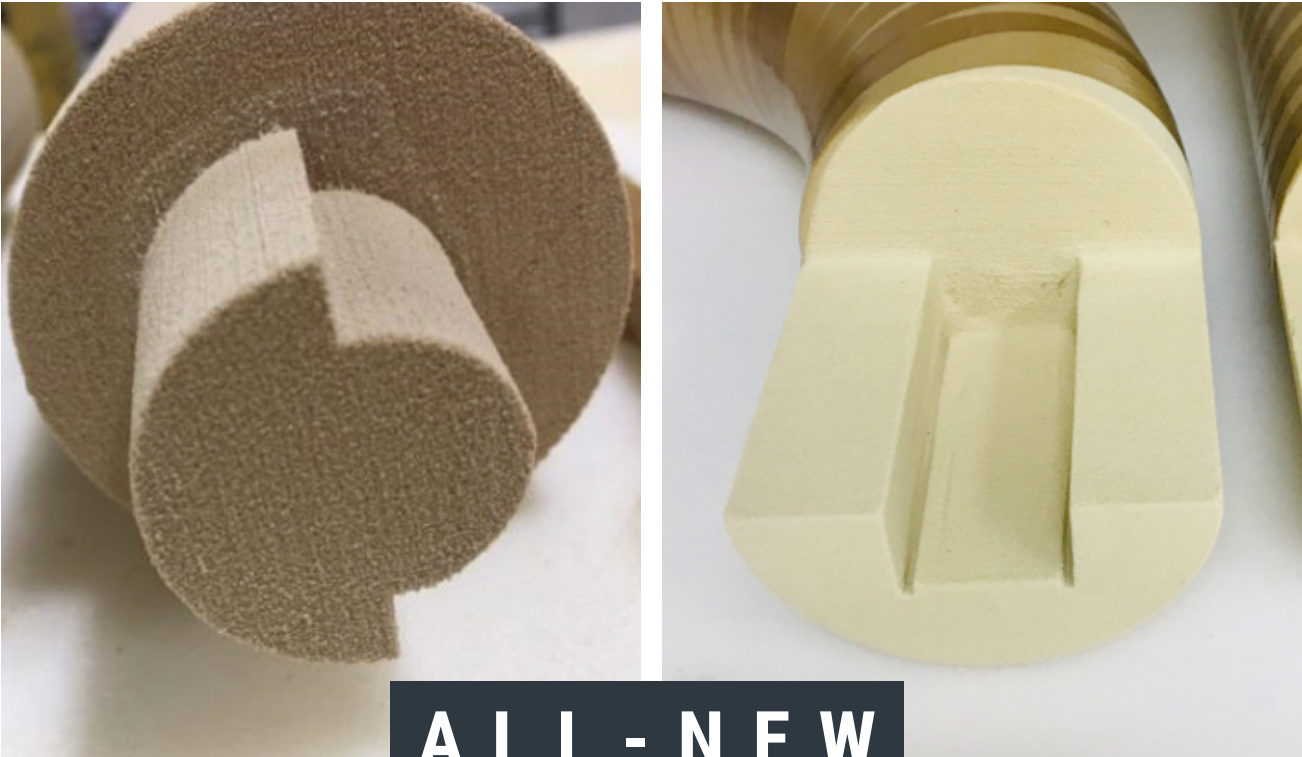


Proprietary Green Coating  
Water soluble to 132° Celsius  
or 270° Fahrenheit



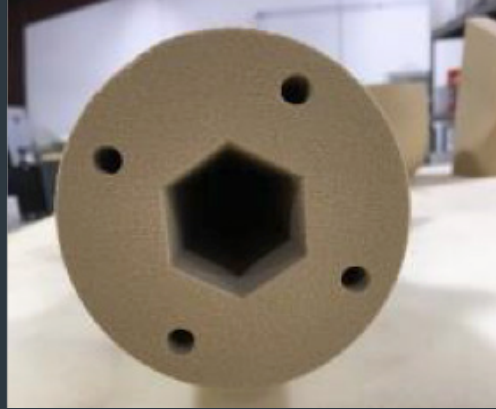
Teflon Tape.  
Water soluble to 180° Celsius  
or 356° Fahrenheit. Pulled  
out after washout.

# DESIGN BENEFITS OF WASHOUT TOOLING

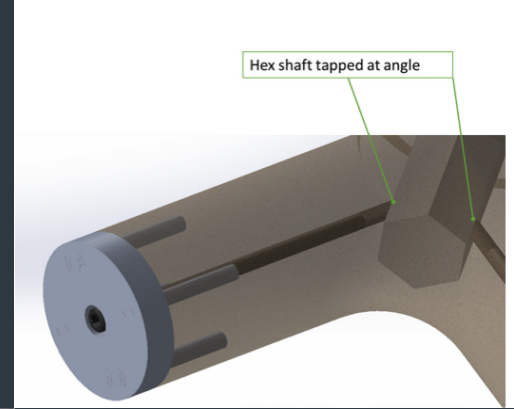


**ALL - NEW**  
FREEDOM FOR  
COMPOSITES

# INTEGRATED METALLIC HARDWARE OPTIONS



Machined metallic hardware integrated into mandrel for composite winding.



3D printed ceramic sand mandrel, Teflon wrapped.



# WASHOUT TOOLING MATERIAL PROPERTIES

By 3D printing sand tooling with proprietary ExOne binder that remains water-soluble to 180°C (350°F), we deliver a durable, accurate sacrificial tool.

ExOne washout tooling withstands high temperatures and pressures. It also has a CTE whose isotropic expansion can be selected by the chosen printing media.

Technology	Silica Sand	Ceramic Sand
Density	1.44 g/cm <sup>3</sup> (90 lbs/ft <sup>3</sup> )	1.52 g/cm <sup>3</sup> (95 lbs/ft <sup>3</sup> )
Maximum Use Temperature	180°C (350°F)	180°C (350°F)
Coefficient of Thermal Expansion*	20 ppm/°C (11 ppm/°F)	3 ppm/°C (2 ppm/°F)
Compressive Strength	>3.45 Mpa (500 PSI)	Ceramic Sand
Tolerance	+/- 0.4 MM (0.015")	+/- 0.4 MM (0.015")
Coating Options	Teflon tape wrap or spray on-soluble coating	
Washout Method	Room temperature tap water	

\* CTE | RT to 180°C (RT to 350°F)



There are many ways to manufacture sacrificial tooling for the creation of composites. However, none is as fast, inexpensive and easy-to-use as washout tooling from ExOne.

A sustainable process that uses water and reusable sand or ceramic sand media, washout tooling also delivers the additional benefit of user-selectable expansion features for dimensional accuracy.

## COMPARING SACRIFICIAL TOOLING PROCESSES

Technology	NRE Cost	Build Cost	Build Time	Tooling Required	Use Temp.	Tool Removal	CTE	Use Driver
Binder Jetting	\$	\$	Low	No	180°C	Tap Water	Low or High	Easy New Technology, Sustainable
FDM	\$	\$\$	Med	No	180°C	Hot Solvent	High	New Technology
Plaster/Castable	\$\$	\$	Low*	Yes	120°C	Breakout	Med	High Quantity, Legacy, Inexpensive
Bladder Molding	\$\$\$	\$\$\$	High	Yes	>180°C	Deflate	CTE	High Quantity, OML & IML Control
Breakdown Tooling	\$\$\$	\$\$\$	High	Yes	>180°C	Multi-pc	CTE	High Quantity



\*after tooling is made

# WASHOUT TOOLING CUSTOMERS



## USERS OF OUR TECHNOLOGY

ExOne washout tooling is used by major manufacturers in the aerospace and automotive sectors.



### LIGHTWEIGHT, INNOVATIVE AEROSPACE PARTS

Air ducting being fabricated for production units of the Sikorsky CH-53K helicopter. Currently in logistics demonstration (LOG demo).



**LIGHTWEIGHT, INNOVATIVE AUTOMOTIVE PARTS**

ExOne supplied the Formula SAE Race Car team at the University of Texas at Austin with a washout mandrel for the production of an engine air intake manifold.

# OUR FACILITIES

ExOne washout tooling products are precision 3D printed and coated at our **R&D facilities in St. Clairsville, Ohio**, which is ISO 9001: 2015 certified. In 2020, ExOne will begin production of our 3D printed tooling products at our **European headquarters in Gersthofen**, located in the Augsburg district of Bavaria, Germany.

Our Ohio facility, just a short drive from our International headquarters outside of Pittsburgh, features two S-Print sand printers and one M-Flex multi-material printer dedicated to washout tooling production. In addition to large curing ovens, our Ohio site also has a full quality-control facility for testing print bars created with every build. Our experienced mission-critical manufacturing team tests for bend strength, solubility and dimensional accuracy.

Additionally, ExOne has several larger S-Max and S-Max Pro models available for producing sand parts at our **ExOne Adoption Center (EAC) in Metro Detroit**.

## United States



## Germany





# WASHOUT TOOLING 3D PRINTERS



## The M-Flex

An affordable, large and reliable 3D printer for metal, ceramic or composite powders. Since 2013.

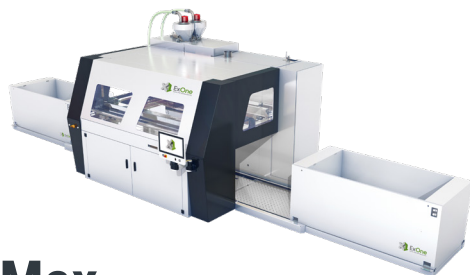
Build envelope: 160 x 65 x 65 mm (6.3 x 2.5 x 2.5 in)  
Volume: 25L



## The S-Print

A fast, flexible, reliable and compact sand 3D printing machine. Delivering highly accurate complex parts from digital data since 2005.

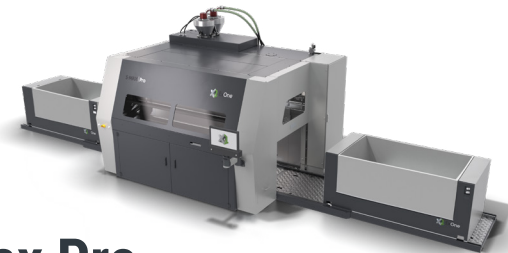
Build envelope: 800 × 500 × 400 mm  
Volume: 160 L



## The S-Max

A large and robust sand 3D printer known for reliable performance. Double job box option. Printing cold-hardening binders since 2010.

Build envelope per box: 1800 X 1000 X 700 mm\*  
Volume: 1260 L



## The S-Max Pro

Our largest, fastest and smartest sand 3D printer. All-new automated printhead and recoater. Innovative production features. New in 2019.

Build envelope per box: 1800 X 1000 X 700 mm\*  
Volume: 1260 L

# PRESSURE VESSEL CREATED WITH WASHOUT TOOLING



The mandrel for this pressure vessel was 3D printed using foundry sand mixed with ExOne's water-soluble binder. After layup and autoclaving, the tool was simply washed out with water.

By contrast, other methods of sacrificial tooling must be dissolved with hot chemicals, manually broken out, or deflated.

Washout tooling is a simple, elegant and sustainable alternative – perfect for delivering on complex designs in an eco-conscious era.



**NOW IN PRODUCTION**

Finished sand mandrels with Exone's proprietary blue coating, which is water soluble to 180° Celsius or 356° Fahrenheit.

**LET'S SOLVE THE TOUGHEST PROBLEMS.  
AND CHANGE THE WORLD.**



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1-877-773-9663

