

# Shell Inclusions

A shell inclusion is normally considered to be a defect that results in ceramic breaking free from the shell and ending up in the casting. This defect leaves a void in the casting that will need to be welded or the part may be scrapped. There are a variety of causes for shell inclusions. The most common are as follows:

1. **Improperly dried shells** – if a shell is not dried properly between coats and after the seal coat, weak spots may occur. These weak spots can break free during dewaxing, burnout and casting.
2. **Out of control slurry** – an improperly controlled slurry can cause shell inclusions. If the shell is too weak (due to low binder solids), weak spots may occur. If the binder solids are high, the shell coat could have a gelled versus dried bond.
3. **Improperly set up wax patterns** – the joints between sprues and patterns should be smooth and free of undercuts. Undercuts trap ceramic in thin fins. These fins can be broken off by the metal as it fills the mold.
4. **Pour cup breakage** – if the tree setup is such that the pour cup is formed during the dipping process, care must be taken to reduce inclusions. If the pour cup is made by dipping, it is important to build a uniform pour cup so that there are no jagged edges and thin areas that can be easily broken off.
5. **Shell firing** – shells should be fired with the pour cups down. By firing the shells pour cup down, there is less likelihood for dirt and dust to get into the shell.
6. **Shell spalls** – a spall is a delamination of the shell where a number of coats break free and cause an inclusion. For more information, refer to: *Spalling of Primary Shell Coats Technical Tips*.
7. **Ash in the pattern material** – if the wax or other pattern material contains inert material, it will not completely burn out. This will lead to an effect similar to a ceramic inclusion.



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Issue Date: 021317 / Replaces: 081816

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