General Tolerances

These tolerances apply as a general rule of thumb. Closer tolerances can be obtained depending on part design or the use of special procedures or secondary operations.

GENERAL TOLERANCES

Up to 1.000"	±.005"
Up to 2.000	±.010"
Up to 3.000"	±.015"
Up to 4.000"	±.019"
Up to 5.000"	±.022"
Up to 6.000"	±.025"

FLATNESS

Flatness refers to single plane surface and is usually a function of volumetric shrinkage.

Thickness	Dish per 6 sq. inches of surface
Up to .250"	insignificant
.251" to .500"	.004" TIR
.501" to 1.000"	.008" TIR
1.001" to 2.000"	.016" TIR

STRAIGHTNESS

Tolerances for axial straightness: ±.005"/inch as cast.

CONCENTRICITY

1. Concentricity of diameters in a shaft is also a function of straightness. Centers will be concentric within .005" per inch of maximum separation.
2. Centers of I.D. to O.D. will be concentric within .003" per ½" of wall thickness. This disregards out-of-roundness, and assumes measurements in the same plane If the concentricity is being measured in separate planes, the requirements of paragraph 1 above must be added.

ROUNDNESS—SOLID BARS

Roundness is a function of normal shrinkage variations in the metal. Shrinkage variation increases with diameter and the tolerance required increases proportionately. A general rule of ± .005" per inch may be applied.

ANGLES

As-cast tolerances of angles depend on their location in casting. They range from ± ½° for well supported positions to ± 2° where inherent distortion could be expected. Inclusion of gussets and ribs often minimizes distortion and many sections can be mechanically straightened.

HOLE POSITIONING

± .005" per inch from any single reference point.

BLIND HOLES

Blind holes can be cast if length does not exceed the diameter. In nonferrous materials, blind holes under 2" may be cast if length does not exceed twice the diameter.

PARALLEL SECTIONS

Controlling relationship is between length and width of the elements being checked. To establish a specific tolerance range for all combinations would be impossible, but a general tolerance of .010" TIR per inch may be used.

WALL THICKNESS

	MINIMUM WALL	
Metal	Small Area	Normal
Beryllium Copper	.035"	.050"
Ductile Iron	.035"	.050"
Aluminum	.040"	.060"
300 Series Stainless	.040"	.060"
Cobalt Chrome	.040"	.060"
400 Series Stainless	.045"	.070"
Carbon Steel	.050"	.080"

ROUNDNESS—HOLLOW TUBING

As-cast tolerances are ± .005" per inch. Tubular section out-of-roundness may be altered mechanically according to wall thickness and ductility. Tolerances are as follows:

Diameter	Tolerances
Up to 1"	.006" TIR
1" to 1½"	.008" TIR
1½" to 2"	.010" TIR
2" to 3"	.015" TIR

SURFACE FINISH

Metal	Average RMS value
Aluminum	60-100
Beryllium Copper	60-100
Cobalt Chrome	80-100
300 Series Stainless	90-125
Carbon Steel	90-125
400 Series Stainless	100-125

Plant Locations

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Nonferrous Division
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Fax (314) 272-6180

Hitchiner S.A. de C.V.
Cruce de las Carreteras
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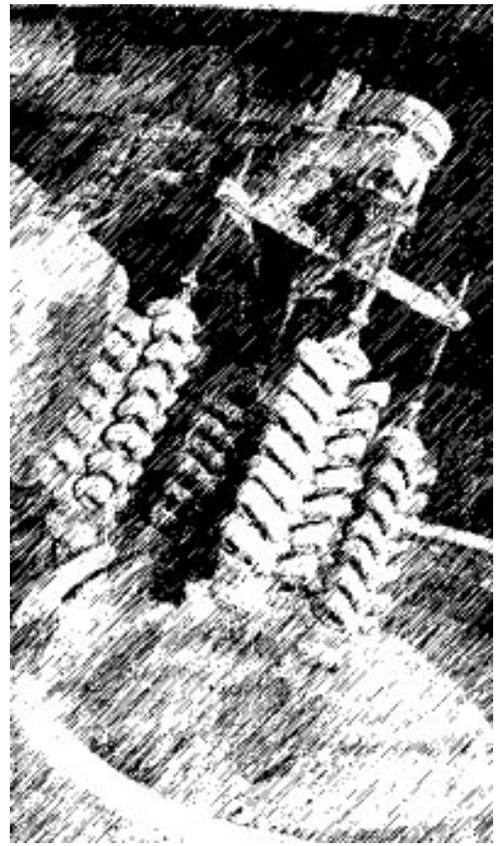
Quick Facts

and General Tolerances



HITCHINER
MANUFACTURING CO., INC.

- **Ferrous and Nonferrous Investment Castings**
- **Vacuum and Air Melt Capabilities**

The Advantages of Investment Casting . . .

■ **DESIGN FLEXIBILITY**
Investment casting produces "near net shape" configurations, offering designers and engineers freedom of design in a wide range of alloys. The process is capable of producing precise detail and dimensional accuracy in parts weighing many pounds or just a few ounces.

■ **WIDE CHOICE OF ALLOYS**
More than 120 ferrous and nonferrous metals are routinely cast at Hitchiner.

■ **ELIMINATE TOOLING SET-UP**
By offering "near net shape" configuration, fixturing costs are substantially reduced or eliminated.

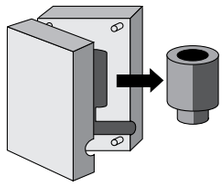
■ **REDUCE PRODUCTION COSTS**
Costly machining operations are reduced and often eliminated. No capital equipment investment is needed to produce parts in-house.

■ **CUT ASSEMBLY OPERATIONS**
Several parts can be made as one casting, reducing handling, assembly and inspection costs.

■ **REPRODUCE FINE DETAILS**
Splines, holes, bosses, lettering, choke grooves, iris pins, serrations and even some threads can be cast.

The Basics of the Investment Casting Process

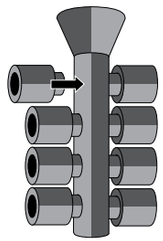
Wax replicas of the desired castings are produced by injection molding. These replicas are called patterns.



WAX INJECTION

Patterns are attached to a central wax stick, called a sprue, to form an assembly.

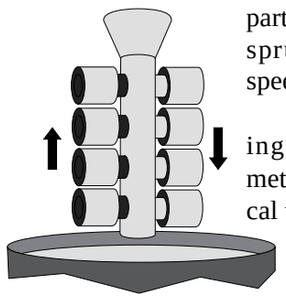
The shell is built by immersing the assembly in a liquid ceramic slurry and then into a bed of extremely fine sand. Up to eight layers are applied in this manner.



ASSEMBLY

Once the ceramic is dry, the wax is melted out of the shell, forming a hollow mold.

In the conventional process, the shell is filled with molten metal by gravity pouring. As the metal cools, the parts and gates, sprue and pouring cup become one solid casting. The ceramic shell is broken off and the parts are cut from the sprue using a high speed friction saw.

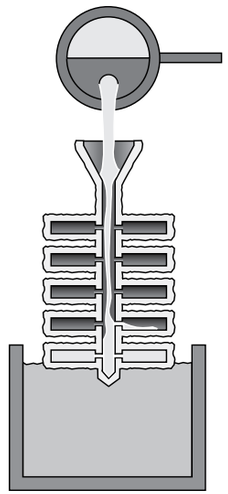


SHELL BUILDING

After minor finishing operations, the metal castings, identical to the original wax patterns, are ready for shipment to the customer.

Conventional Gravity Pouring vs Hitchiner's Exclusive Countergravity Casting Processes

Until recently, the method of mold filling by gravity pouring had changed very little since antiquity. While simple, this time honored practice suffers many limitations.



GRAVITY POURING

As molten metal is poured, turbulence and splatter causes air to be mixed with metal. Steel is highly reactive in air, which causes oxidation of the exposed metal, leaving small oxide defects in the casting.

Gravity poured metal is almost always accompanied by the inclusion of slag. Slag forms and floats on the surface of the melt, adheres to the furnace lining and is washed into the metal as it is poured.

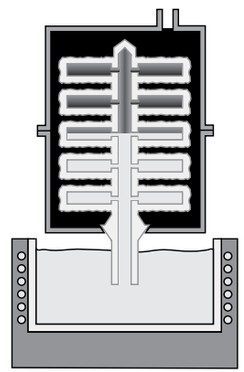
Additionally, filling a mold by gravity pouring requires the buildup of pressure to force the liquid metal into the part cavities. Air trapped in the thin sections of the mold creates back pressure which resists the flow of metal and inhibits fill-out.

Hitchiner has developed and put into production a superior casting process known by the acronym "CLA" for Countergravity Low pressure Air melt. In this process, the shell is placed in a vacuum chamber. A fill pipe extends out of the chamber and is lowered into the clean central portion of the melt. Vacuum is applied which siphons up the molten metal, filling every section completely. CLA offers a controlled rate of mold filling at metal and mold temperatures lower than those required by gravity pouring, resulting in finer grain structure and improved mechanical properties.

After a brief hold time, allowing the parts and a portion of the gate to solidify, the vacuum is released and residual metal flows back into the furnace. Only a short, easily machined gate stub remains on the casting.

Since a path for the cut-off blade need not be provided in the design of a CLA casting cluster, the yield is significantly better than that of a conventional sprue.

CLA produces castings with far less slag and non-metallic inclusions since the sprue is filled in a non-turbulent fashion from clean metal beneath the surface of the melt. This cleaner metal has been shown to reduce tool wear in comparative machining tests done under controlled conditions.



CLA PROCESS

In the years since its development, the CLA process has lent itself to many adaptations designed for specific applications. These include the CLV, CLI, CV and Supported Shell CLA processes.