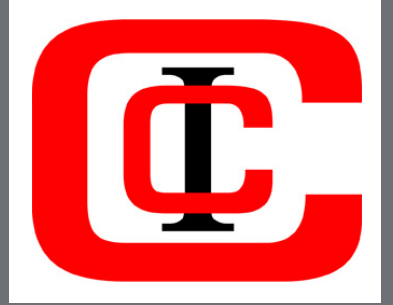
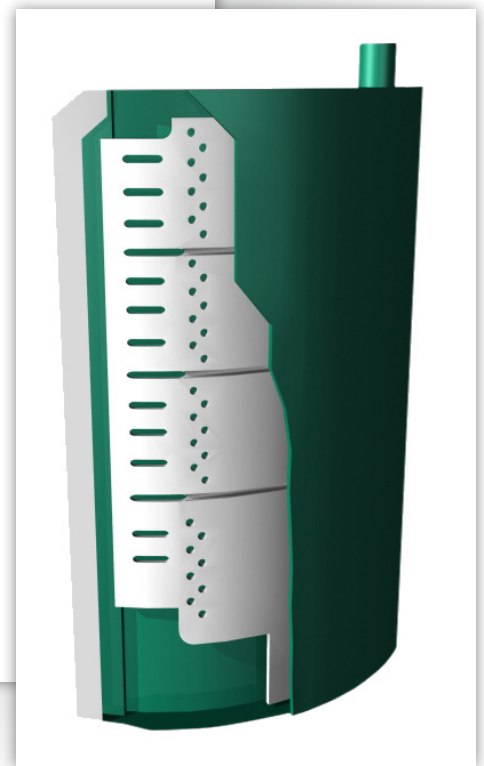
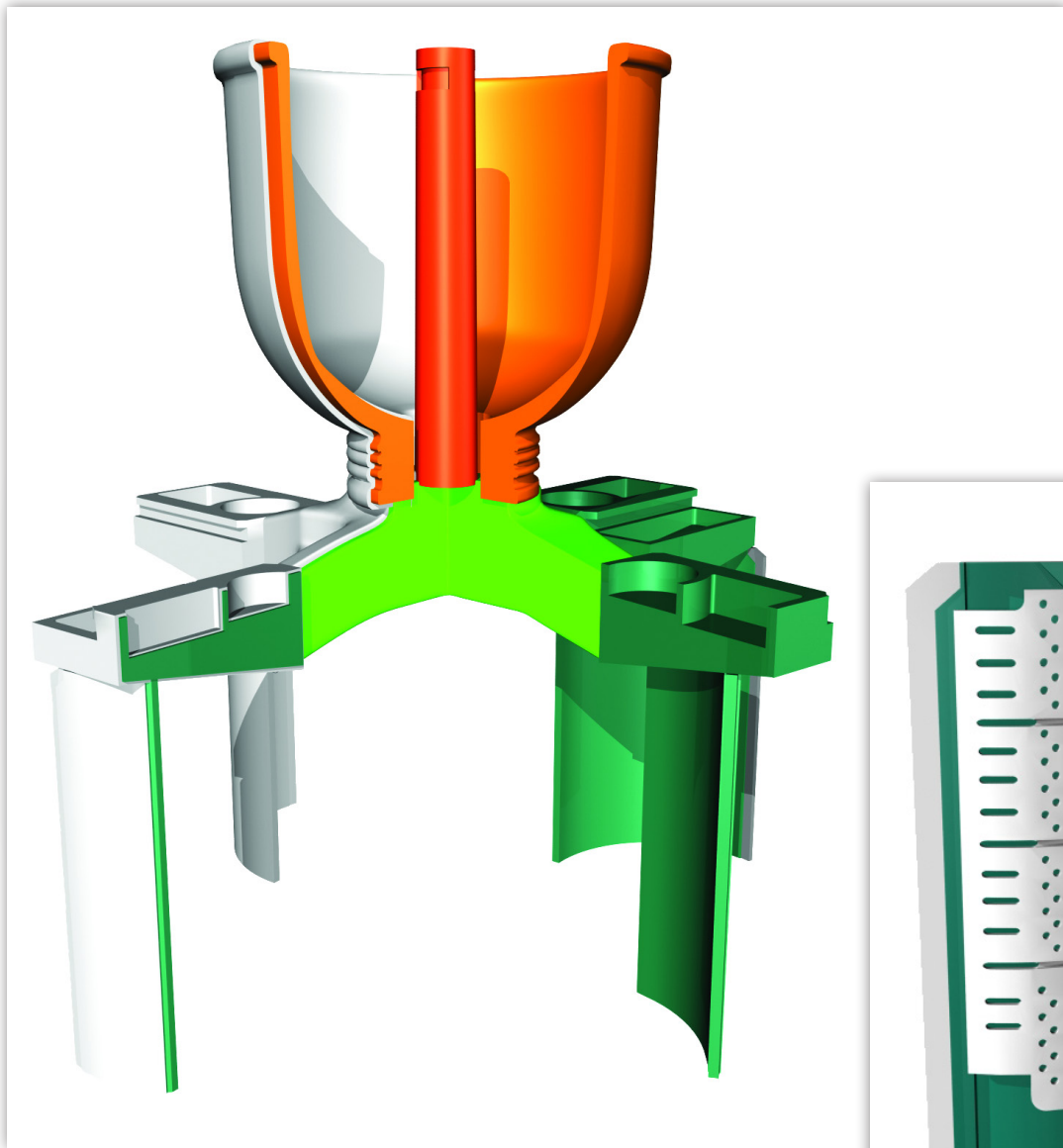


Capital Injection Ceramics Limited



Ceramic Cores for the Investment Casting Industry





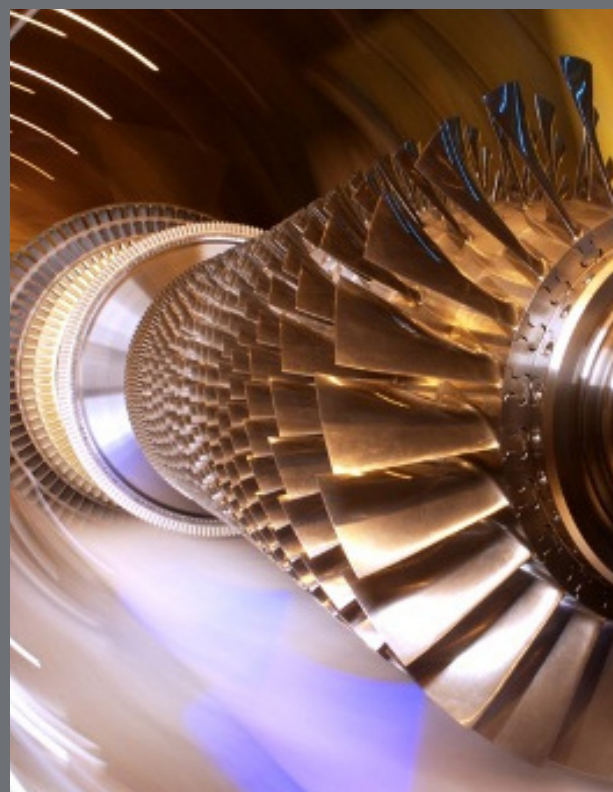
Introduction

CIC, a subsidiary company of Capital Refractories Limited, is based in Corby, UK and was first established in 2005.

CIC produces some of the largest and most complex blades and vanes for IGT and aerospace.

In addition, CIC supplies a wide range of cores to the medical, hardware, construction and automotive casting industries. CIC has/can:

- Technical approvals on complex IGT blade and vane cores that other leading core manufacturers have been unable to produce satisfactorily
- Produce IGT cores up to 1084mm (42.7in) in length
- Produce items from a few grams to over 10kg (22 Lbs)
- Over 650+ tools developed for Production. With an average of 150 cores in production/year
- CIC is certified to the Quality Standard AS9100



Our Solutions for You

In summary, CIC offers the following:

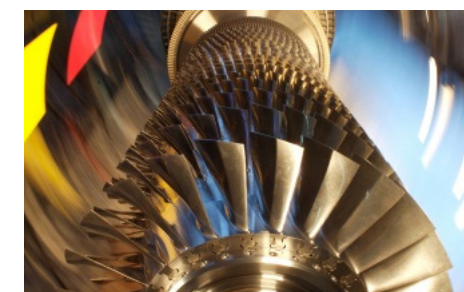
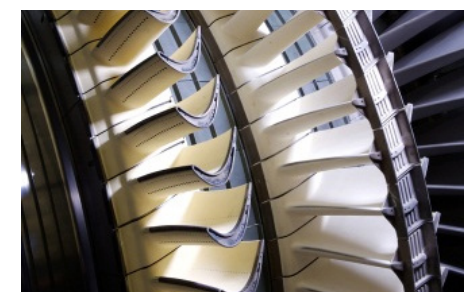
- Suitable for casting by Equiax, Directional Solidification and Single Crystal processes
- Suitable for casting in nickel, chrome & cobalt based, stainless steels, aluminium
- Proactive technical problem solving
- Green core reforming techniques are used; core setter technology utilised where necessary
- Expert service & support
- Shrinkage controllable to suit other injected core manufacturers' tooling

- State-of-the-art facility based in Corby including on-site CNC & CMM & Core Preparation
- Certified to AS9100 aerospace quality standard and ISO9001
- Exceptionally stable core bodies with very high tolerance
- Where comparison has been possible, customers report that CIC's core bodies exhibit higher strength than competitors' cores resulting in higher casting yields
- Ceramic cores for aerospace, industrial gas turbines, medical, hardware and automotive castings

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References



Customers include:

- Arconic-Howmet
- Adv. Airfoil Comp.
- Bet Shemesh
- CPP Group
- Chromalloy
- Deloro
- Doncasters Group
- EMA
- Hitachi
- KBK-ICC
- ITP Aero
- Microsteel
- Mitsubishi
- PCC Group
- GF Precicast
- Snecma
- Triax Turb
- Turbine Castings

Among others, we have produced cores for the following engines/engine part manufacturers:

- **Alstom**
GT10 Blade 1
GT13E2M Vane 2, 3 Blade 3, 4
GT13 E2M SU Vane 2, 3, 4 & 5 Blade 2,
GT13EM Blade 4
GT26 2.1 Vane 2, 3, Blade 3, Blade 3 & 4 upgrade
13E Blade 1, 13E2 Vane 2
- **GE**
6B Vane 1, 3
61B Stage 2, 3 Vane
7E Stage 1, 2, 3 Vane
7FA Vane 1, 2, 3
7HA.02/9HA.02 Vane 2, 3, 4 Vane 1 SideWall
9FA Vane 1, 2, 3
9FB Vane 3, 4 NG
- **Siemens**
V64 3A Blade 1, 2 Vane 2
V84.3A2 Vane 2, Blade 3
V94.2 Blade 1, Vane 1, 2, 3
V94.3 Blade 3,
V94.3A1 Blade 2
V94.3A2 Vane 1, 2, 3, 4 Blade 1, 2, 3 NGV 1
NG60 Vane 1
NG50 Vane 3 Blade 1, 2
SGT 4000 Blade 2,
SGT5-9000HL Vane 2, 3
SGT6-9000HL Vane 2, 3; Blade 3
SGT 200, 300, (600, 800)-SX
Blade 1, Vane 1
501D Vane 1,2,3, Blade 1
501D5 SU Blade 1
501F Vane 2, 3, 4

Since achieving the AS9100 standard CIC has begun production for aerospace applications including the following programs:

- GE: GE-90, GE-9X, GENX, CFM56, LEAP1B
- Pratt & Whitney: PW305, PW814, PW1000G GTF NEO
- Rolls Royce: Trent 900, 1000, XWB, Viper
- Honeywell Blades and Vanes

Overview

The parent company, Capital Refractories Limited (CRL), is one of the largest independent refractory and industrial ceramics companies in the UK. CRL has been manufacturing, supplying and installing high quality refractory ceramic products to metal melters for over 50 years. Capital provides a wide range of bespoke or specialised ceramic and refractory products such as isopressed and cast crucibles for investment casters, complex ceramic distribution systems for special alloy producers as well as dry rammed induction furnace linings to aerospace, medical, automotive and other industries.

CIC is committed to offering customers the very highest quality ceramic core products with the excellent onsite support and customer service for which Capital has become renowned. CIC prides itself on building up relationships with customers, proactively working alongside them to achieve their specific and often complex requirements.



Lean 6 Sigma



CIC use a "Define, Measure, Analyse, Improve, Control" methodology for:

- **Process Control** tracked real-time in key processes from Raw Material to Dimensional inspection to ensure consistent results in key areas
- Developing and fixing the process for new cores
- Core yield troubleshooting
- Ongoing process improvement – quality and cost



Pictured above, one of CIC's injection presses, designed to accommodate transfer core tooling

CIC's Process

CIC has invested in the most up to date production, process control, measurement and testing equipment to ensure product quality and consistency.

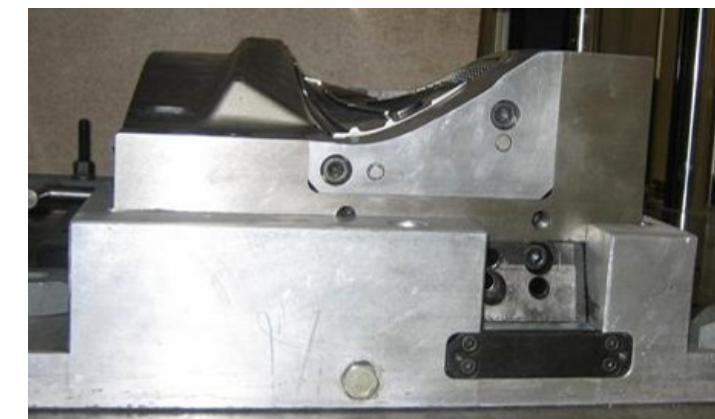
Injection Moulding

Ceramic cores are manufactured by medium pressure injection moulding. This gives an extremely dimensionally accurate and consistent product. CIC material shrinkage can be fine tuned to suit customers' existing tools. CIC can offer a full tooling package and engineering support. The medium pressure process combined with CIC's unique binder system means very low tool wear rates – lifetimes of 50,000 to 100,000 for hardened steel tools are normal depending on geometry. CIC has a range of press sizes suitable for cores ranging from a few grams to over 10 kg (22 Lbs) and from 5mm (0.200") to 1084mm (42.7") in length.

Dimensional Control

CIC's core bodies are exceptionally stable and high tolerances can be maintained with minimal split lines, less dressing and flash. CIC's process can produce features that are not achievable with other methods, examples include Trailing Edge thicknesses of 0.35mm (0.014in) and an M5 thread profile that does not need machining. For the most complex cores prone to distortion during firing, reforming techniques and/or core setter technology can be utilised.

Blue Light Scanner for development, FAIR, and also Process Control.



One of CIC's injection presses

Firing

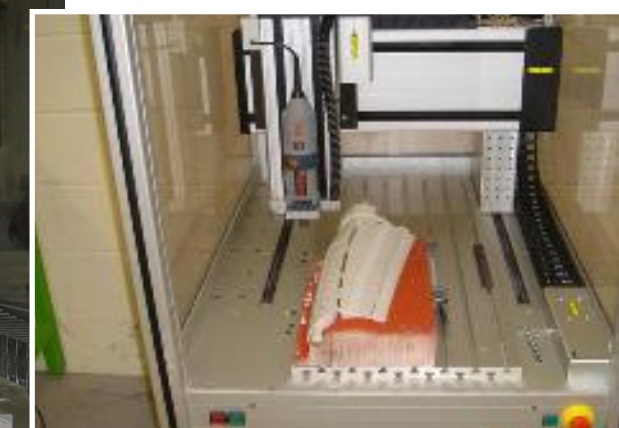
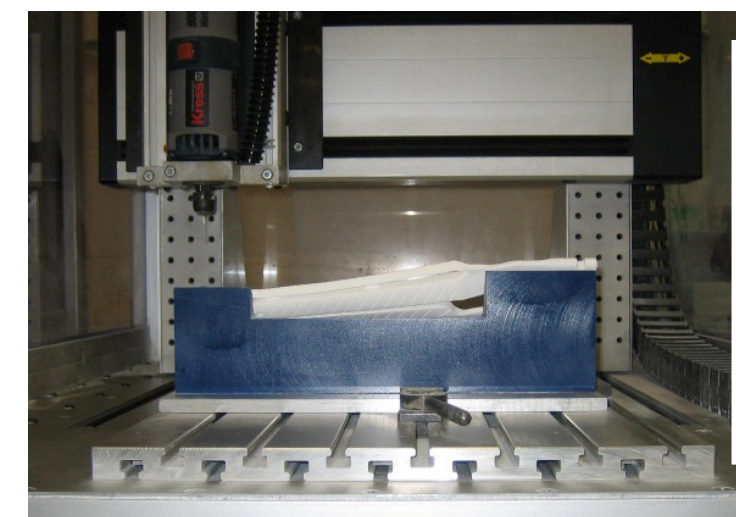
CIC's batch kiln firings are operated with sophisticated cycle controllers; firing cycles are monitored by digital chart recorders as well as Buller's rings in every kiln load.

Finishing

Cores, as well as hand finishing, are CNC finished on-site, giving benefits of accuracy, consistency and efficiency.

Strengthening

Cores can be strengthened if required with either urea or phenolic resin. Dependent on core geometry/cross section, strengths can typically be improved by a factor of 2 to 4 times. Additional specialised strengthening agents can be used in local areas to further strengthen high stress or crack prone areas.



Typical cores during CNC finishing



Finishing and Quality Control

Coating

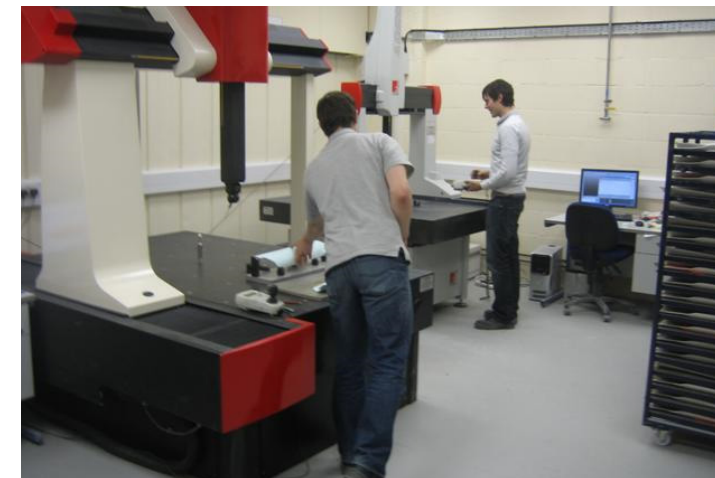
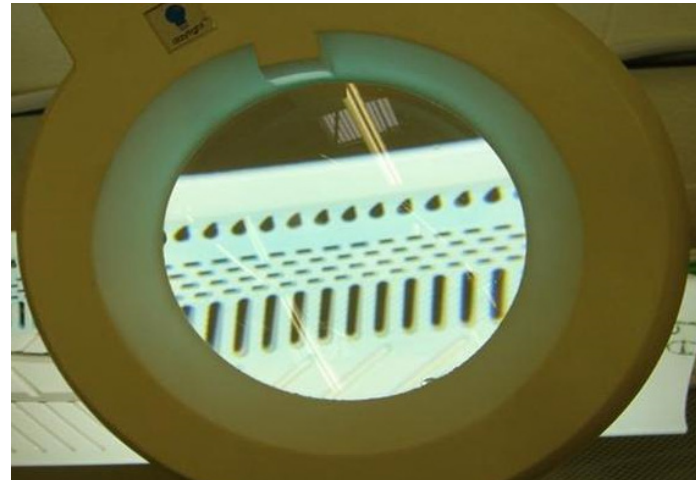
Coatings can be applied to products where suitable to eliminate surface reaction with certain alloys.

Wax Preparation

Including addition of chaplet, can be requested to help expedite wax injection upon delivery of cores to casting house.

Quality Control – Visual Inspection

Penetrant dye is used to highlight any cracks and surface defects - cores are inspected under a X5 magnification.

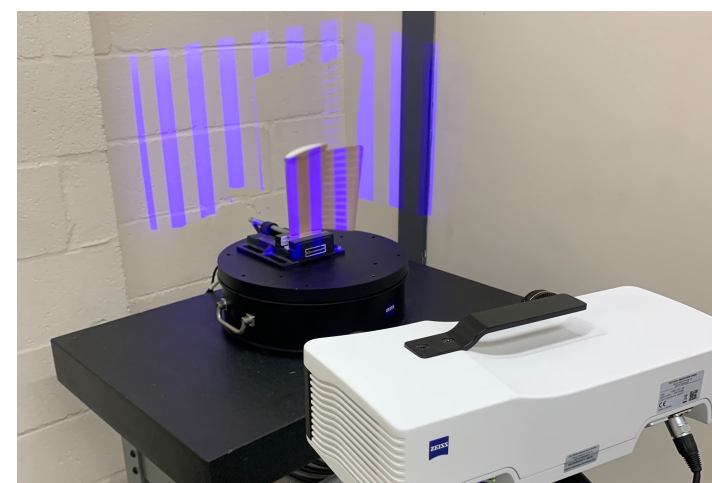


CMM Inspection

Cores can be inspected by CMM. CIC operates several Coord and Brown & Sharpe CMMs using the latest Metrolog XG and PC-DMIS software which provides full CMM data capture and can be supplied to the customer in a number of formats.

First Article Inspection Report

CIC has dedicated CMM/FAIR Engineering capabilities, to provide FAIR reports and ongoing dimensional and statistical reports on customers' pieces.



Blue Light Scanner

Primarily used in development, First Article Inspection Reports (FAIR) and Process Improvement.

This technology gives CIC the ability to perform Pre Kiln to Post Kiln dimensional comparison, which reduces variation and expedites development.

Quality Assurance

CIC has been certified to AS9100 Rev D since March 2009

- AS 9100 is an enhancement of ISO9001, in other words CIC is certified to both ISO9001 and AS9100
- AS9100 is the aerospace quality management system model for quality assurance
- Based on the ISO 9000 model with the inclusion of additional requirements specifically for the aerospace sector
- AS 9100 is the first aerospace global set of standards that meets the requirements of aerospace companies worldwide

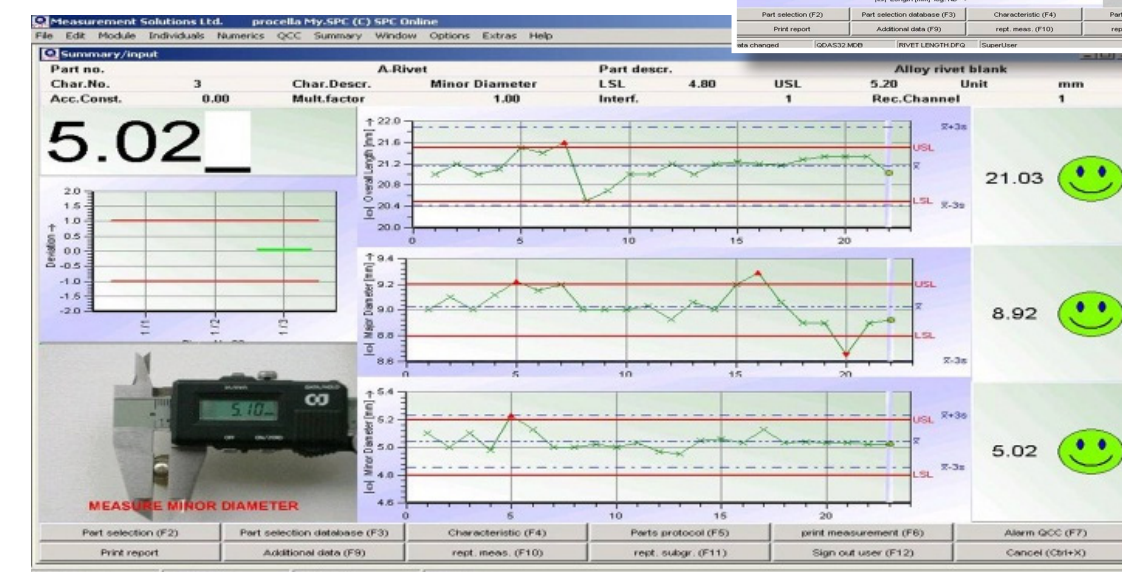
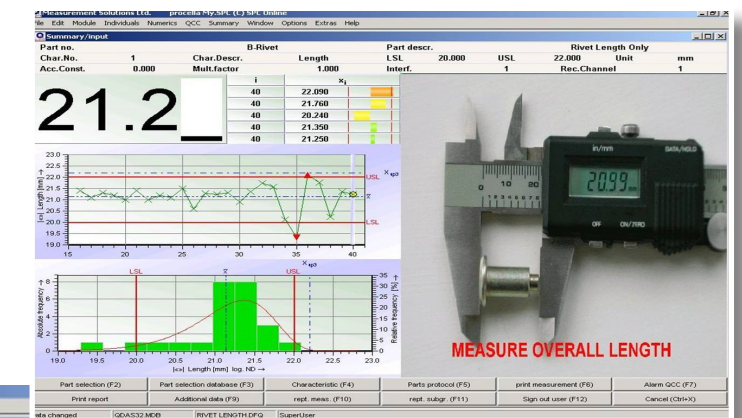


Why was it established?

- With the purpose of achieving significant improvements in quality and reductions in cost throughout the value stream
- With the aim of standardising quality management system requirements for the industry to improve quality and safety and reduce costs

Statistical Process Control

Process control is paramount in this industry. CIC use QDAS software which is the leading company for SPC manufacturing environments. This is the recognised standard for the automotive industry. Above all, CIC prides itself on strong customer partnerships and a flexible approach to individual requirements.

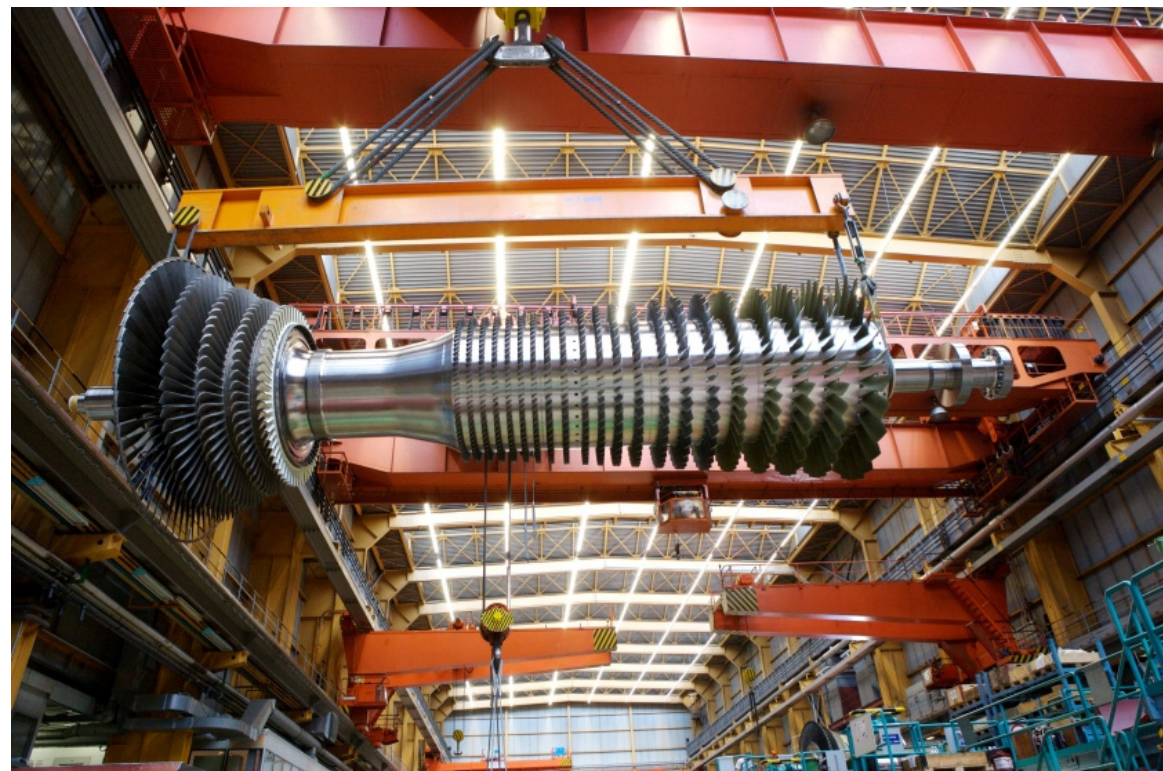


Material Qualities

A number of different core qualities are available to cater for most applications. All cores are 100% leachable, and tests have shown that CIC cores can be leached 20–30% faster than those from other suppliers. Customer feedback indicates that CIC cores withstand the casting process better than other ceramic cores, improving their casting yield.

MIX	DESCRIPTION	USE
CIC1	Used for large land base and aerospace type cores with good stability	Super Alloy-based equiax, DS (directional solidification) castings
CIC2	High silica core material	Super Alloy-based equiax and DS alloys
CIC3	Silica-based core material with high temperature stability	Super Alloy-based equiax DS and SX (single crystal) castings
CIC4	Silica-based core material with good high temperature stability	DS and SX castings
CIC5	Silica-based core material with good high temperature stability. Particularly suited where hot tearing is a problem	Super Alloy-based equiax DS and SX castings

The above mixes are a small part of CIC's portfolio. CIC has considerable experience and expertise at adapting mixes to achieve customer expansion and casting profiles – please discuss your requirements with us.

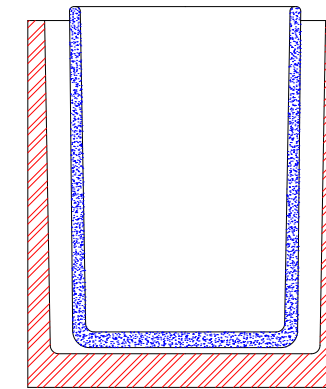


Other Capital Group Capabilities – Crucibles

One-Shot Crucibles

Capital supply one-shot crucibles which they manufacture in a modern state-of-the-art purpose-built facility in mainland Europe. These provide the quality-conscious investment caster with considerable improvements in terms of product quality. Since the liner is only used once, there is no risk of cross-contamination of alloys and inclusions are drastically reduced.

The system comprises of a multi-use outer crucible (back-up liner) and a fused silica or alumina single-use, crucible liner.

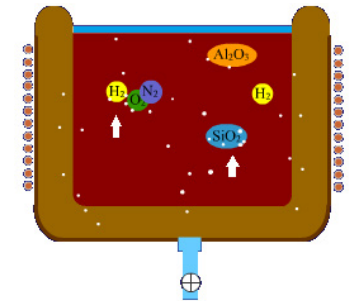


Crucible Gas Diffusers

Capital has incorporated their gas diffuser technology into a pressed crucible. The resultant metallurgical treatment crucible is a multi-use, isostatically pressed one-piece refractory vessel with an integral gas supply device.

The granulometry of the crucible's walls and base is such that gas can easily travel through it. This allows the gas to enter the metal not just from the base but also the side walls as shown in the schematic to the right. The outer wall of the crucible is coated with an inorganic sealant to inhibit loss of gas through the external surface.

Gas consumption has been proven to be substantially reduced when compared with surface gas blanket techniques.



Other Crucibles



Capital also manufacture a wide range of crucibles manufactured by vibro-casting or isostatically pressing. Crucibles are available in a range of alumina, chrome-alumina, magnesia, zircon, zirconia and mullite.





Other Capital Group Products for Investment Casting

Pouring Cups

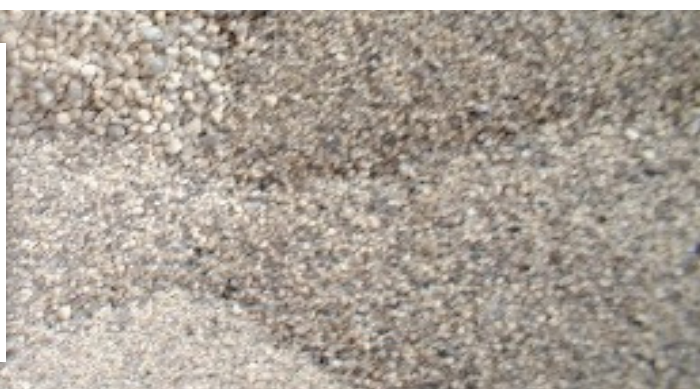
Capital manufactures pouring cups in the FS76J quality. They are available in a wide range of shapes and sizes.



SPECIES	Al ₂ O ₃	SiO ₂	Fe ₂ O ₃
Typical* / wt. %	21.9	76.4	0.60

Shell Moulds

Capital supply a variety of materials used by investment casters for shell build-up. These include high quality chamotte under the Refracoarse name. Fused silica and fused mullite is available for more specialist applications. Chemical details of these are shown in the table below. All of these materials are available in a wide range of gradings that can be tailored to the customer's requirements. Sizings are also available with very low dust levels.



Shell Repair Material

Capital supply a range of high quality shell repair materials that are available with a range of target setting times under the CerSett brand (manufactured exclusively for the investment casting industry by Cermatco). CerSett products are available based on fused mullite, sintered mullite, alumina, zirconia mullite, fused spinel, fused silica or magnesia. The most popular product is a CerSett Z4: a zircon-enriched chamotte-based product with a target set time of 4 minutes; the chemical analysis shown below.

QUALITIES	CHEMISTRY / %					
	Al ₂ O ₃	SiO ₂	Fe ₂ O ₃	TiO ₂	Na ₂ O	K ₂ O
Refracoarse	43.9	53.0	1.1	1.6	0.1	0.7
Fused Silica	0.05	99.8	0.015	0.05	<0.05	<0.05
Fused Mullite	76.0	23.5	0.05	0.05	<0.05	<0.05

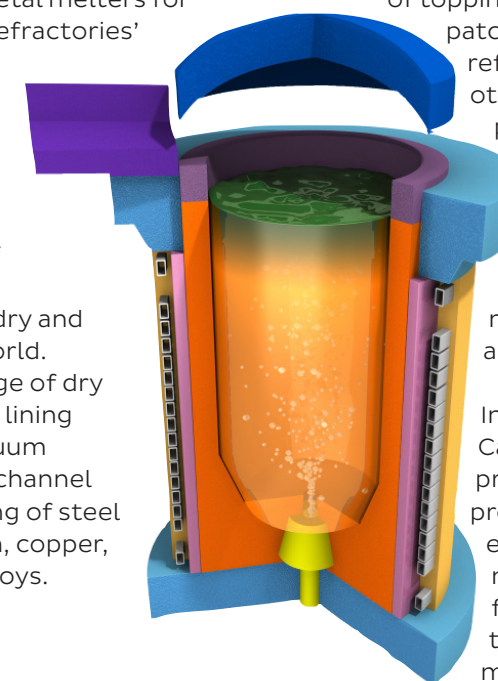
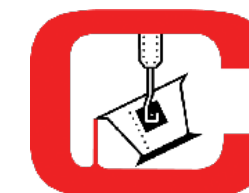
SPECIES	Al ₂ O ₃	SiO ₂	ZrO ₂ + HfO ₂	Fe ₂ O ₃	MgO	P ₂ O ₅
Typical* / wt. %	50	17	16	0.1	7	6

Capital Group

Capital Refractories is one of the largest independent refractory companies in the UK. Capital Refractories has been manufacturing, supplying and installing high quality refractory products to metal melters for almost 50 years. Today, Capital Refractories' services to the metallurgical and thermal process industries operate on a global scale, with clients in over 40 countries worldwide.

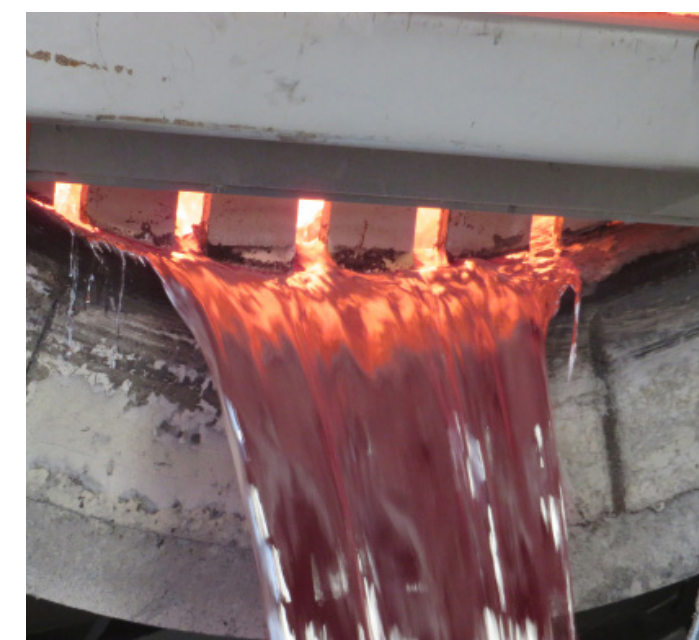
Capital specialise in the supply of refractory linings and associated products to metal melting, foundry and cement industries around the world. Capital manufactures a wide range of dry vibration rammable products for lining coreless induction furnaces, vacuum coreless induction furnaces and channel induction furnaces for the melting of steel and high temperature alloys, iron, copper, bronze, aluminium and masteralloys. Capital also supply magnesia and magnesia-chrome bricks for furnace linings.

The dry vibration induction furnace rammables are supplemented by a wide range of topping, ramming and patching refractories and other refractory products.



Capital's gas-permeable diffuser (also known as a porous or purge plug) can significantly improve the quality of both ferrous and non-ferrous metal when installed in melting furnaces and ladles.

In addition to refractory consumables, Capital supplies a range of ancillary products including mica slip plane products, coil screeds, earth leakage electrodes, vibratory installation equipment, furnace and ladle formers, ceramic fibre shapes, holloware, ladle opening technology, sampling and temperature measuring equipment.





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For production facilities,
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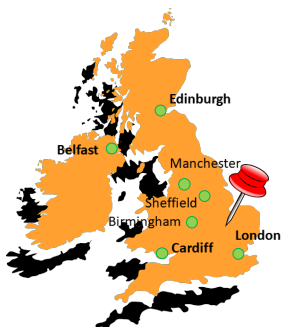
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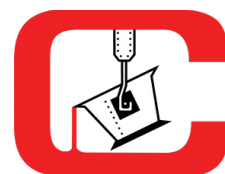
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CAPITAL REFRACTORIES