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Webinar Quick Reference

- **Joining via telephone** - be sure to enter the Audio PIN noted in your Control Panel. **(A)**
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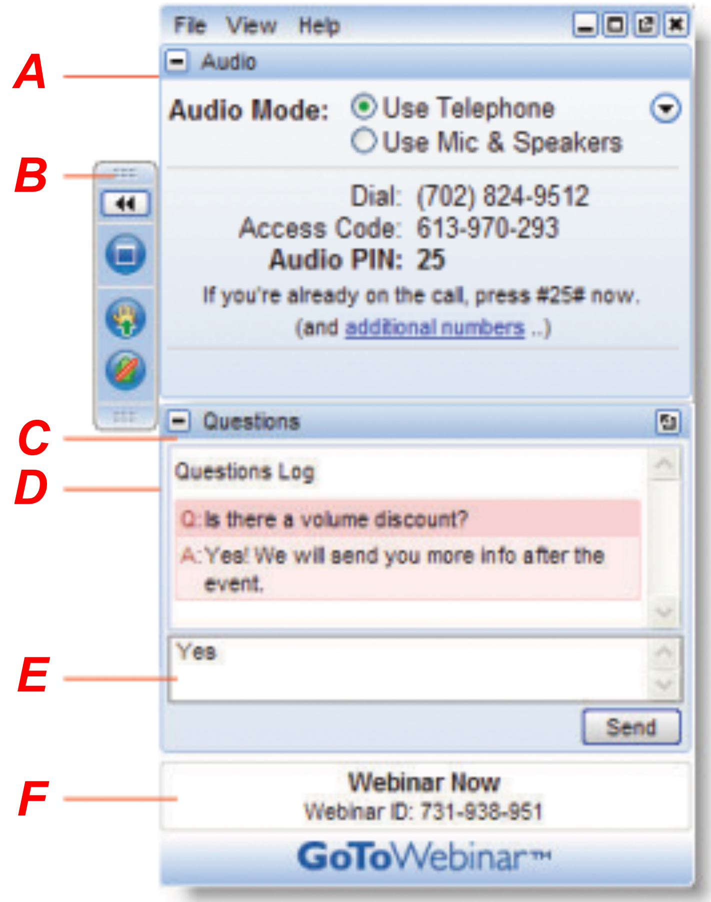

High Integrity Diecasting

A holistic approach to improved die casting quality

Martin Hartlieb
Viami International Inc.
www.viami.ca

November 5, 2013

Outline

- Aluminum content in automotive - The opportunity for diecasters
- Requirements for High Integrity Aluminum HPDC
- Success factors for high integrity HPDC with technological solutions & case studies
- Alloys and tempers for structural diecastings
- Products and services for you
- Summary and Q & A

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Why Invest in Aluminum Die-casting technologies

- Use of aluminum in automobile components continues to grow significantly
- To reduce weight and improve fuel economy (*6.5% reduction in fuel consumption for 10% reduction in mass),* and reduce emissions
- Political/regulatory, social, and consumer pressures – auto manufacturers are listening.
- HPDC offers many advantages over other processes – if the right technologies and alloys are applied

Aluminum content in automotive
The opportunity for diecasters

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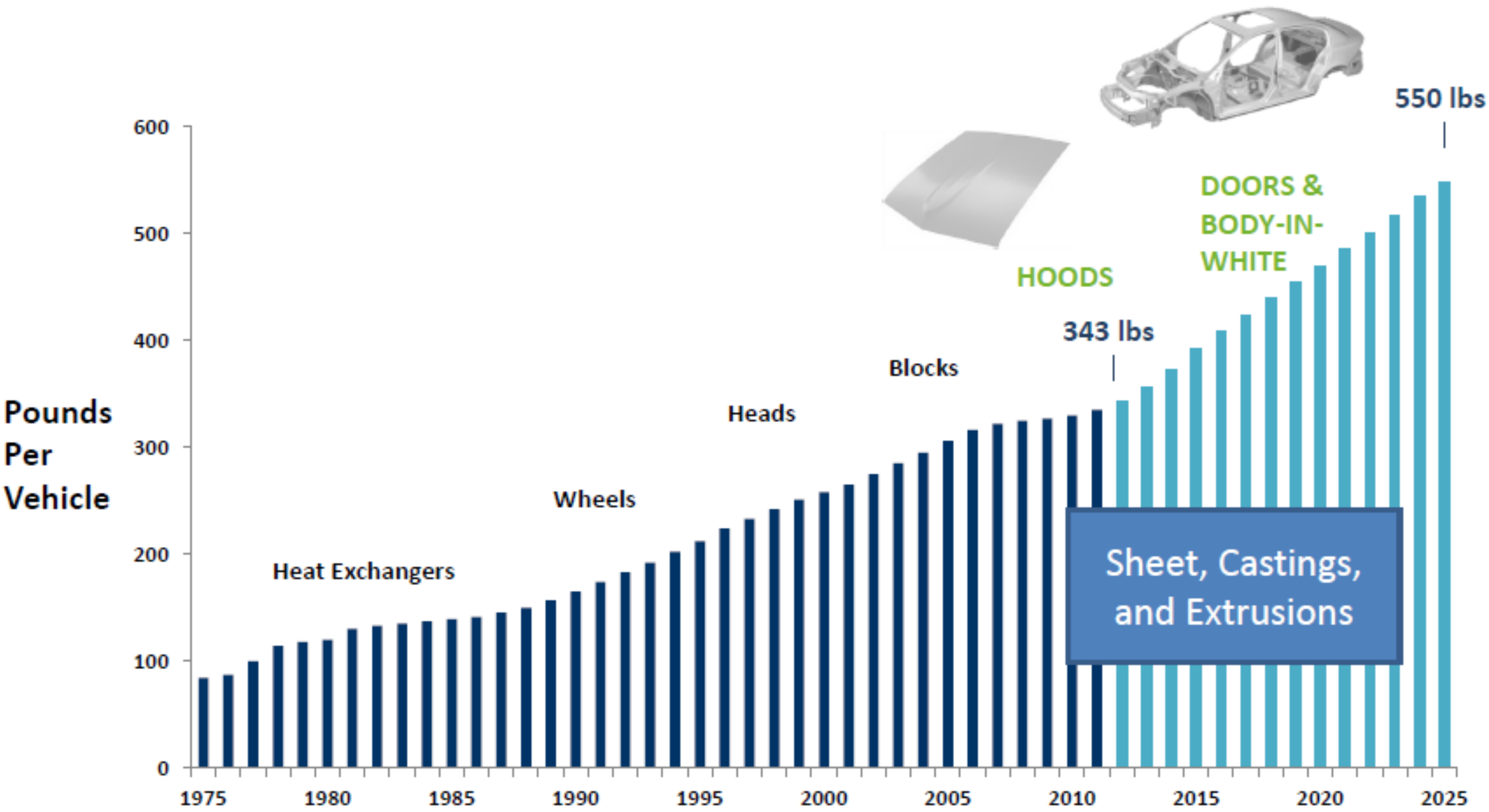

Source: Ducker Worldwide 2011

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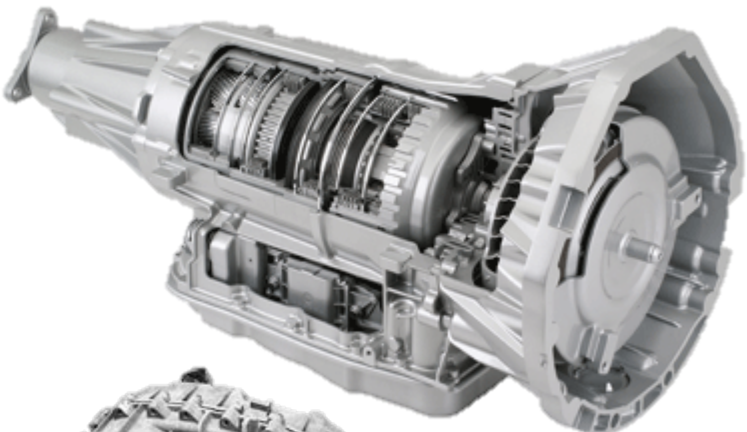
Most of the HPCD weight is currently in three vehicle systems

90% of the current HPDC aluminum use is in these three systems



Engines
44 lbs. of HPDC

Transmissions and Driveline
57 lbs. of HPDC

Heat Exchangers
5 lbs. of HPDC

Source: Ducker Worldwide, LLC.

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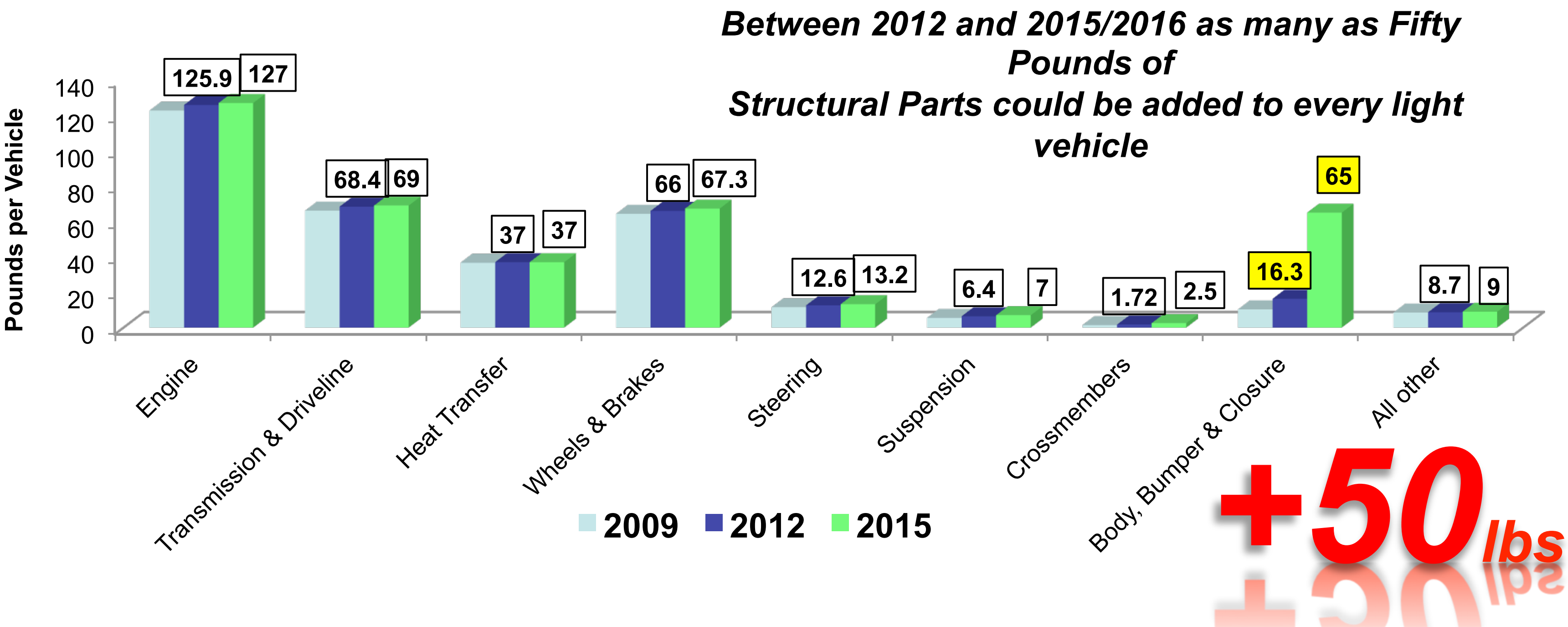
2015 Aluminum Content – growth is mainly in body structure expected!

The growth of aluminum to 400 pounds by 2015/2016 will depend almost entirely on body and closure growth that is well above normal



Source: Ducker Worldwide, LLC.

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Aluminum Opportunities – structural diecasting

- New applications like heat-treatable structural aluminum parts will see the largest growth as entire new markets are created.
- Applications are mainly in automotive where lightweighting is becoming a big driver, but also in other industries like motorbikes and recreational vehiles.
- Those parts are higher value added and margin, and offer a clear competitive distinction for die-casters – basically eliminating off-shore competition.
- Already driving substantial growth for European die-casters.

Aluminum content in automotive
The opportunity for diecasters

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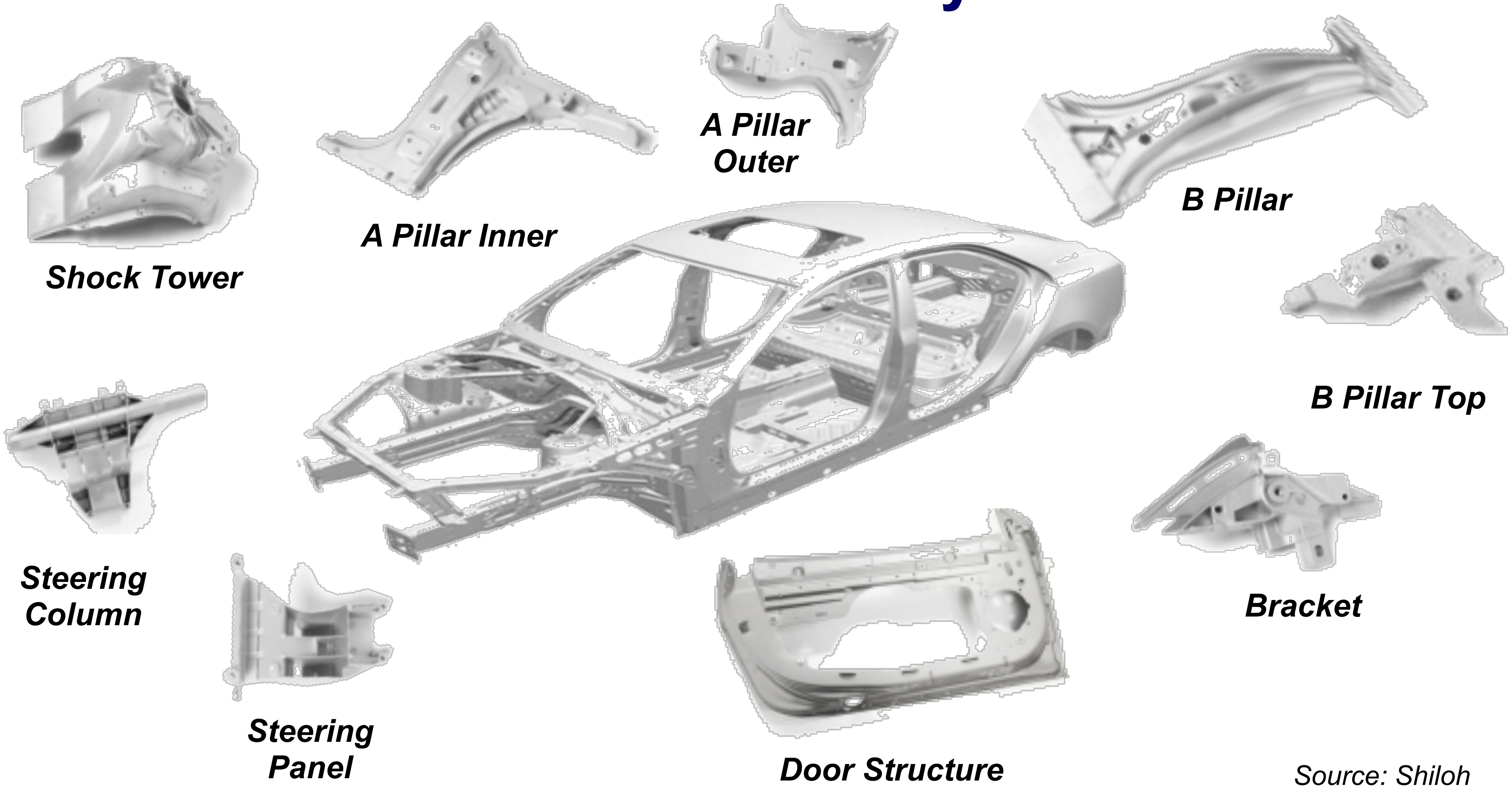
Opportunities for high pressure, high vacuum die cast aluminum body structures



Source: Shiloh

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Structural aluminum diecastings

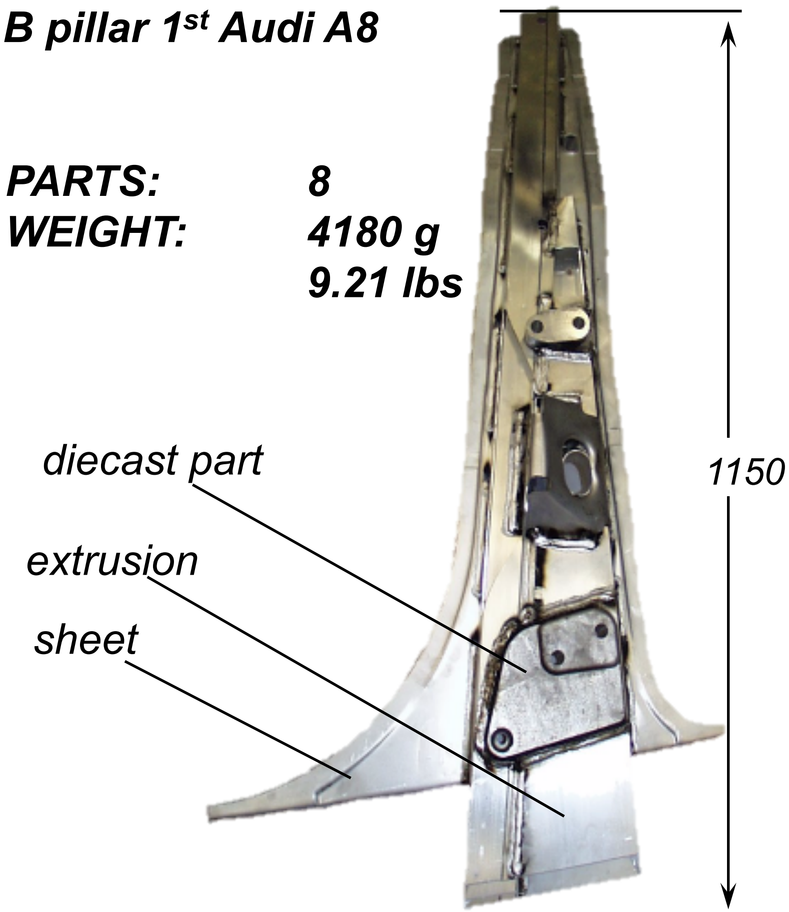
are being used for

- Replacing
  - Heavier materials
  - Steel/Al assemblies and stampings
  - Higher cost materials and processes
- Weldments
- Lower weight (thin walls)
  - Increased fuel economy
- Performance increases
- Pressure tight hydraulics
- …

Part integration and weight reduction are drivers

B pillar 1st Audi A8

PARTS: ***8***
WEIGHT: ***4180 g***
9.21 lbs



B pillar Audi A2

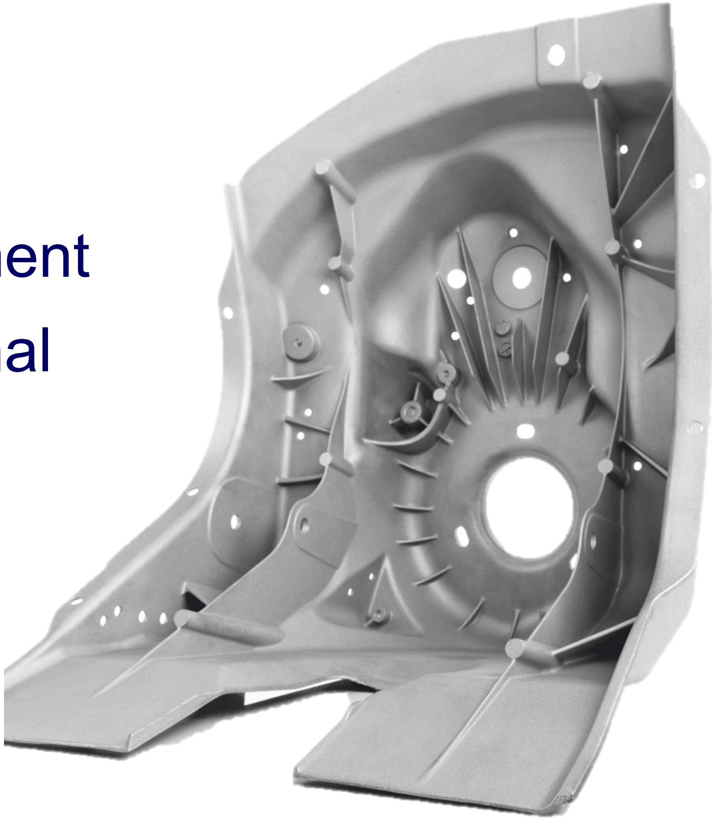
PARTS: ***1***
WEIGHT: ***2300 g***
5.07 lbs

Part integration and weight reduction are drivers

BMW X5 shock tower

- Very low level of entrapped gasses allowing for subsequent heat treatment
- BMW part is 40% weight of traditional steel part and comparably priced.
- **High strength and ductility**

***Before**: required 5 welded steel stampings weighing 18 lbs.*



***After**: One piece, 7.2 pounds or 40% of traditional steel fender well*

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The opportunity for diecasters

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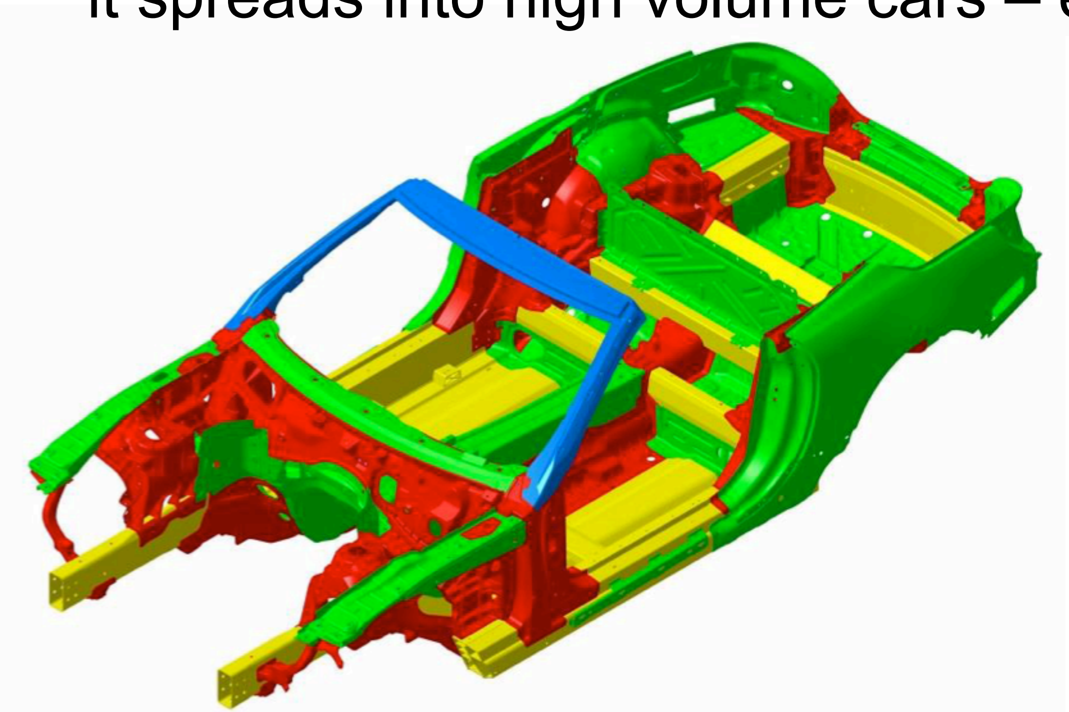
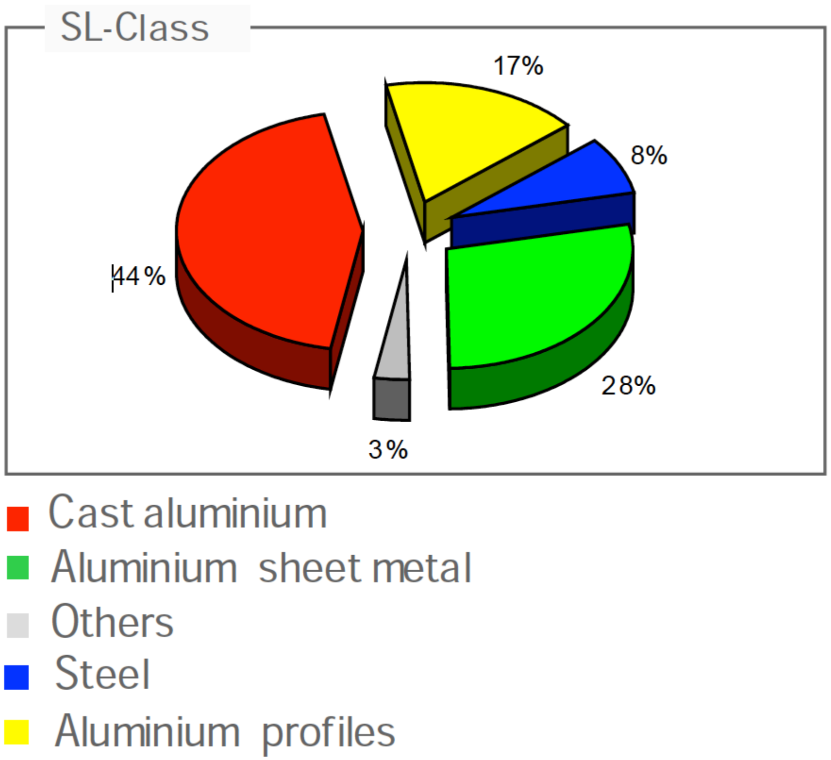
BIW structures: It usually starts in very high-end vehicles before it spreads into high volume cars – example of Mercedes SL





- *World premiere in January 2012 - Launch March 2012*
- *Aluminium and FRP detachable body components*
- *Weight advantage of approx. 110 kg versus conv. steel design*

Source: Daimler AG, Dr. Lutz Storsberg, Mercedes-Benz Cars, Structural Symposium Bühler AG, Hamilton, Canada, October 1, 2013

Aluminum content in automotive
The opportunity for diecasters

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BIW structure Mercedes SL

34 Vacuum-HPDC parts

2 low pressure diecasting parts

Total weight of castings:110 kg

Source: Daimler AG, Dr. Lutz Storsberg, Mercedes-Benz Cars, Structural Symposium Bühler AG, Hamilton, Canada, October 1, 2013

Example – Fire wall

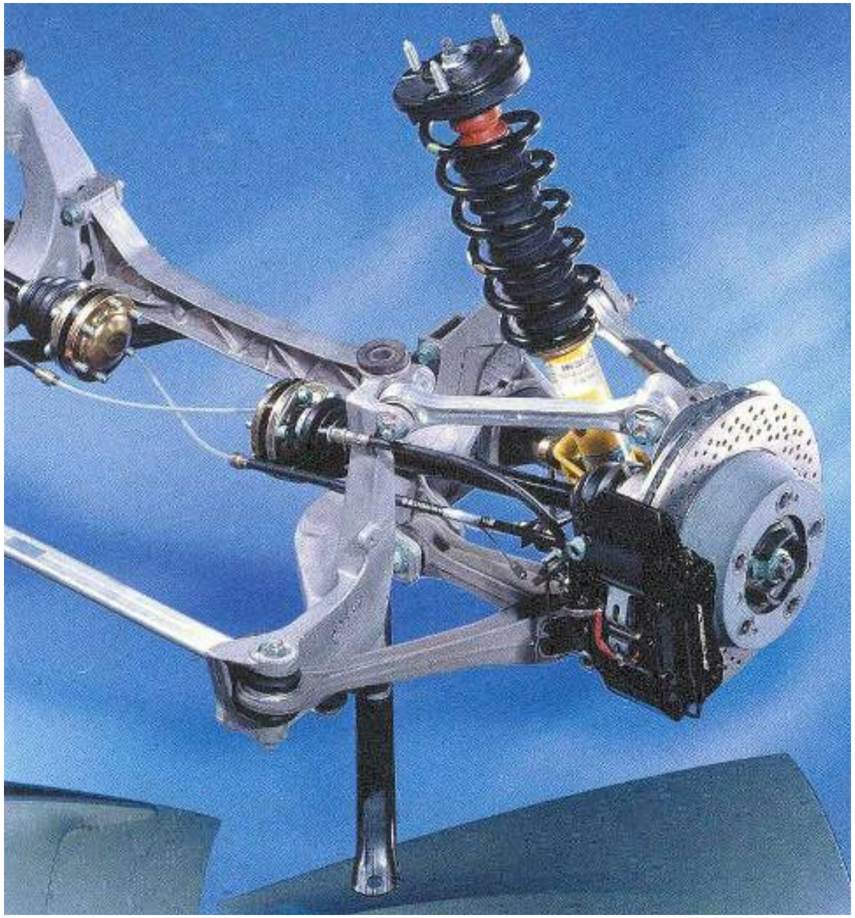
BIW structure Mercedes SL

Dimensions : 356mm,1463mm, 389mm
weight : 7,0kg
Integrated parts : 6
Optimal for the reaching of rigidity goals in a roadster

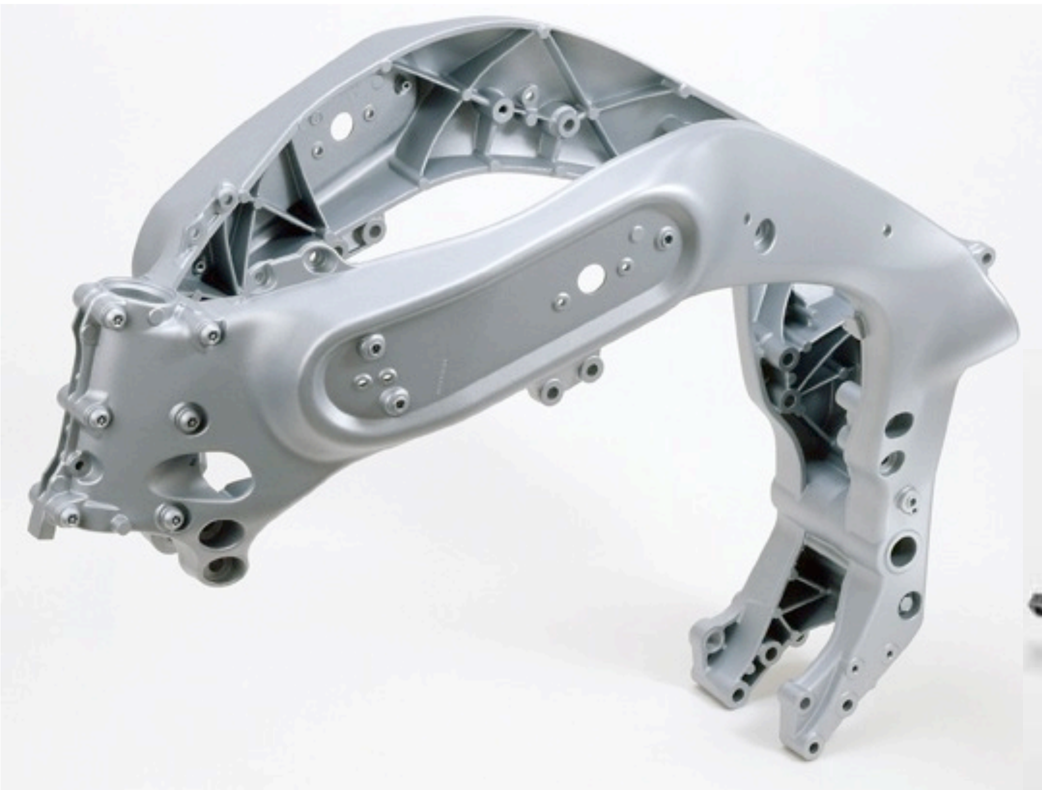
Source: Daimler AG, Dr. Lutz Storsberg, Mercedes-Benz Cars, Structural Symposium Bühler AG, Hamilton, Canada, October 1, 2013

Current and potential applications

Porsche
Side beam member, rear axle



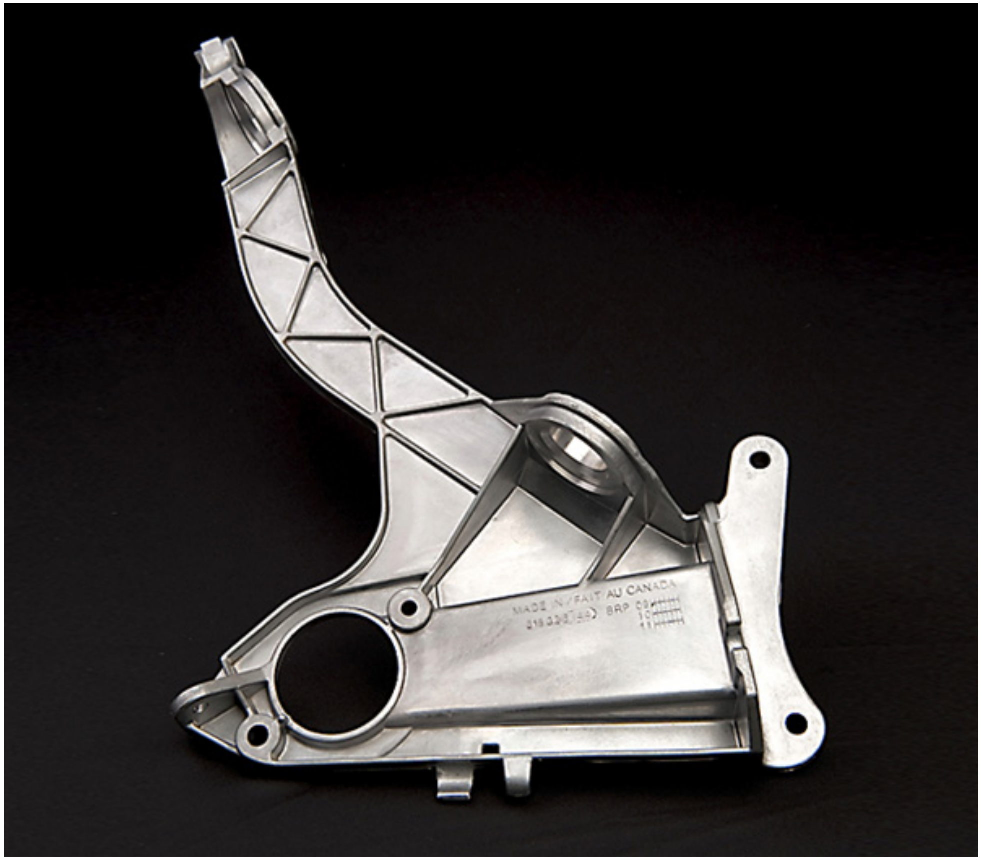
Current and potential applications



Yamaha motorbike main and seat frame in Silafont™ 36 in T5

Current and potential applications

- BRP part produced by AMT in Silafont 36 / Aural-2
- replaces two gravity cast parts.
- Significant reduction in machining costs



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Requirements for high integrity diecastings

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- *Weight reduction*
- *Part integration*
- *High mechanical properties*
- *Crash performance*
- *Corrosion resistance*
- *Weldable / heat treatable (blisters!)*
- *Surface quality (esp. joining / contact surfaces)*
- *Distortion free with tight tolerances*
- *Pressure tightness*
- *…*

Typical mechanical properties:

YS	*100/120MPa*
UTS	*180MPa*
El	*≥10%*
Bending angle (d=2mm)	*≥50/60°*

Requirements for high integrity diecastings

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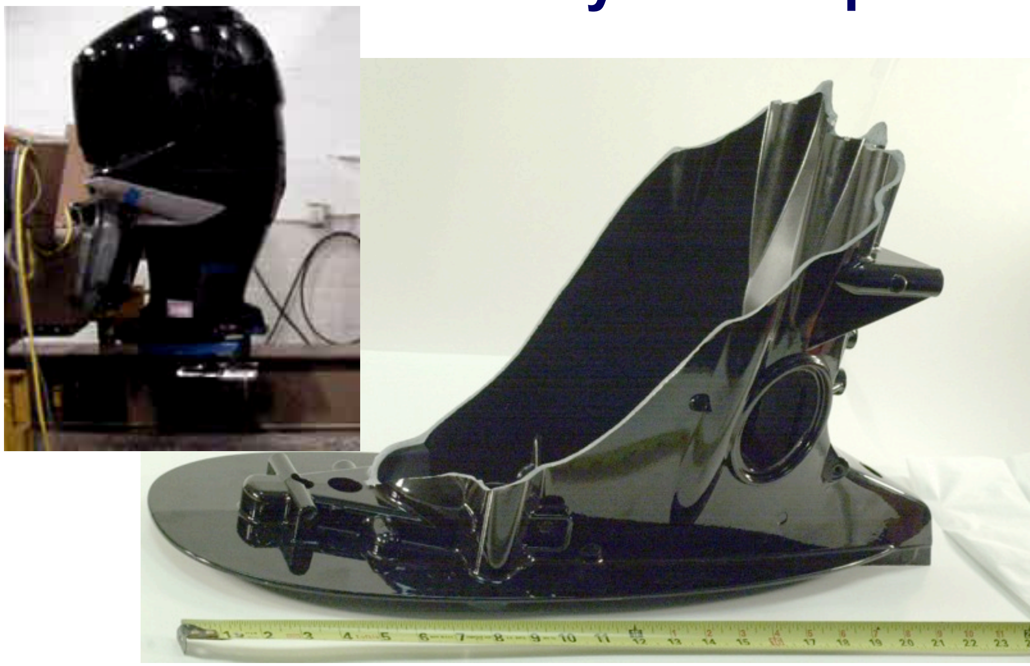
Crash performance: Static loading of 25 lb. drive shaft housings illustrates Mercalloy's far superior energy absorption



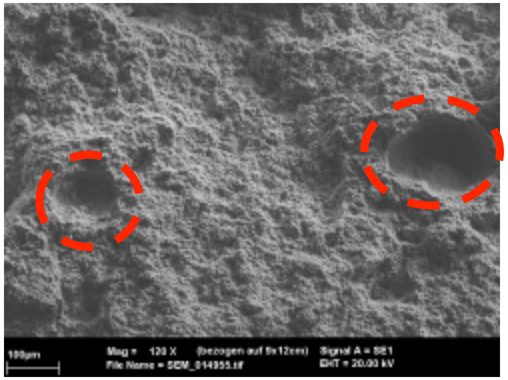
Alloy: XK 360 with 1.3% max Fe
One sudden, fast-propagating failure mode [in less than 100 milliseconds]

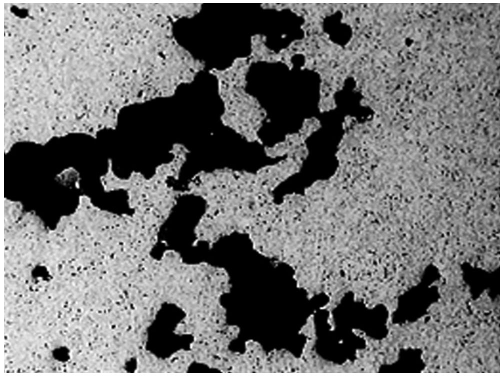
Alloy: ***Mercalloy 367*** *- Crush-like failure never splitting completely – Honorable Mention in 2010 NADCA Casting of the Year Competition*

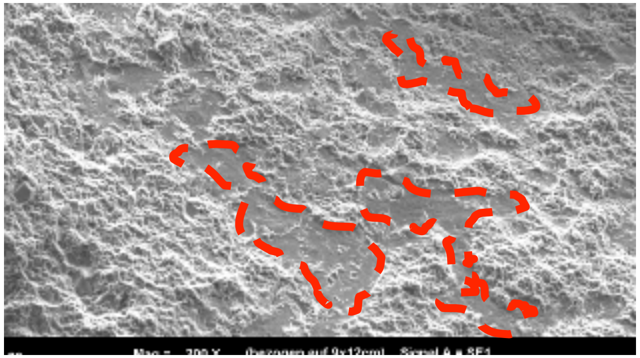
Courtesy of MERCURY MARINE, a division of BRUNSWICK CORPORATION

Requirements for high integrity diecastings

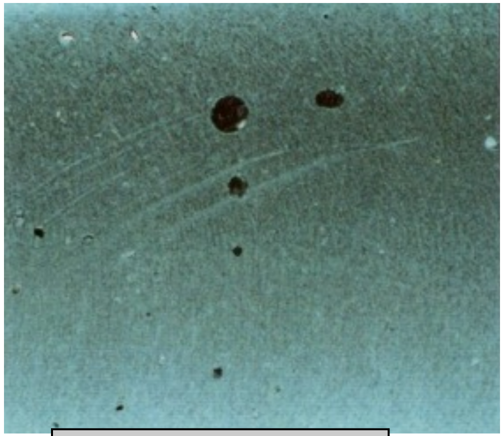
Typical Diecasting Defects



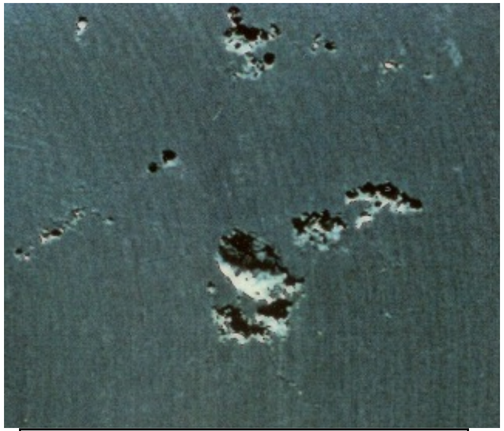




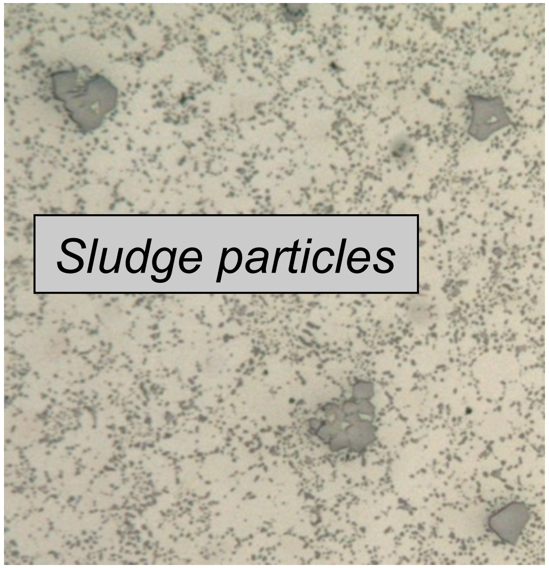
Oxide inclusions



Gas porosity



Shrinkage porosity



Sludge particles

Other inclusions, etc.

Factors affecting die-casting quality

- Alloy composition and impurity
- Metal quality (oxides, hydrogen content, sludge, dross, other inclusions)
- Metal temperature, treatment, transfer, delivery to shot sleeve
- Die-casting machine (size, type, equipment)
  - Clamp/platen: clamp pressure/platen programmable
  - Shot end: shot speeds/profile, pressure, closed loop control
- Monitoring/Control system:
  - for all critical process parameters
  - full machine diagnostics
  - graphical user interface (HMI) provide SPC

Factors affecting die-casting quality

- Shot tooling:
  - Cold chamber (proper size, internal temperature control, etc.)
  - Shot tip (with ring to create seal and internal cooling),
  - Plunger lube (type and application)
- Die-casting dies / gating design / overflow design
- Part design (wall thickness, changes, etc.)
- Die temperature
- Lubricant type, application and efficiency
- Vacuum system: level & type / cavity pressure / control
- Part extraction and quench system
- Trimming
- Heat treatment and other process steps

Requirements for high integrity diecastings

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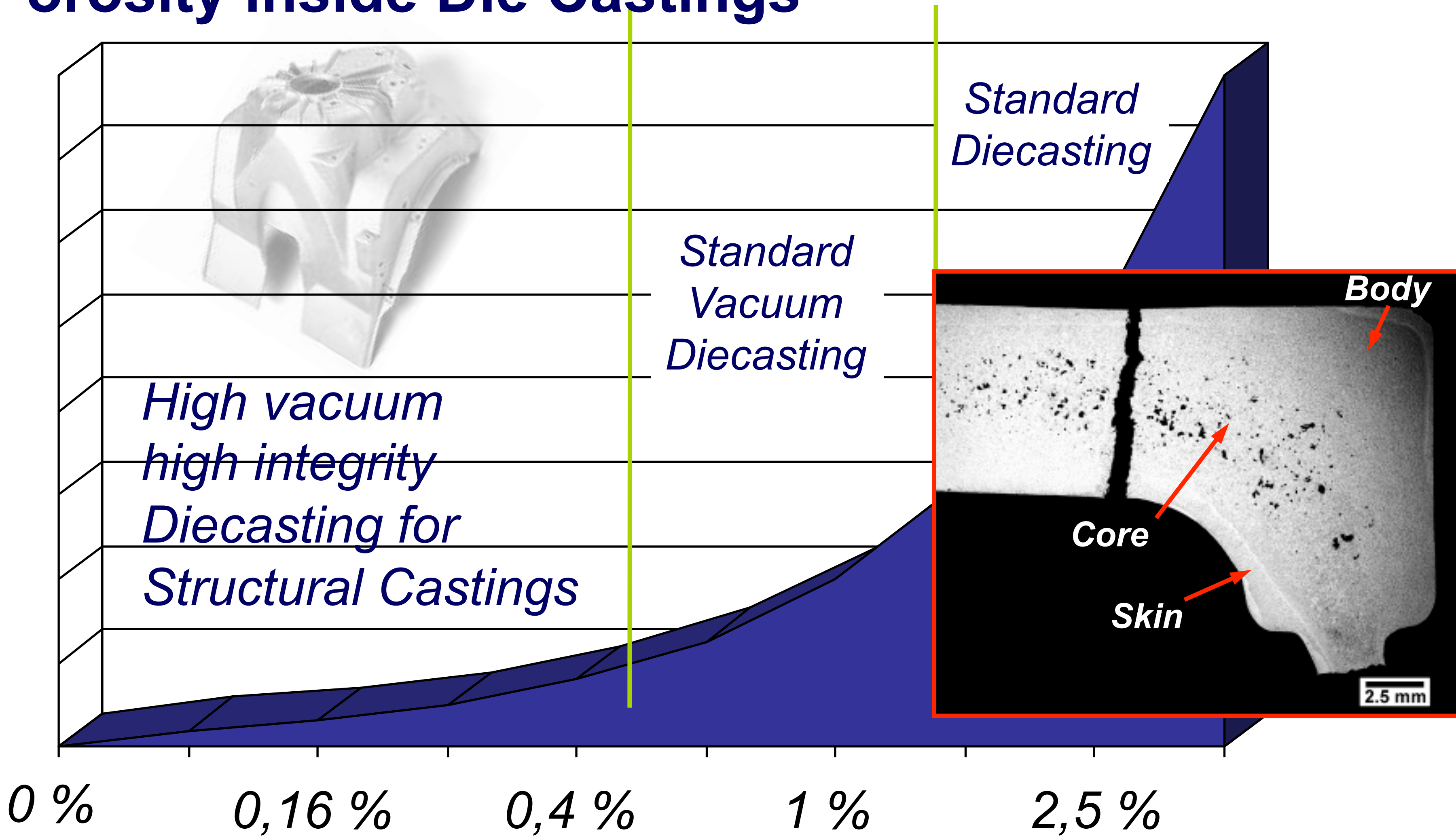
Porosity inside Die Castings



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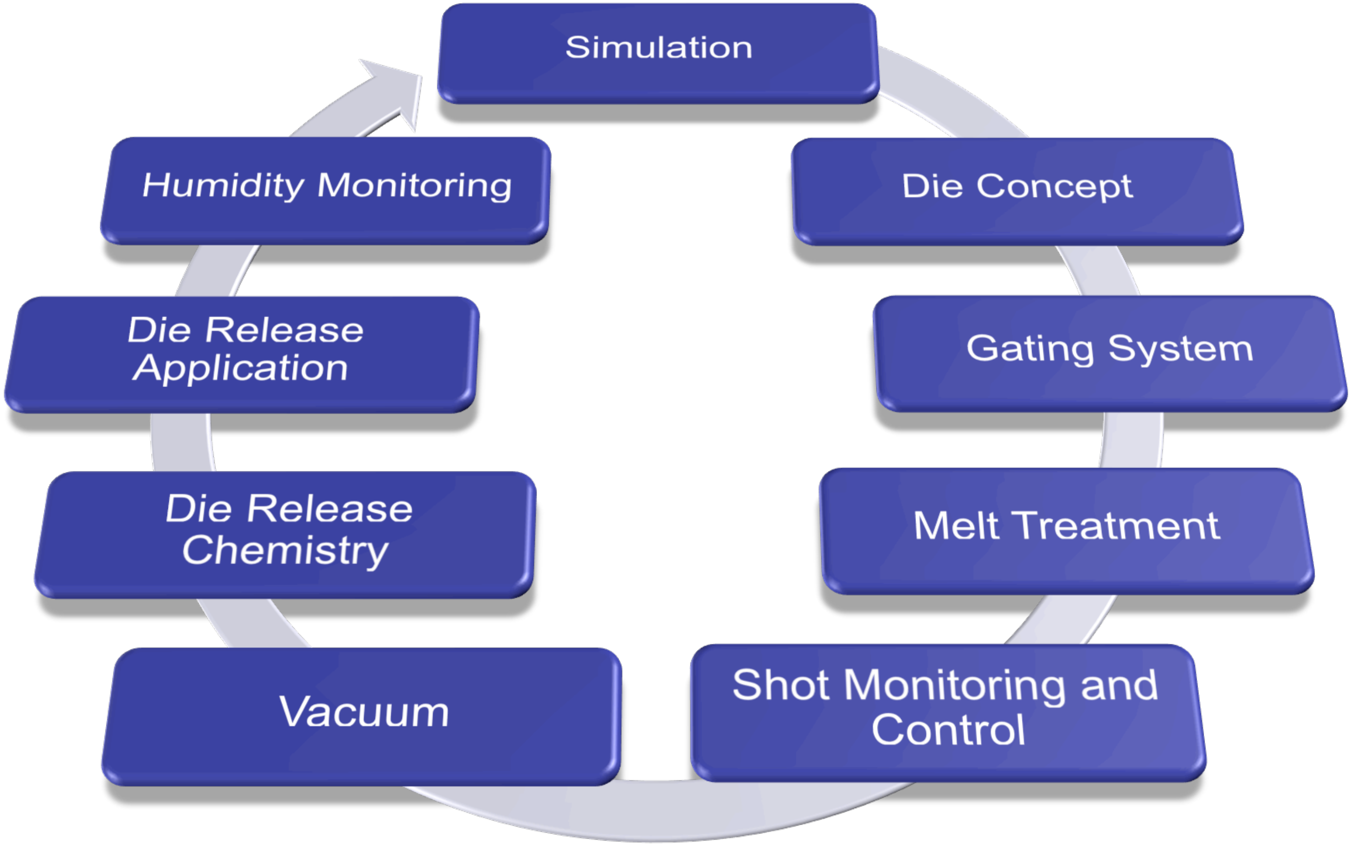
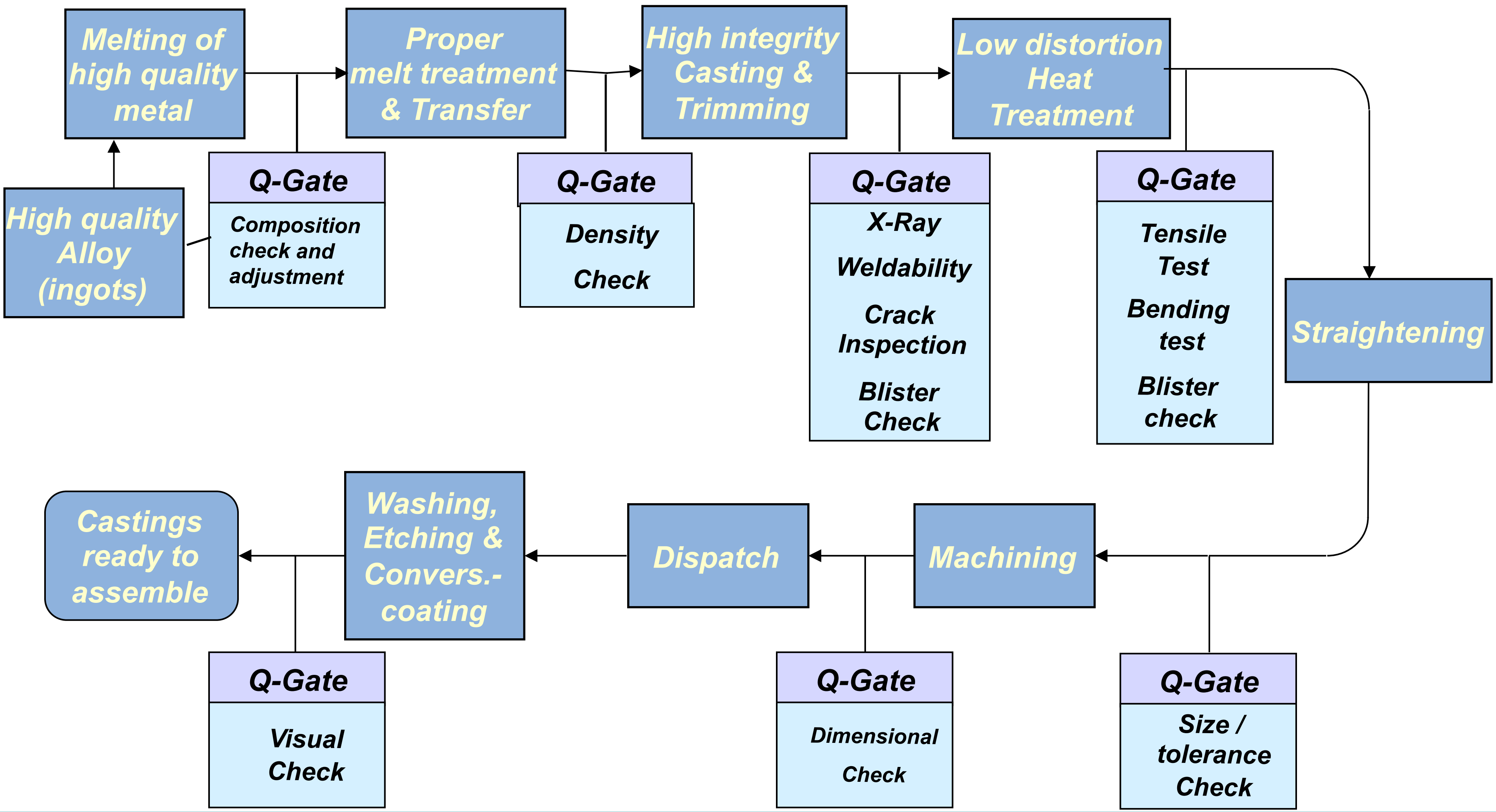
Complete Die Casting Process Technology



Typical Process Chain for Structural Castings



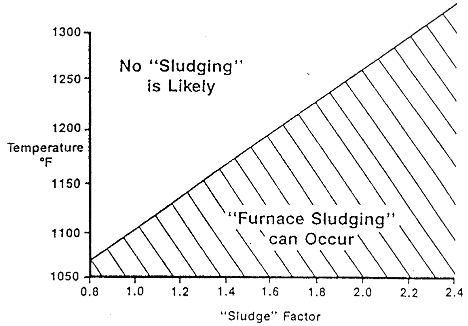
Success factors

Melting, melt treatment & transfer

Items to pay attention to:

- Oxides
- Hydrogen
- Sludge
- Dross
- Other inclusions

"Sludge" Factor =
(1 × %Fe) + (2 × %Mn) + (3 × %Cr)



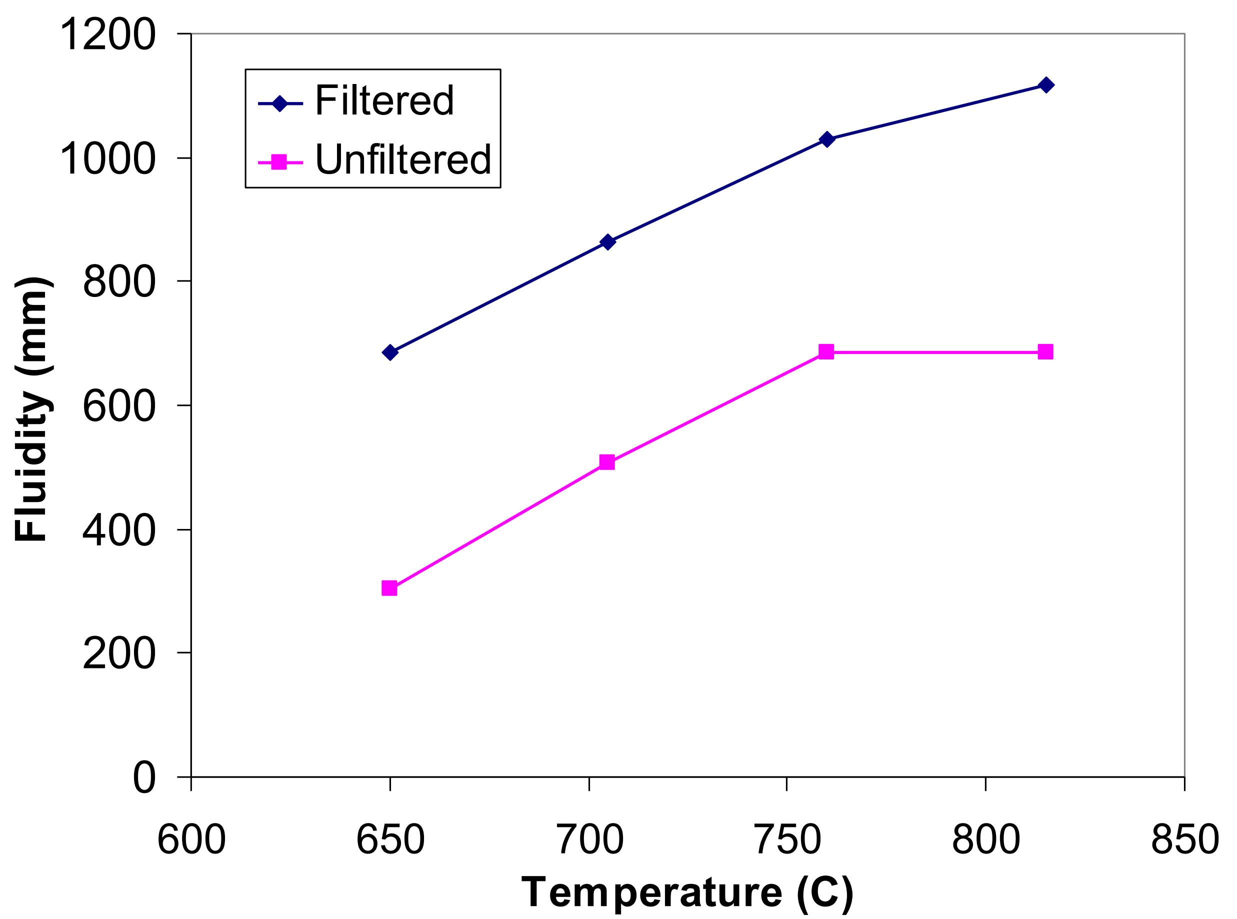
Measures to be taken:

- Proper temperature control of melt
- Avoiding excessive turbulences/splashing
- Degassing
- Fluxing
- Filtering
- Settling

Melting, melt treatment & transfer

Impact of filtering on fluidity

It is a better and more efficient to filter the metal than to increase the melt temperature!



Melting, melt treatment & transfer

Degassing

*Removal of **hydrogen** from molten aluminum*
Sparging with dry inter gas (Nitrogen or Argon)
Reduces gas porosity in castings
Not standard in standard HPDC

Fluxing *(Drossing and cleaning fluxes)*

*Use of reactive gases or salt fluxes to remove **dirt** (oxides) from molten aluminum*
Aim to make inclusions stick to surface flux layer or flux films inside inert gas bubbles (removal to dross layer to be skimmed off)

Success factors

Melting, melt treatment & transfer

Any metal "waterfall" in the metal transfer will generate oxide inclusions!

Traditional metal transfer into the holding furnace causes significant metal splashing …

… and represents also a safety hazard with liquid metal in high positions

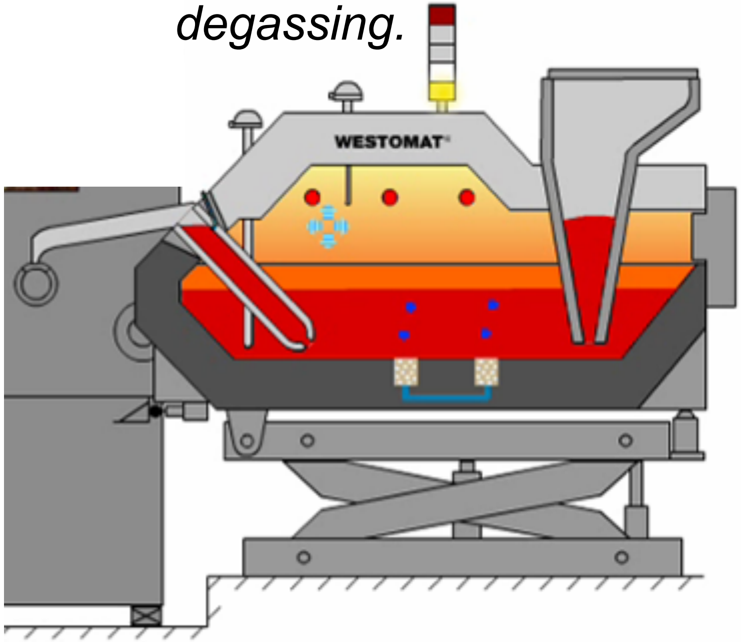
Success factors

Melting, melt treatment & transfer

Støtek DosoTherm

Examples: StrikoWestofen dosing furnace

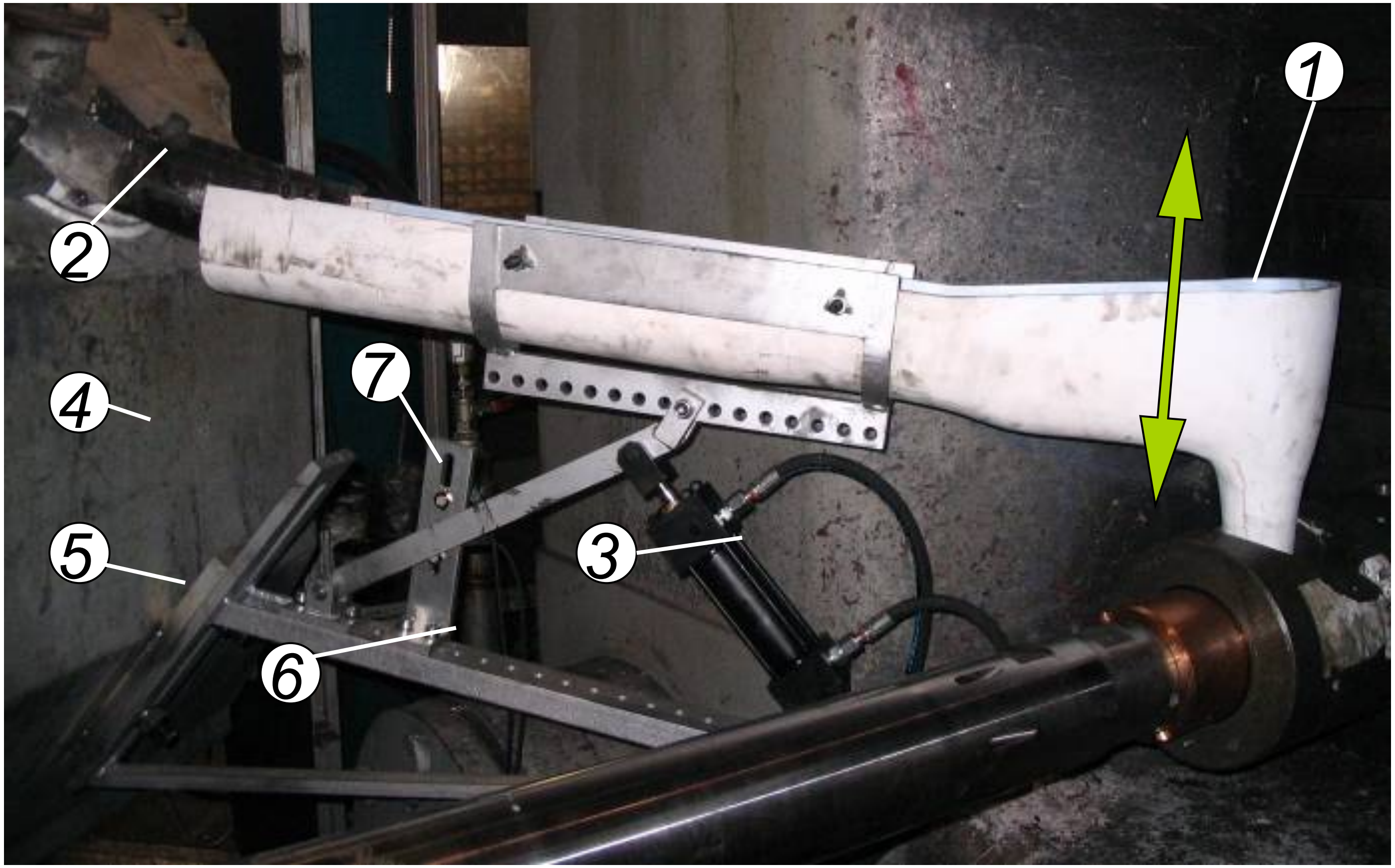
Pressurized dosing furnace with transfer launder and integrated porous plugs for continuous degassing.



Un-pressurized dosing furnace with integrated metal filter, featuring Støtek patented pump technology.

Melting, melt treatment & transfer

Melt transfer:
Swivel Launder



…has developed the design of the launder and the swivel jig in order to achieve a high melt quality level for high integrity diecastings.

Ceramic launder (1); Furnace spout (2); Hydraulic cylinder (3); Holding furnace (4); Swivel jig height adjustment (5); Mechanical swivel jig (6); Position sensors (7)

Success factors

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Numerical Simulation for Die Fill and Solidification

Process-Parameter

Part Design

Simulation Software

Material Data

Defect Prediction

- Incomplete Die Fill
- Soldering
- Trapped Gases
- Shrinkage Porosity
- Distortion
- Thermical Stresses

Optimization

- Gate Desin
- Part Design
- Process Conditions

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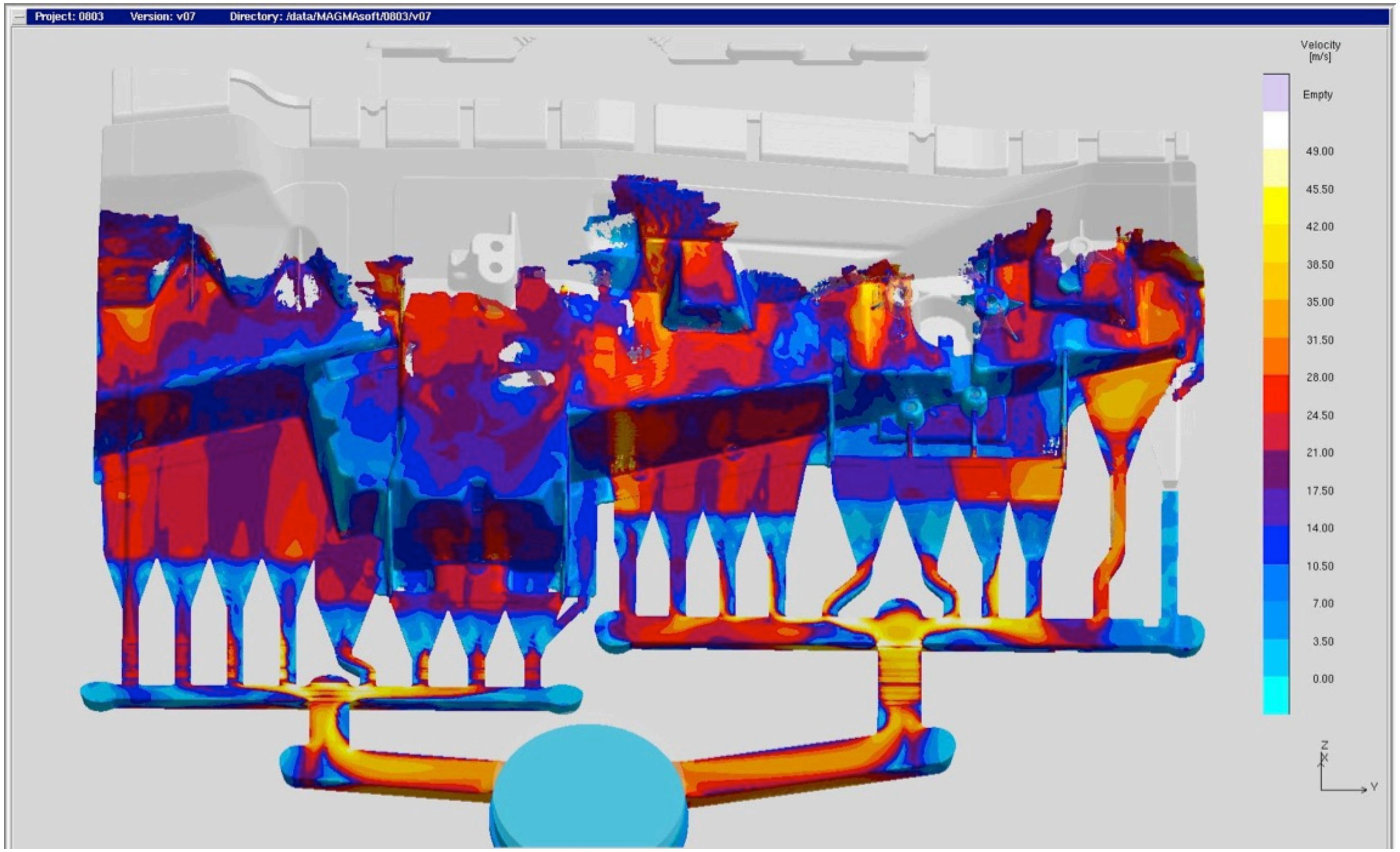
Key to Success: Numerical simulation

- Runner design optimization - provide a continuous flow path into and through the part
- Overflow optimization (including vacuum valve position)
- Utilization of gates along nearly entire front edge of part
- Casting defects prediction
- Temperature distribution at surface of the cavity
- Velocity field in the liquid metal during die filling

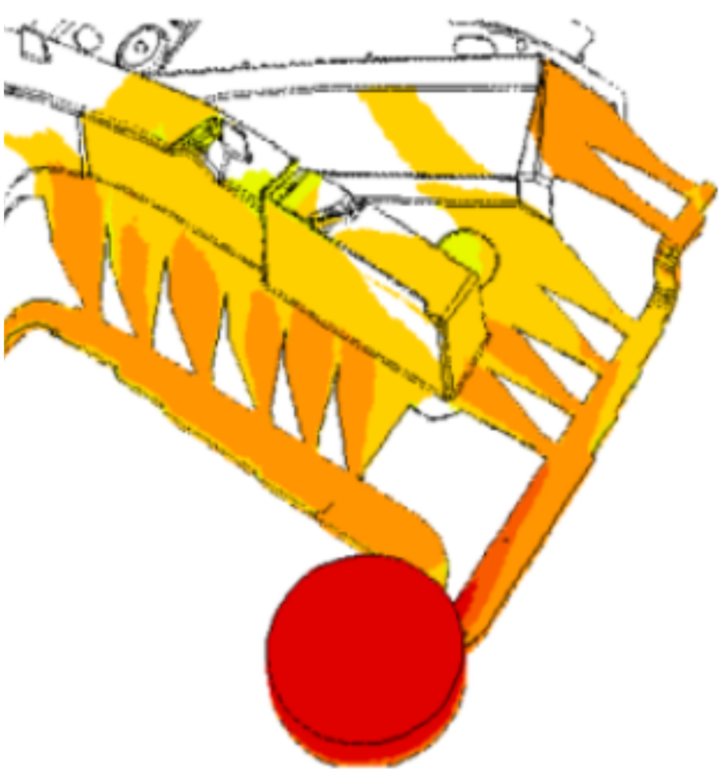
Success factors

Key to Success: Numerical simulation

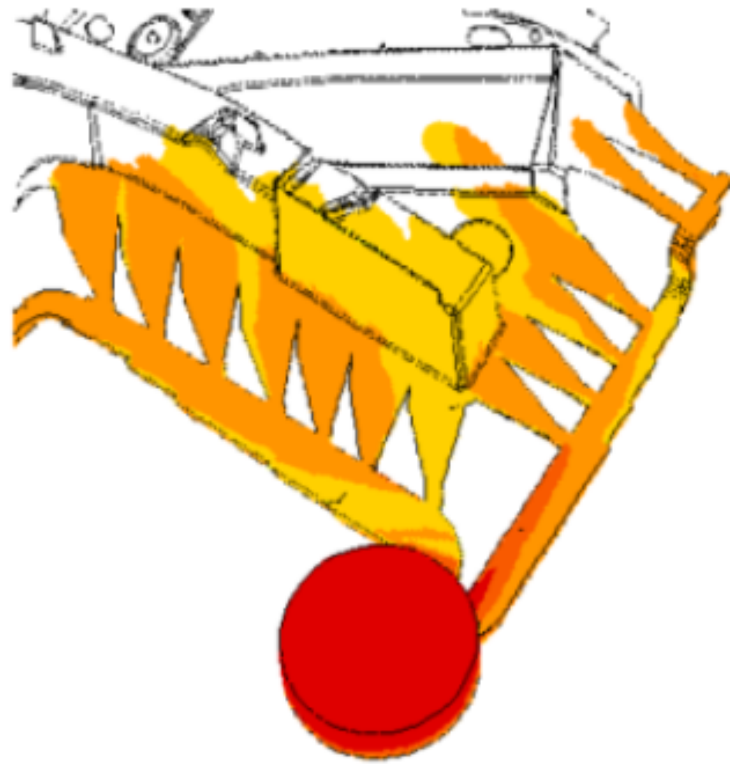
Process Analysis – Die Fill (predicting porosity)



Key to Success: Numerical simulation



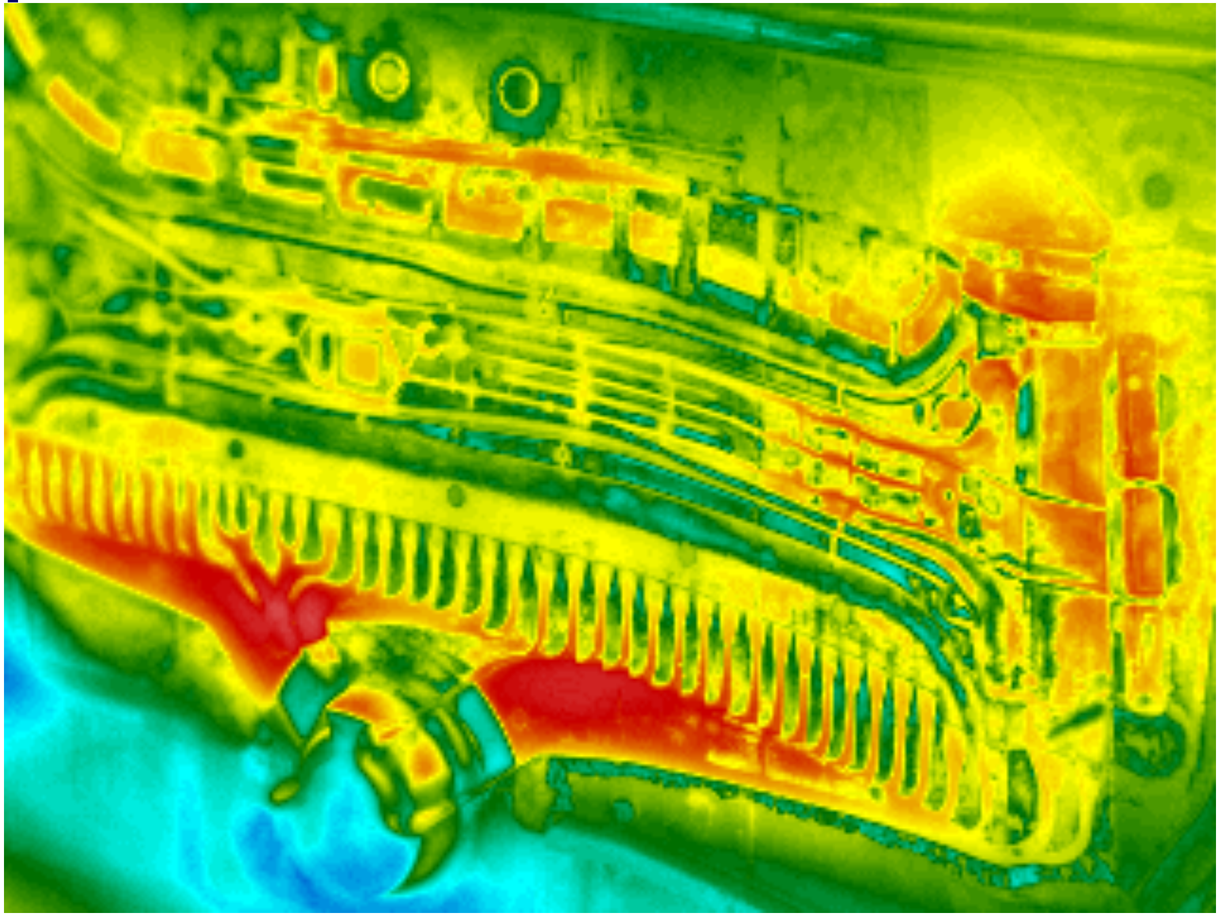
1st flow simulation shows Overlapping flow paths



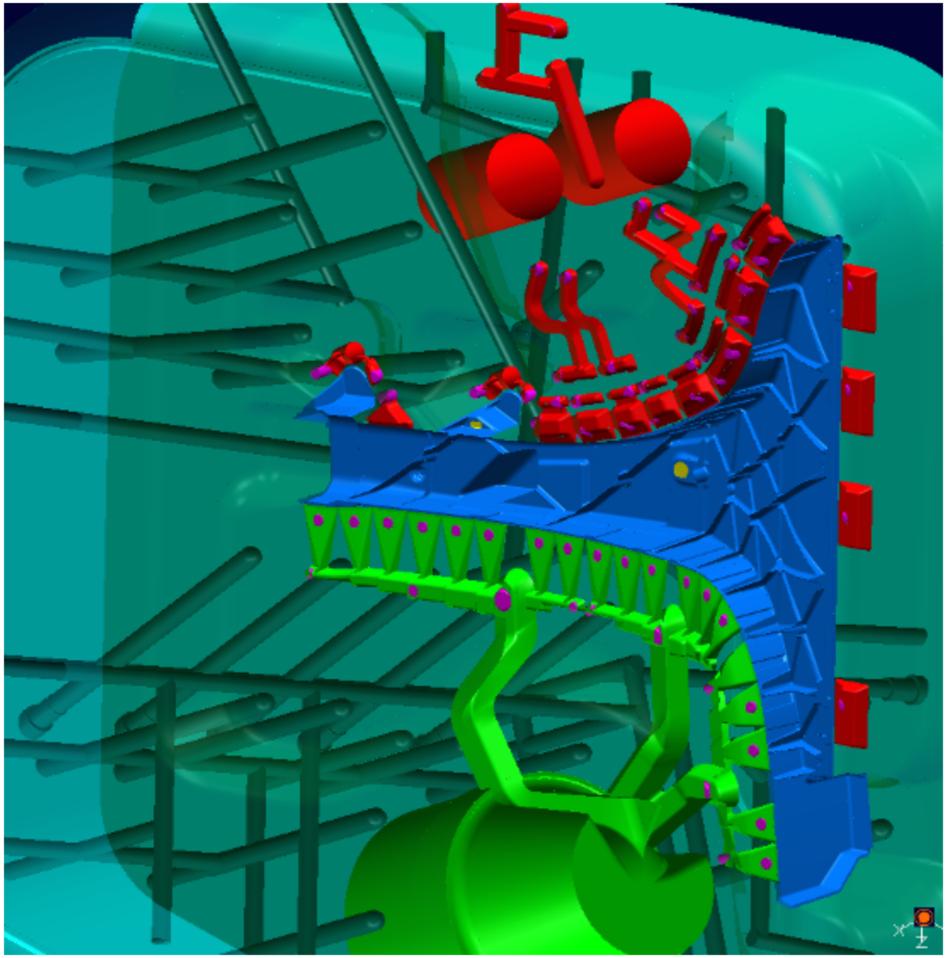
Optimized runner design eliminates trapped air

Key to Success: Numerical simulation, Die design and process control

Process Control – Die Temperature



Key to Success: Die design



Moving half of die with gating system (green) and overflow/vacuum system (red)
Part contour (blue)
position of ejector pins (purple)
cooling/heating systems (dark green)

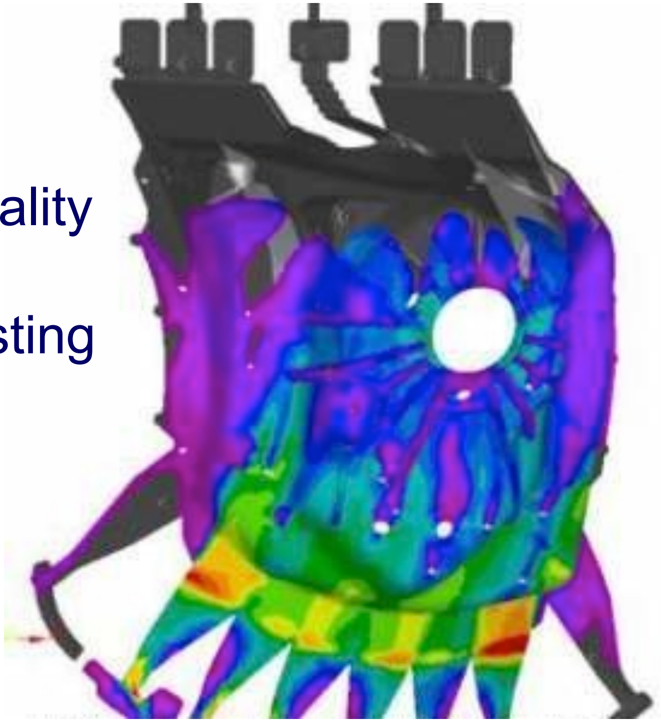
Key to Success: Die design

- O-Rings are used extensively on tooling to prevent leaks
- Thermal isolation plates are used to improve warm-up time
- Multiple short hot oil zones are utilized to control die temperature



Key to Success: Product Development

- Component Design
  - Robust designs meet both functional & manufacturing requirements
  - Robust component designs lead to higher quality products
  - Design engineers should collaborate with casting engineers in the early stages of product development
- Gating and Die Design
  - Simulation is a must
  - Gating design is important
  - Vacuum gating is also important and often overlooked



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Key to Success: Process Monitoring/Control

Successful high integrity die cast process requires advanced process controls and monitoring systems - real time adjustable control system (i.e. closed loop)

- **Shot control**
  - Reduce Air Entrapment during Slow Phase
  - Smooth Metal Flow & Flexibility of adjustments during Fast Shot/ Fill Phase
  - Repeatability regardless of changes
  - Deceleration for Low Impact
  - Programmability (in engineering units for fast and repeatable set-ups; store, recall and download set-ups)

Key to Success: Process Monitoring/Control

Successful high integrity die cast process requires advanced process controls and monitoring systems - real time adjustable control system (i.e. closed loop)

- **Vacuum Monitoring/Control System**
  - Apply vacuum during fast shot - repeatability is key
  - Detecting leaks or blockages is crucial
  - Monitoring system can be used to quickly troubleshoot equipment (improved uptime)
- **Die cavity sensors:**
  - thermal history of die
  - measurement of pressures during solidification

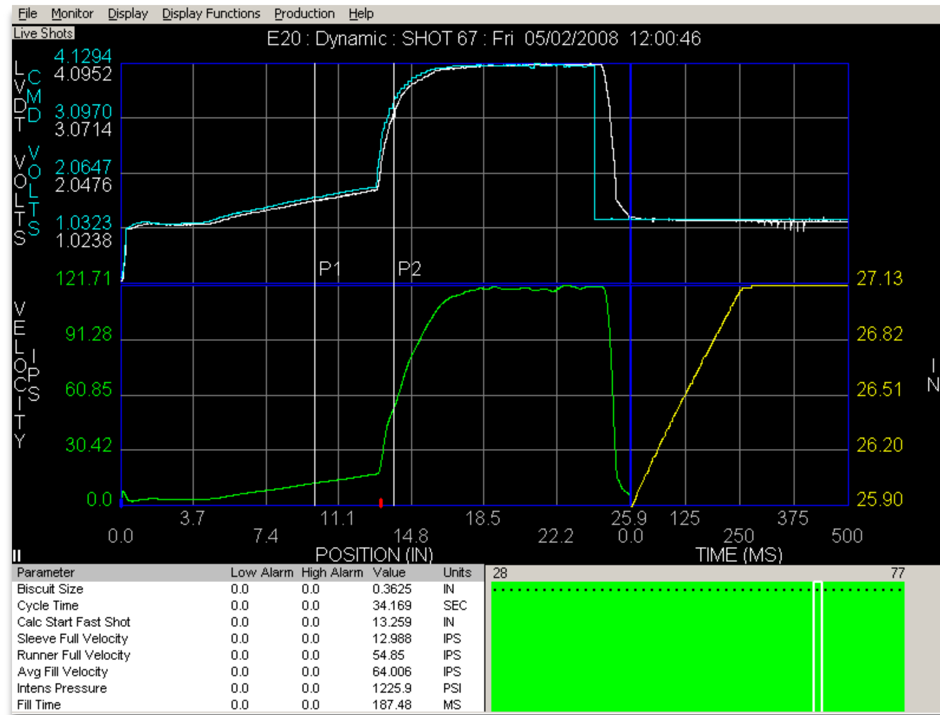
Success factors

A Proactive Approach to Process Control

- **Monitor key variables**
  - Shot-end Hydraulic characteristics
    – Position, Velocity, Pressure, Vacuum
  - Derive key process parameters like:
    - Biscuit length, intensification pressure, intensification squeeze
  - Furnace/metal and die temperatures.
  - Tie-bar stress
  - Cycle times.
- **Casting characteristics are calculated and reported by monitoring equipment**.
- Design experiments to understand relationships and causes of variation
- Accrue production information including scrap and downtime data

Sure-Trak2™ Real Time Shot Control System

- Real time control of shot velocity.
- Six programmable shot steps with low impact.
- Six programmable limit switches.
- Proportional – Integral control loop implemented in firm ware



Produce Precise and Repeatable Injection Control

- Programmable control parameters.
- Programmable dither.

Two Monitoring Methods

Portable Monitoring

- Regularly check variables using portable process monitors
  - Labor intensive and prone to error.
  - Too infrequent to catch sporadic events.

(Plant Wide) Continuous Monitoring

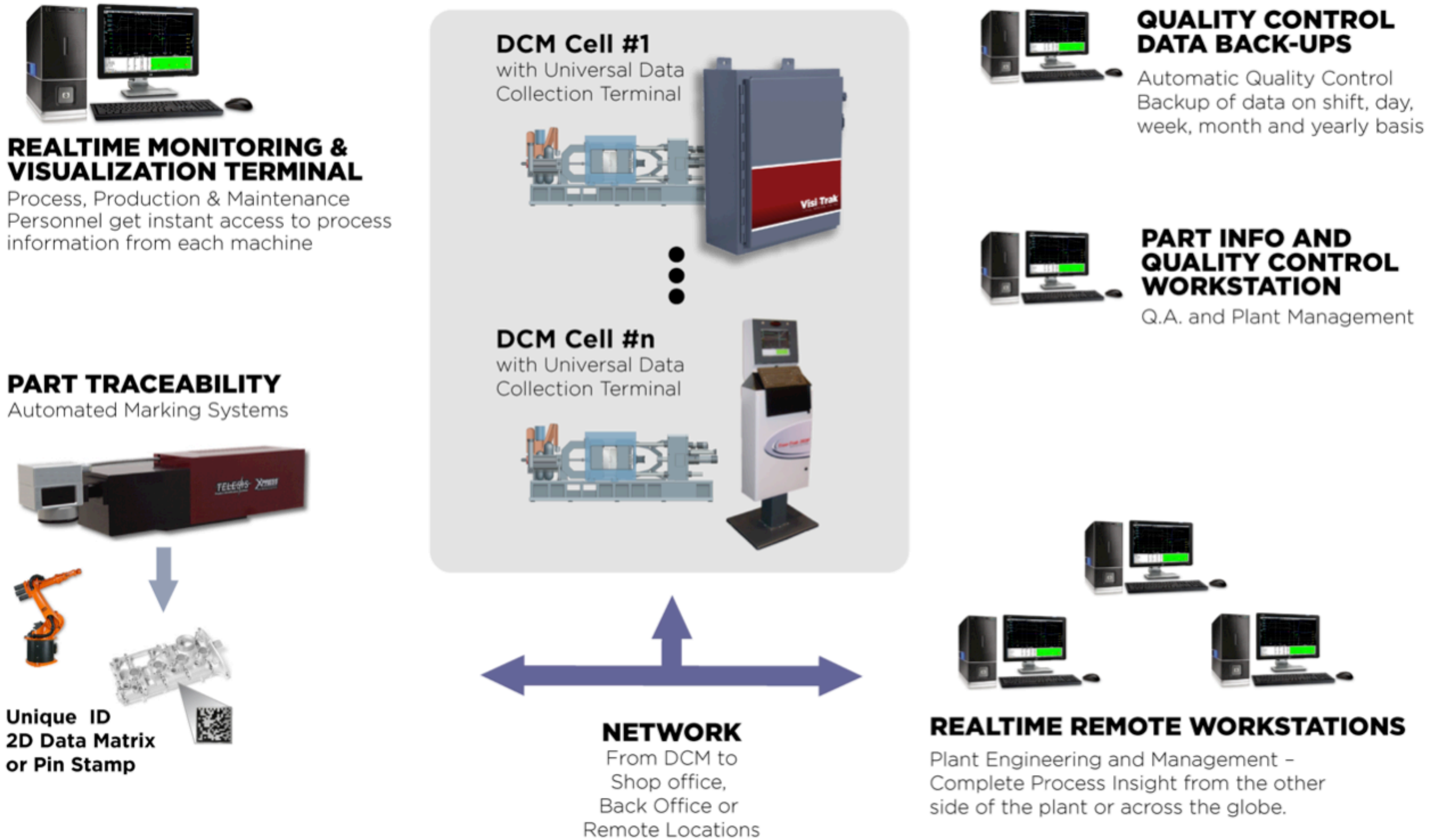
- Full time monitoring identifies each time a key parameter is out of specification.
  - Alarms alert operator as specifications are not met with immediate analysis.
  - System monitors **24/7**

Success factors

Plant Wide Continuous Monitoring (continued)

- Sporadic machine problems can be identified and solutions developed from real data.
- Automatically segregate suspect and “start up” castings. Greatly reducing the incidence of “cold shots” reaching the customers.
- Permanent installation means cabling and sensors can be shielded from the environment for longer life and lower maintenance.

Plant Wide Continuous Monitoring (continued)



Sleeve Fill Phase

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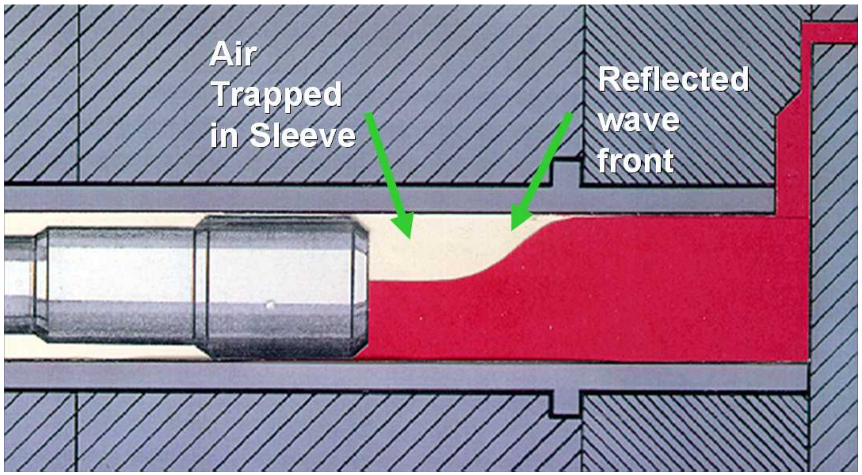
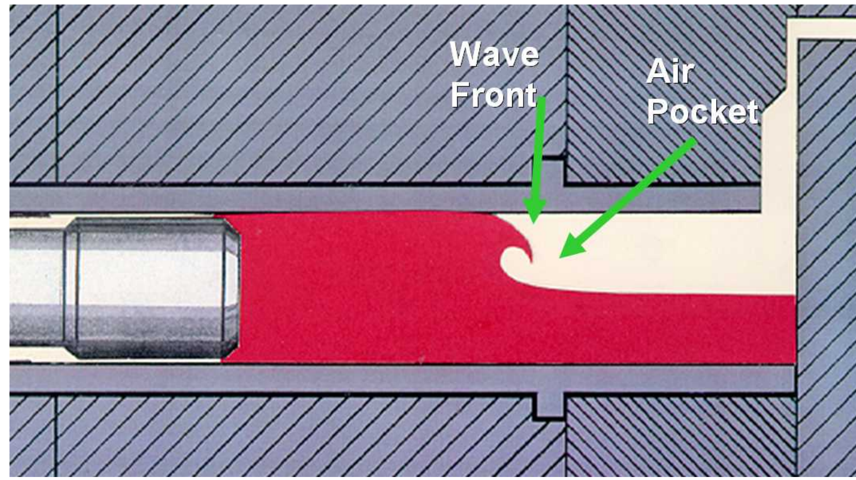
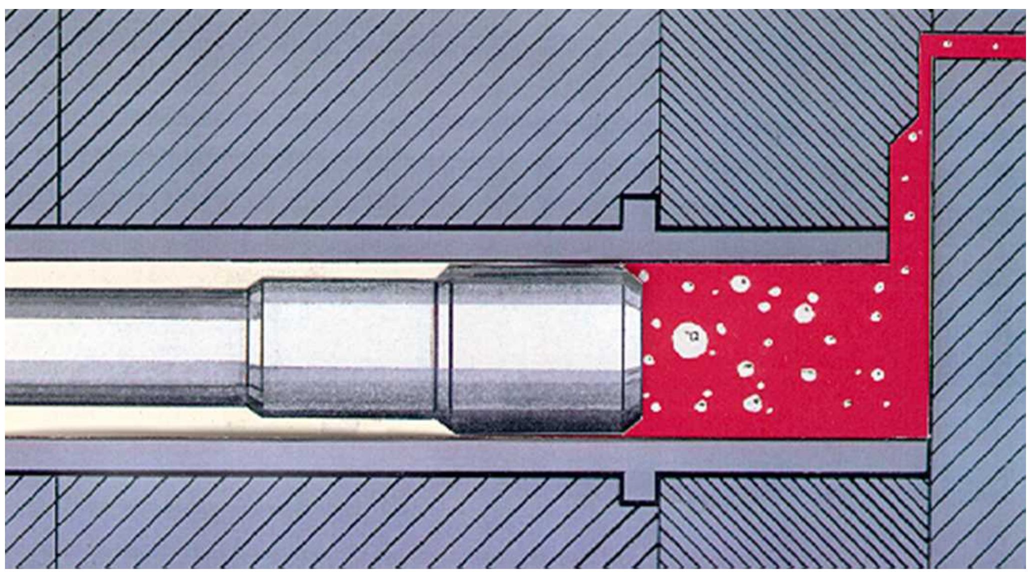




Too Slow?



Too Fast?

Cavity Fill Phase – Critical Slow Shot Velocity

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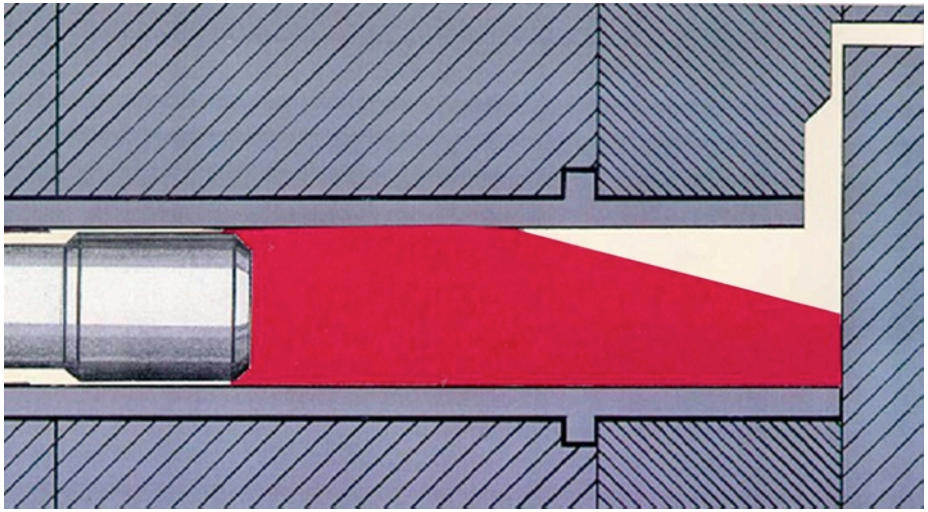
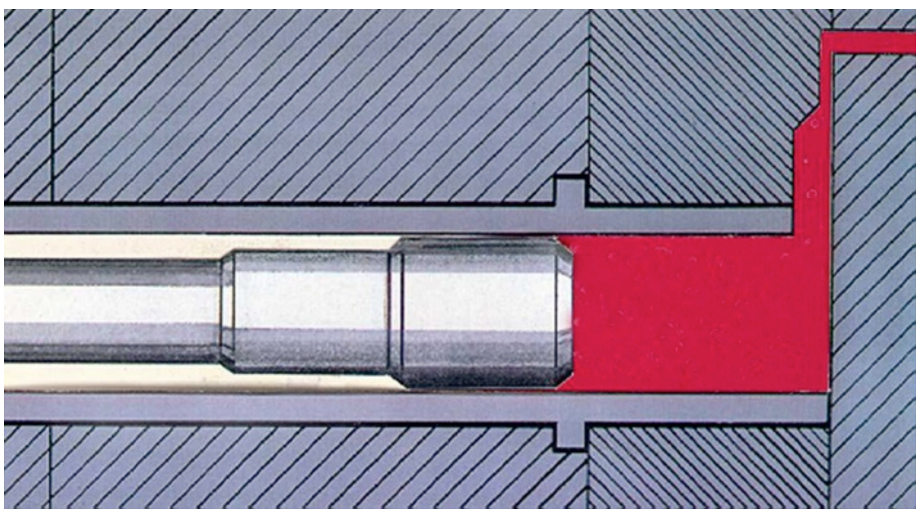
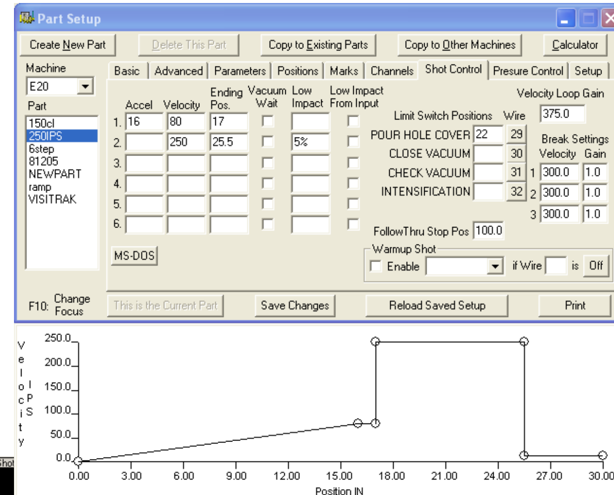
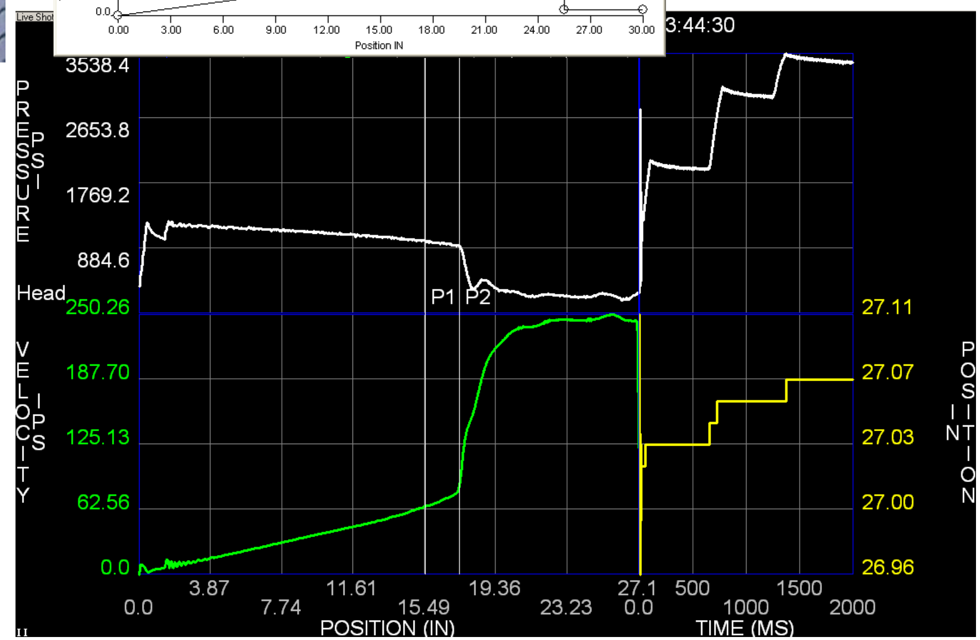






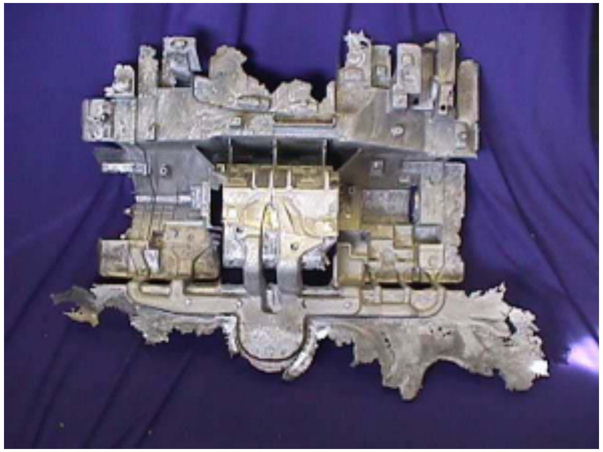


Constant acceleration

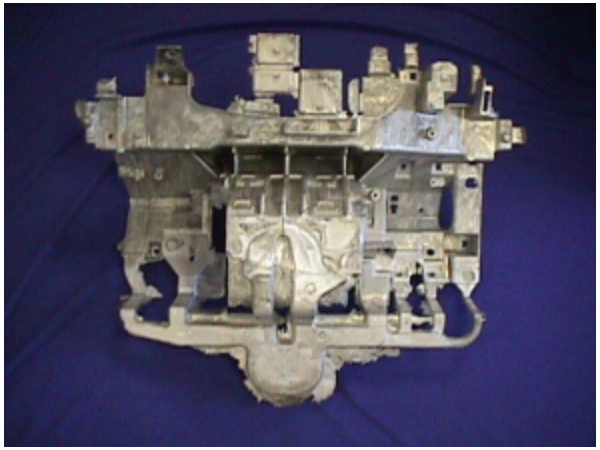
Key to Success: Process Monitoring/Control

Process Control - example: ***VISI-TRAK's SoftSHOT Technology***

- Design of the overflows to absorb kinetic energy and thus decelerate the shot system (positioned in the die where the final filling occurs)
- Ultimate pressure in the cavity area can be controlled to a level that the clamp end of the machine can hold closed, thereby eliminating flashes
- Smoothly decelerate the shot system automatically compensates for metal pour variation
  - *Improves vacuum*
  - *Less wear and tear on shot end clamp end*
  - *Improves part quality*
  - *Extends die life*



Before



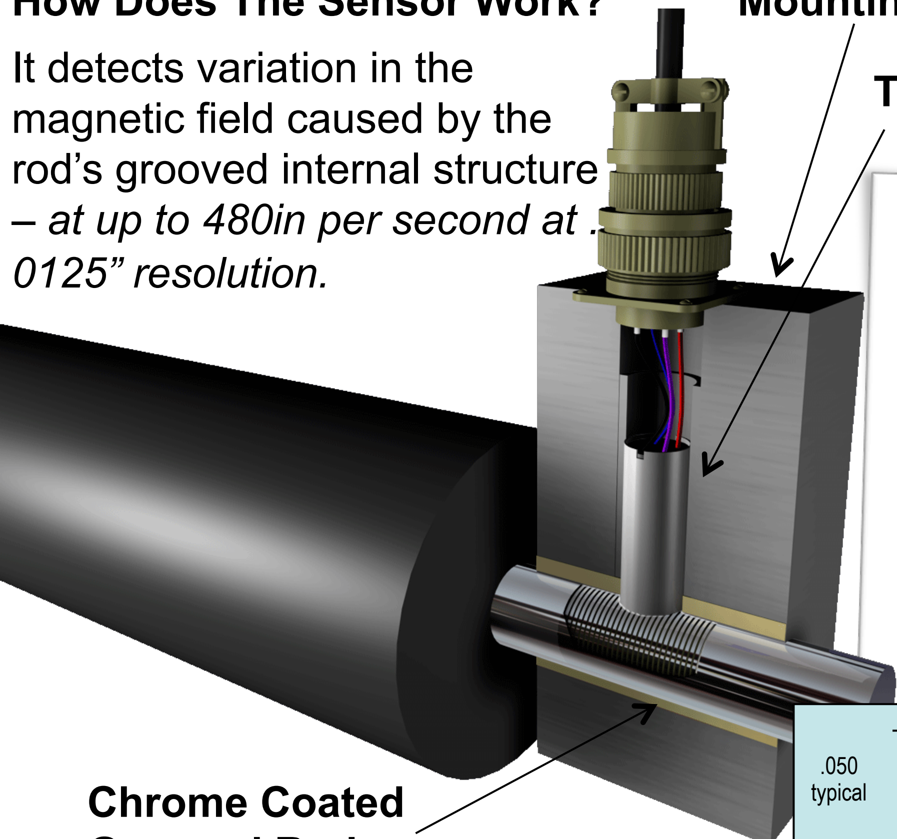
After

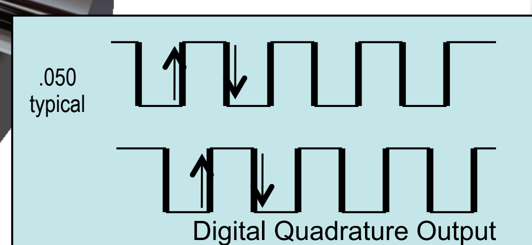
Cadillac Instrument Panel

Key to Success: Process Monitoring/Control

How Does The Sensor Work?

It detects variation in the magnetic field caused by the rod's grooved internal structure – *at up to 480in per second at .0125" resolution.*





TOUGH + RELIABLE

Design Simplicity
for inherent reliability.

Extreme Accuracy
up to 480IPS/12MPS.

Non-contact sensor
minimizes equipment wear.

No calibration or alignment
means no set-up problems.

Proven Performance
for over 25 years.

Easy to install & operate
nearly maintenance free.

Success factors

Visi-Trak®
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Visi-Trak SV Series servo throttling valves

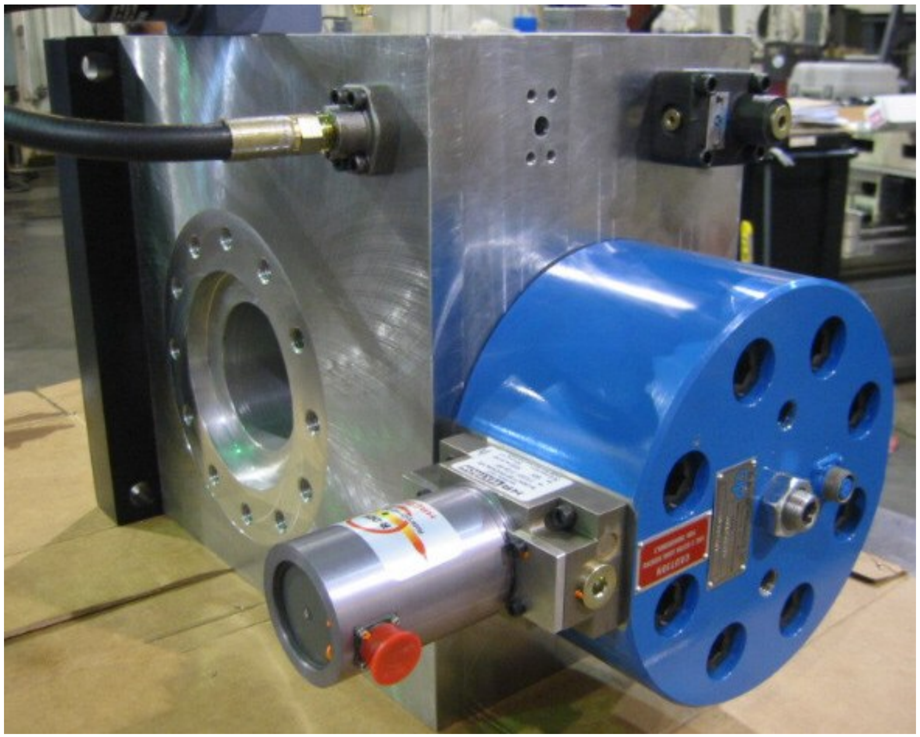
- **Precise Slow-shot Speed Control** for reduced porosity
- **High Flow Rates** for explosive acceleration & deceleration
- **Fastest Response Time** for the most dynamic shot profiles
- **Easy To Implement** in a variety of styles and sizes
- **Rugged Design** for exceptionally long life

WHY CHOOSE A SV SERIES VALVE?

DYNAMICALLY RESPONSIVE	TOUGH + RELIABLE	EASY TO IMPLEMENT
Unique design enables **fine low speed control and very high flow rates**, allowing precise control over a broad speed range.	All working valve surfaces utilize **hardened & ground 8620 carburizing steel**, for exceptionally long life.	Available in a **cast body for in-line installations** (50mm and 80mm sizes).
The **fastest response time** of any servo piloted throttling valve tested - instant response for even the most dynamic shot profiles.	In-line version is **fully sleeved**, allowing replacement of any worn components, **for amazing valve life**.	Available in **cartridge style for manifold mounting** for clean hydraulic designs (32 mm, 40 mm, 50 mm, 63 mm, 80 mm, and 100 mm sizes).
Pressure rated up to 6000 PSI	**Improved LVDT design eliminates leakage**	

Visi-Trak®
SENSE, MONITOR, CONTROL

Retrofit solution



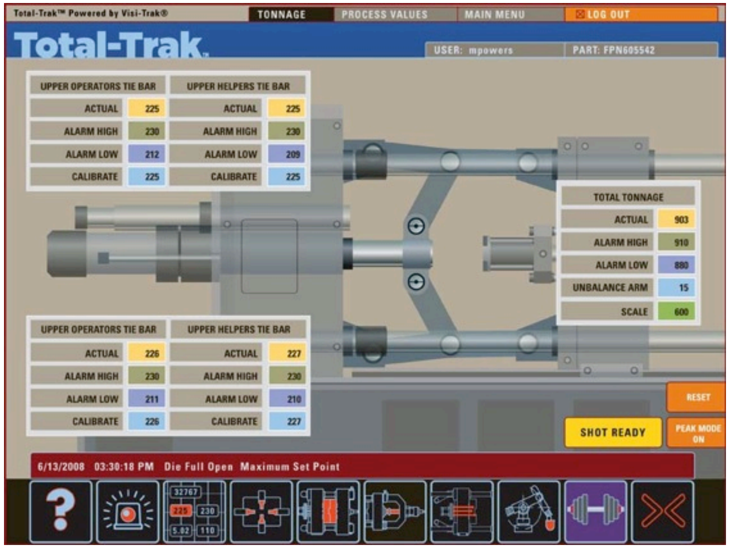
- Remove Binary II shot valve and manifold block
- Direct bolt-in replacement with:
  - Olmsted 80mm two-way, servo-piloted throttling valve slip-in cartridge format
  - Piloted by an H.R. Textron R-DDV servo pilot valve
  - PO check valve releases oil to retract the shot cylinder
  - Cartridge valve develops pressure to retract the shot cylinder
  - Cartridge filter ensures a clean oil supply

Success factors

Visi-Trak®
SENSE, MONITOR, CONTROL

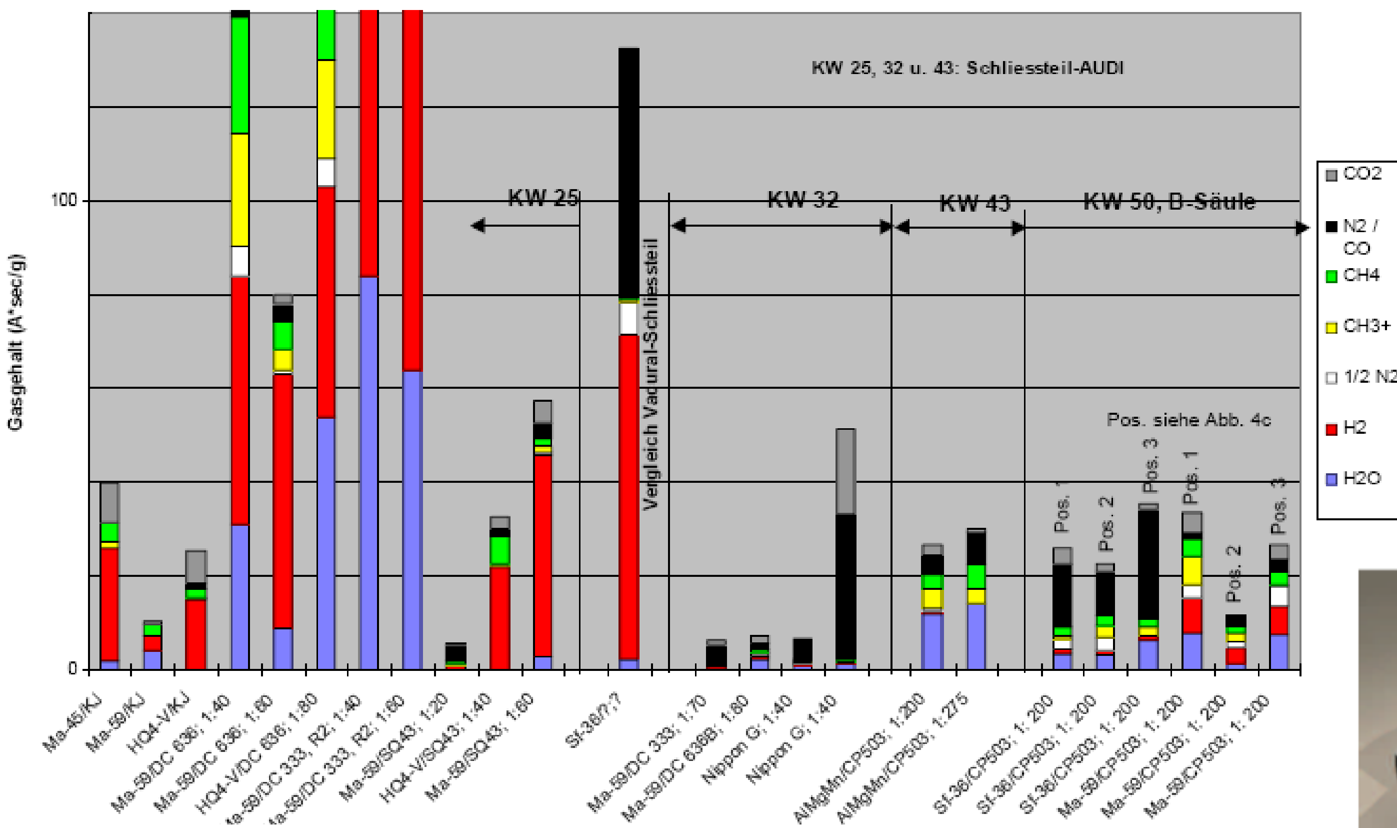
Total-Trak HMI – PLC Front End

- **Monitor & control**, your entire automated machine cell.
- **Easy set-up** - restore saved jobs in seconds.
- **Complete I/O Diagnostics** for a comprehensive view.
- **Integrated control** with the True-Trak20/20™ or Sure-Trak2™.
- **Ladder logic display** options available.
- **Cost-effectively replace your obsolete systems**.



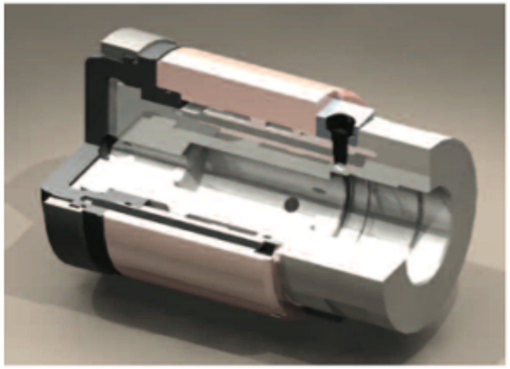
Key to Success: Lubricant

Minimize evolution of gas (and subsequent entrapment in castings) resulting from reaction between lubricants and molten metal



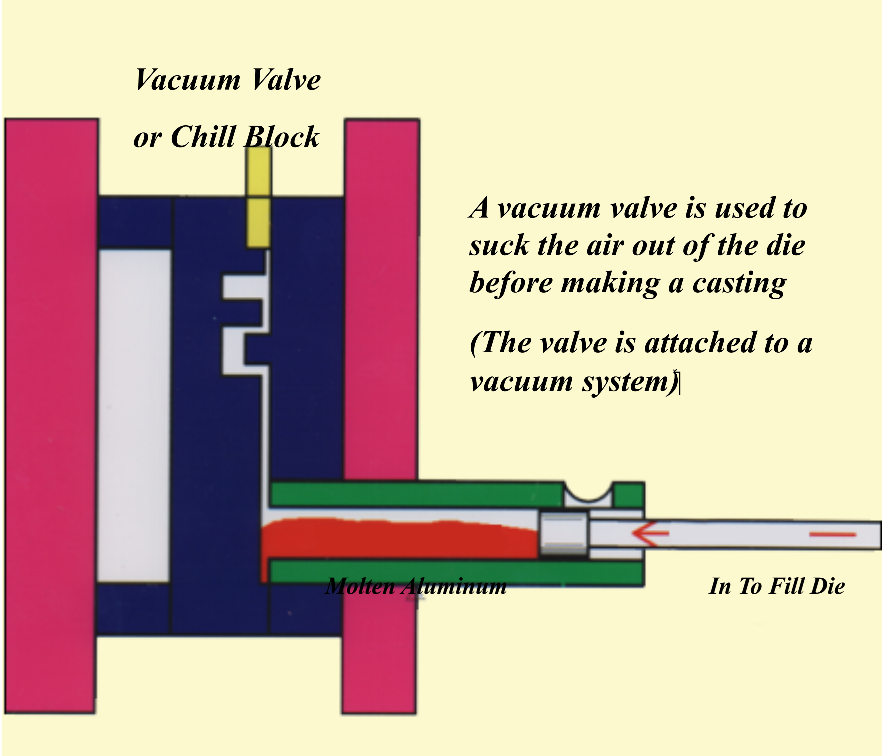
Various Gases Generated from Different Lubricants

Shot tip with ring to seal cold chamber



Key to Success: Vacuum

Why vacuum diecasting:



- Vacuum levels in the die cavity 20-300 millibar.
- Reduced cavity gases from the shot sleeve and die.
- Reduced porosity levels
- Reduced scrap
- Reduced wall-thickness
- Reduction of rejected shots
- Reduced scrap after welding or heat treatment
- Ability to produce otherwise unsuitable parts in aluminium die casting

Key to Success: Vacuum

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High vacuum die casting processes should be capable of:

- *Achieving high levels of vacuum (typically < 50 mbar) in the cavity and shot sleeve (ideally 2 stage vacuum) prior to injection and keep them during the shot*
- *Monitoring and control the vacuum level during the casting process*
- *Main differences in equipment/processes are in:*
  - *Vacuum valve type*
  - *Vacuum control system*
  - *Vacuum monitoring approach*

Key to Success: Vacuum

Visi-Trak®
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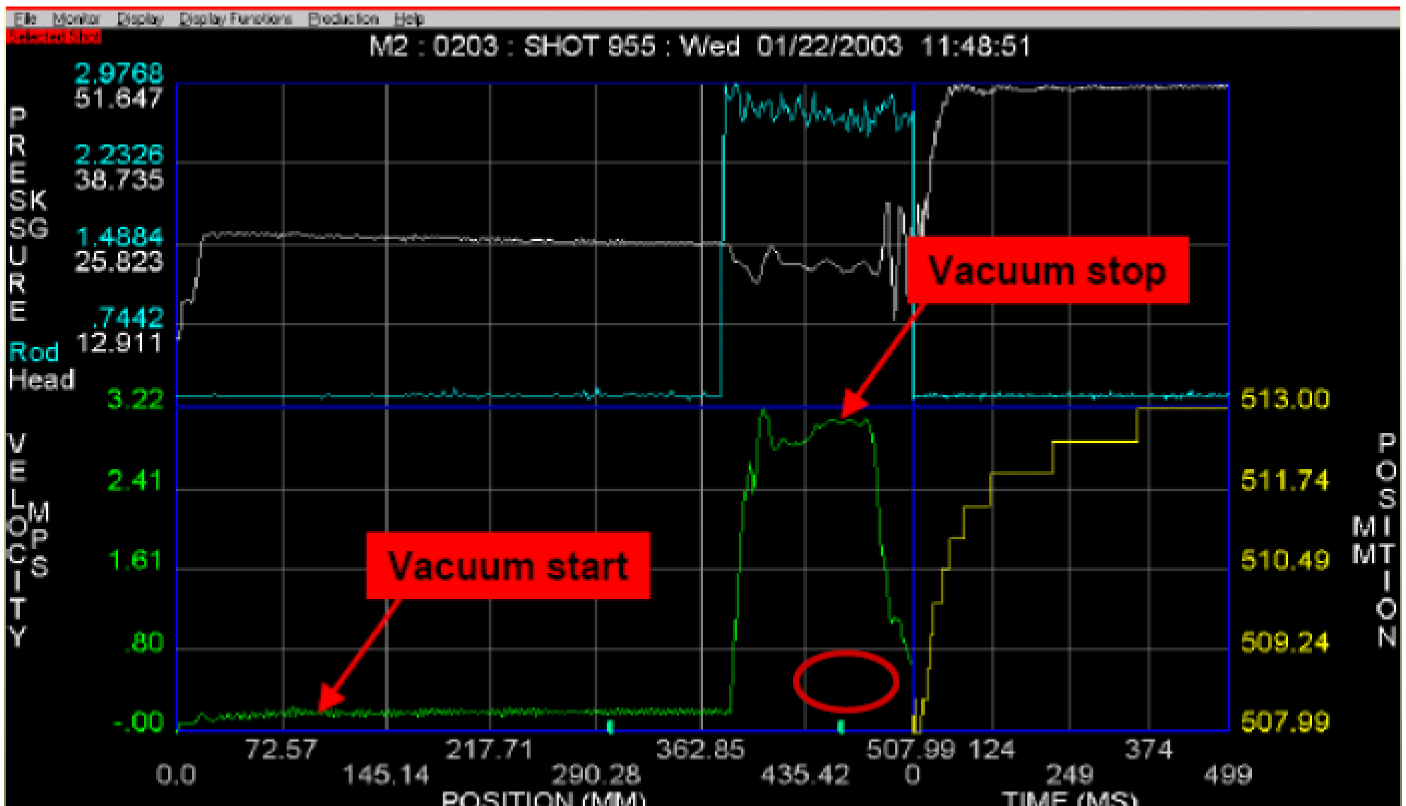
Advanced monitoring techniques used to insure proper vacuum level during the casting process, proper vacuum response & vacuum evacuation time and to detect vacuum leaks, vacuum blockages as well as excessive moisture



Key to Success: Vacuum

Mechanical Valves

Pros

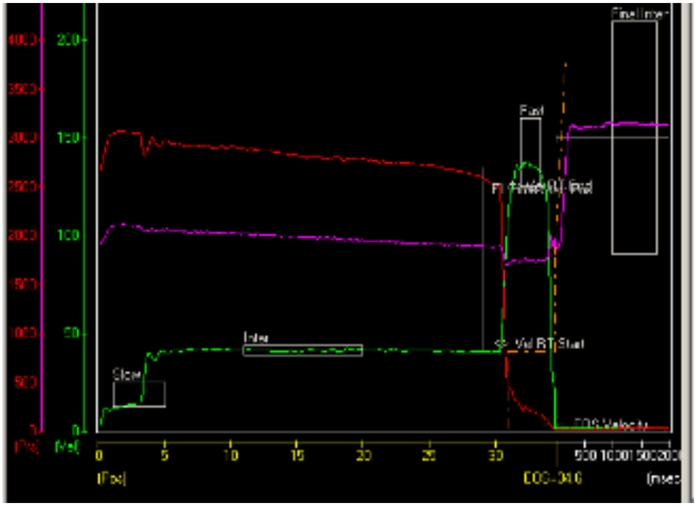
- Vacuum pulled through entire shot
- Does not require expensive controller
- Easy to remove and clean
- Biscuit size variation is not an issue

Cons

- *Smaller valve cross sectional area – less vacuum*
- *Potential for metal to fill evacuation line if metal does not completely fi''*
- *Valves are expensive*

Suppliers

- *Castool*
- *Provac/VDS*
- *Fondarex*
- *…*



Key to Success: Vacuum

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Hydraulic/ Pneumatic vacuum valves

Pros

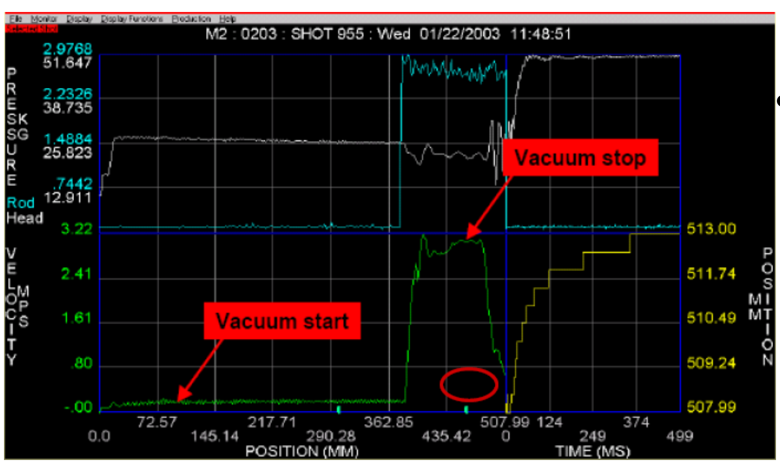
- Allows for larger valve (cross sectional area up to 400 square mm)
- Does not rely on metal to close valve (no issues with startup)
- Usually less down time (no metal shot into valve)

Cons

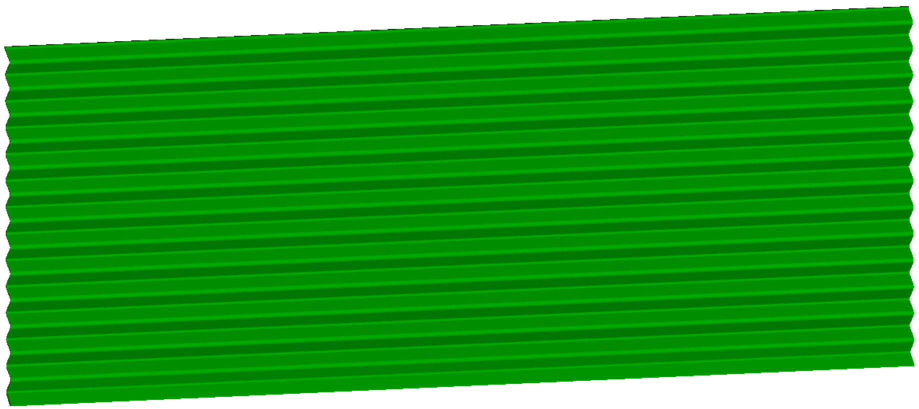
- *Requires better control system*
- *drawing vacuum through entire shot is more difficult*
- *Does not account for biscuit variation (requires very stable process)*
- *Requires hydraulic cylinders within tool*

Suppliers

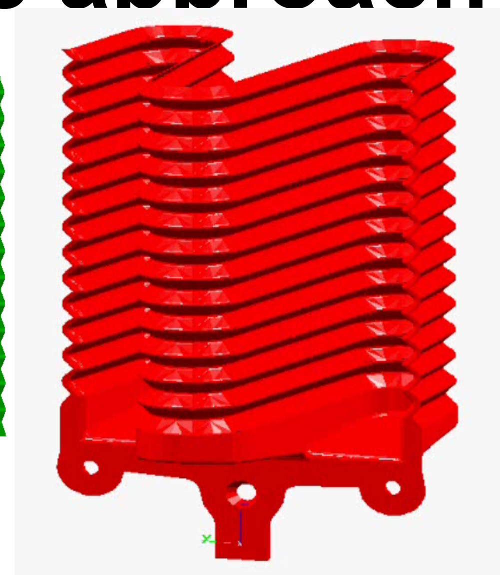
- *MFT*
- *Buhler/ Prince*
- *…*



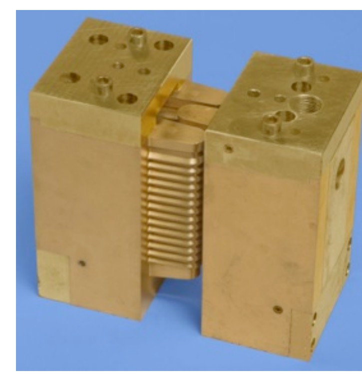
New chill vent/valve approach CASTvac



Chill face: 100mm x 100mm requires 80tonne locking force;
Increased by 4 times: 400mmx100mm requires 320tonne locking force



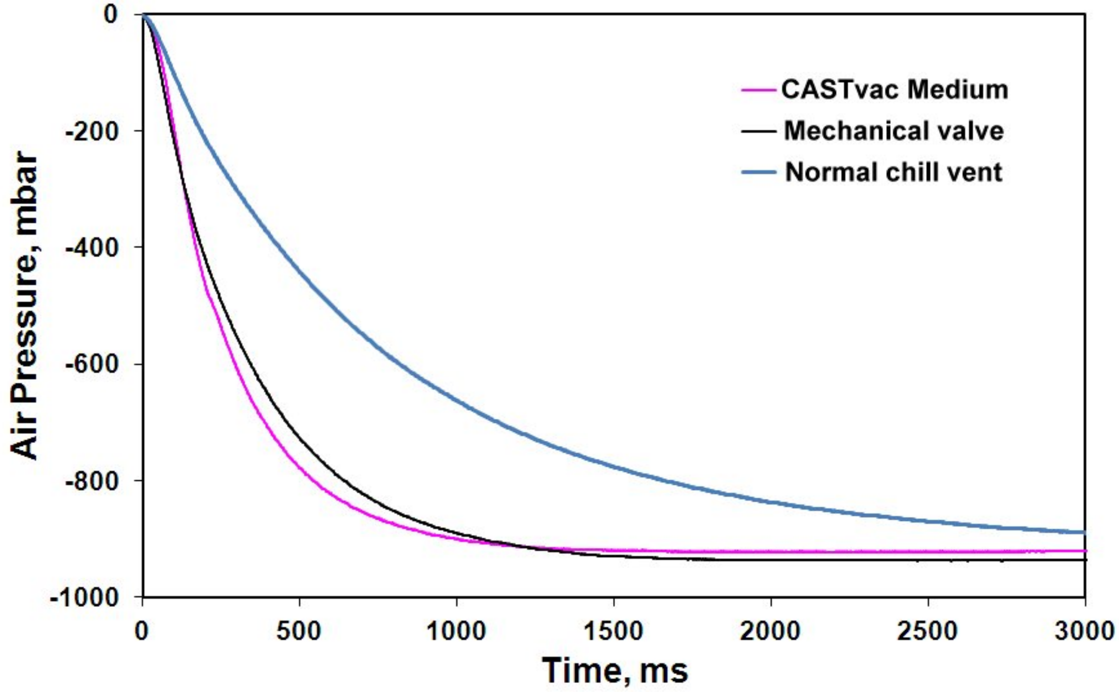
3D (CASTvac)
4 times of chill face but only 80tonne force

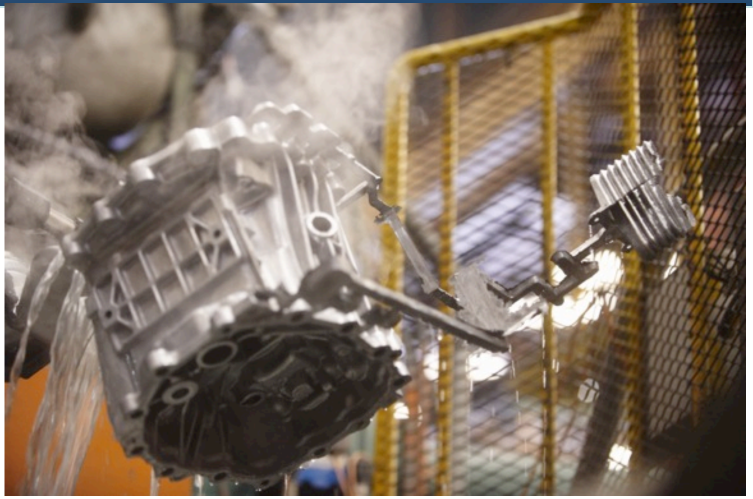


In production in Nissan Australia for 6 years

Key to Success: Vacuum

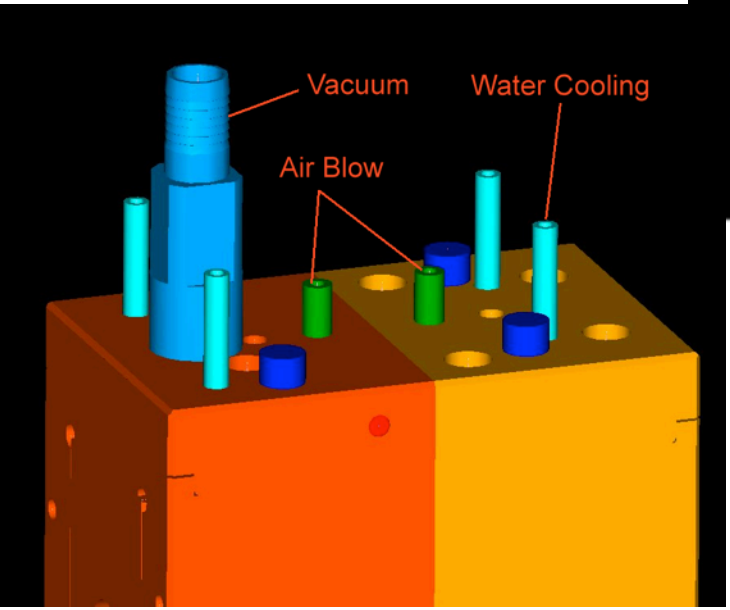
Efficiency comparison with bench test

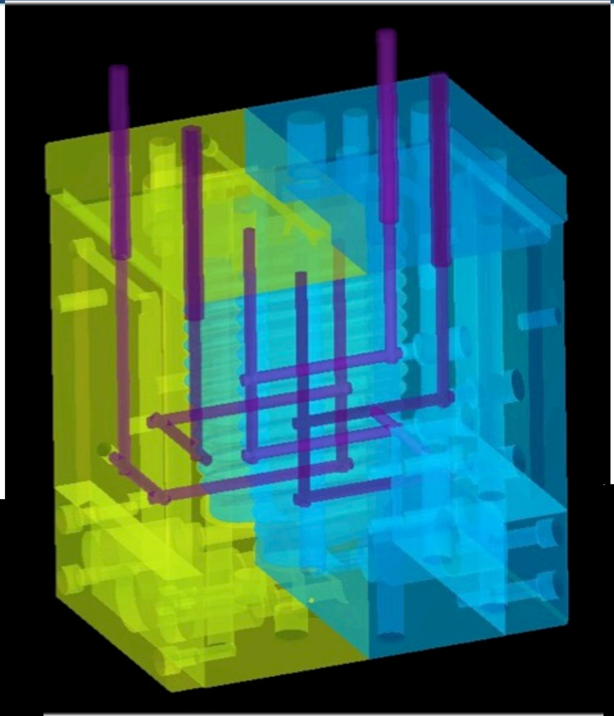




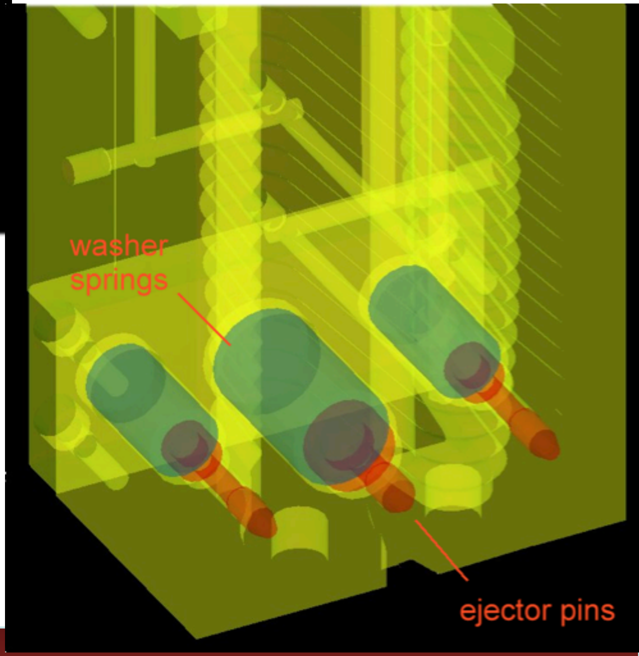
Key to Success: Vacuum

- *Internal water cooling.*
- *Built-in air blow to self-clean the washboard.*



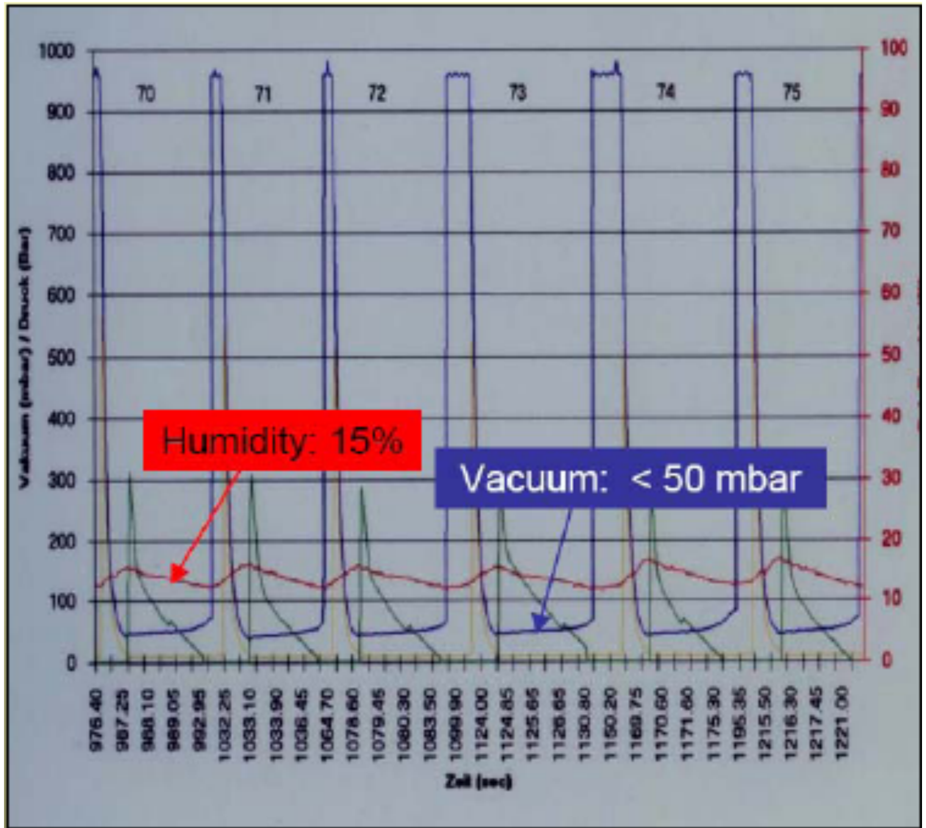


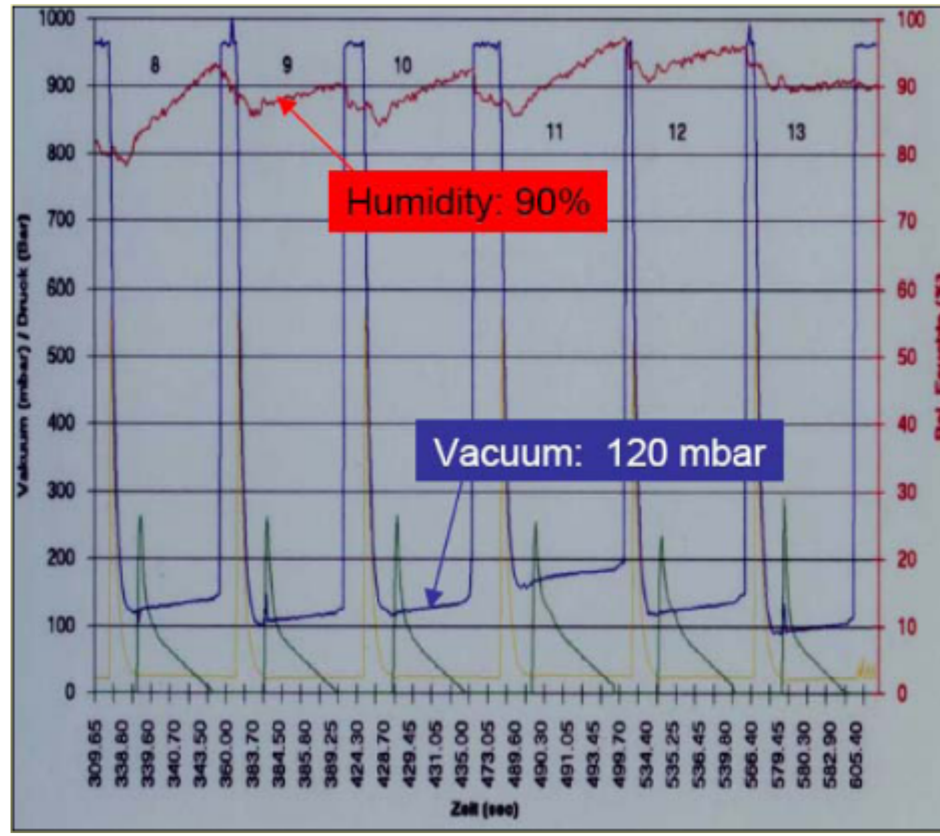
Built-in spring-loaded ejector pin to enhance the metal ejection; Additional ejection is not required.



Key to Success: Vacuum

Vacuum and moisture are not compatible!





Key to Success: Traceability

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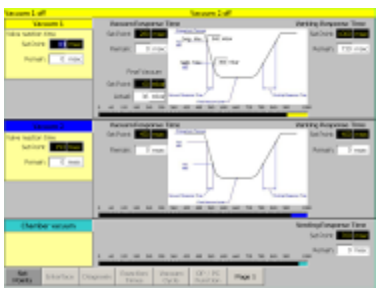
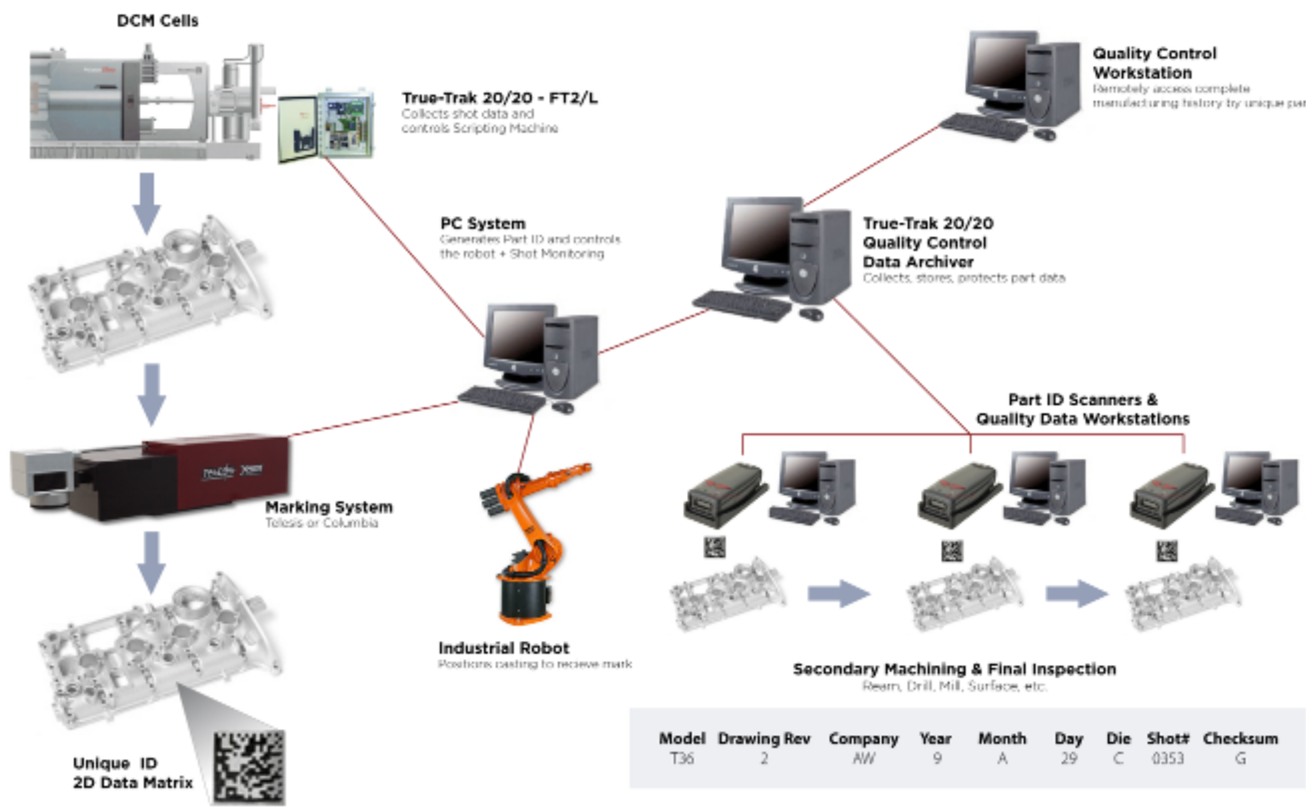
- Proper identification of each part for customer and quality improvement
- Collect, store, archive, recall and download all process information





Key to Success: Traceability

Network Data Archiver:

- Automatically **collect and archive valuable shot data** for each part (automatic back-up, compress data, store in database)
- **Uniquely identify each part** you produce.
- Capture and **link important secondary process (heat treatment, machining, etc.) and test data**.
- Analyze your data to
  - **Determine cause of variation**
  - **inform your customers and improve quality**.
- **Archive your information** for future access.

Key to Success: Traceability

Visi-Trak®
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Plant wide Building Blocks

Visi-Trak®
SENSE, MONITOR, CONTROL

Plant Mngmt. Solutions	Remote Machine Monitoring
	Quality Control Data Archiving
Advanced DCM Control	Part Scribing & Traceability
	PLC HMI – Visualization, Diagnostic, and Set-up Software
Shot Control	Shot Velocity and Pressure Control Software
	Precision Shot Control Package
	High Performance Valves
Process Monitoring	Data Visualization, Diagnostic, and Shot Monitoring Software
High Speed Data Acquisition	High Speed Data Acquisition System
	Precision Sensor Package

Outline

- Aluminum content in automotive - The opportunity for diecasters
- Requirements of High Integrity Aluminum HPDC
- Success factors for high integrity HPDC
  with technological solutions & case studies
- **Alloys and tempers for structural diecastings**
- Products and services for you
- Summary and Q & A

Visi-Trak®
SENSE, MONITOR, CONTROL

Alloys for high integrity diecastings

Low Fe (<0.25%), Mn to beat die soldering; low Cu; Sr addition

Al-Si alloy family: Al + 4-12%Si +0-0.6%Mg, Mn, Fe

- Silafont®-36 (365), Aural®-2/-3 (A365) and -5S, Mercalloy® (362, 367, 368), Castasil®-37, W3, etc.
- Excellent castability, heat treatable, most commonly used and wide variety of alloys commercially available

Al-Mg-Si family: Al + 2-5.5%Mg + 1.5-3%Si

- Magsimal®-59, C446, Aural®-11, Calypso 53 & 54SM, etc.
- Excellent properties as cast and in T5 temper
- Difficult to cast, properties extremely wall thickness dependent, require Be, hot tear and SCC susceptible

Alloys for high integrity diecastings

The key role of each element:

Si ⇒ higher silicon content alloy promotes fluidity & castability

Mg ⇒ imparts strength

Fe ⇒ helps reduce solder but impacts negatively ductility

Mn ⇒ higher manganese content helps minimize solder and corrects Fe phase

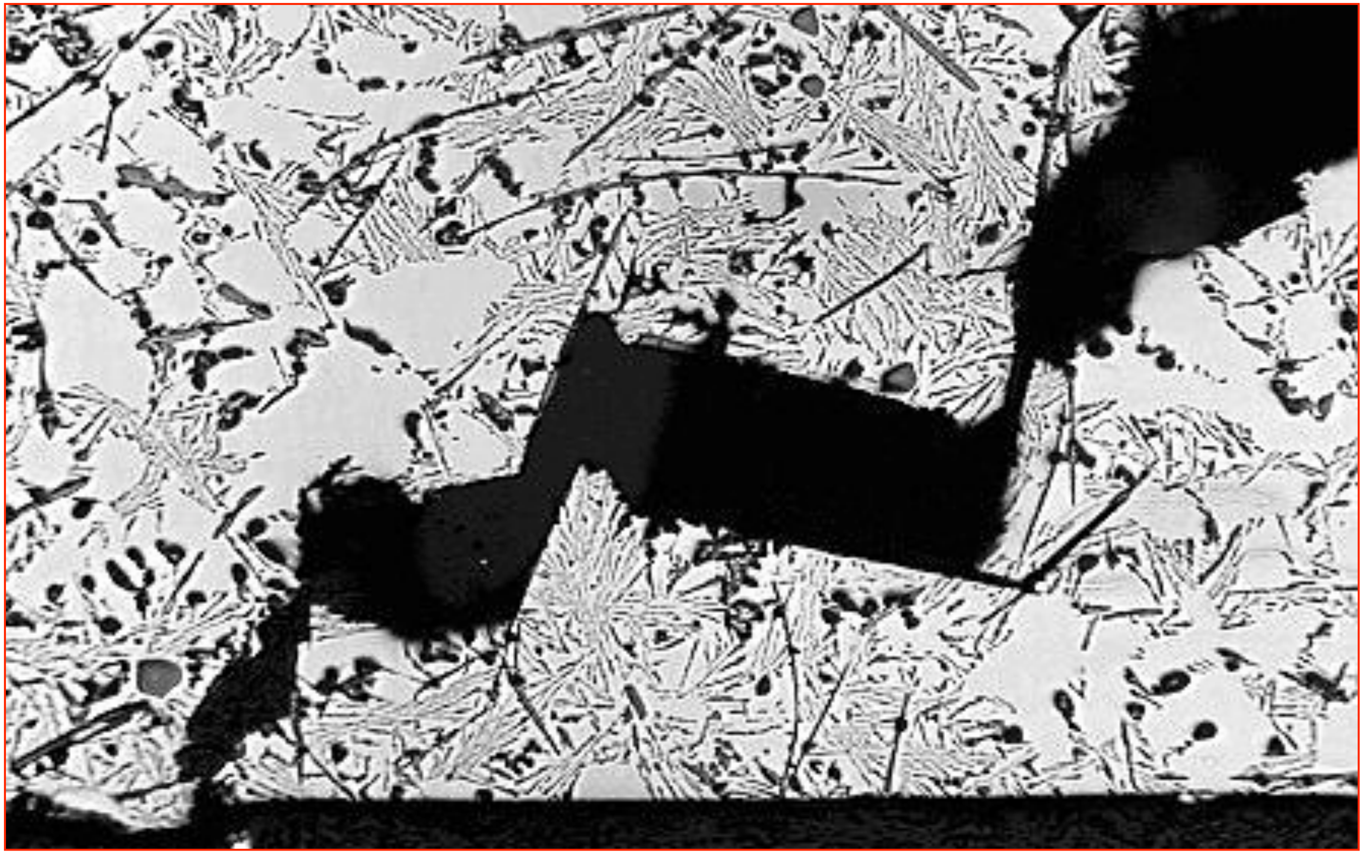
Ti ⇒ used as a grain refiner

Cu ⇒ lower copper content of the alloy imparts higher corrosion resistance (usually strengthening element)

Sr ⇒ helps modify the eutectic silicon, thereby improving ductility of the alloy – also helps beat die soldering

Alloys for high vacuum high integrity HPDC

Very high Fe:
An extreme example



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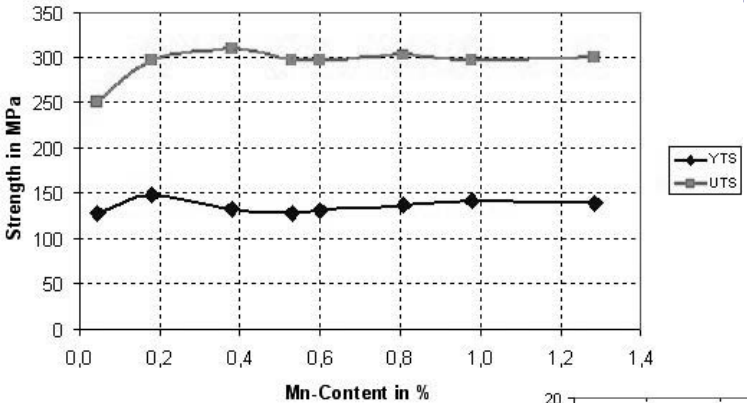
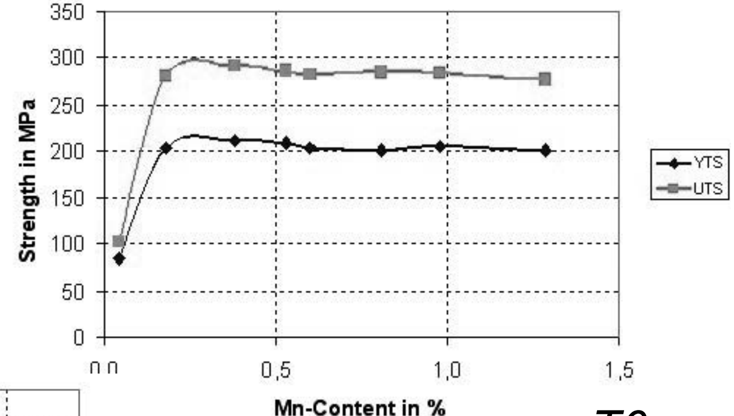
Alloys for high integrity diecastings

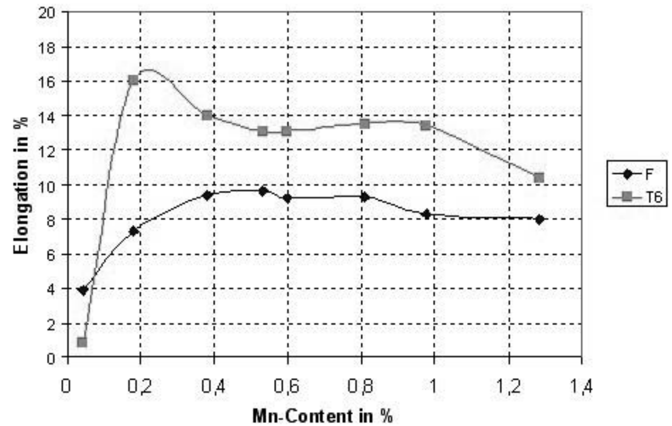
The influence of Mn (replacing Fe) mechanical properties (example of Silafont® 36)



F temper

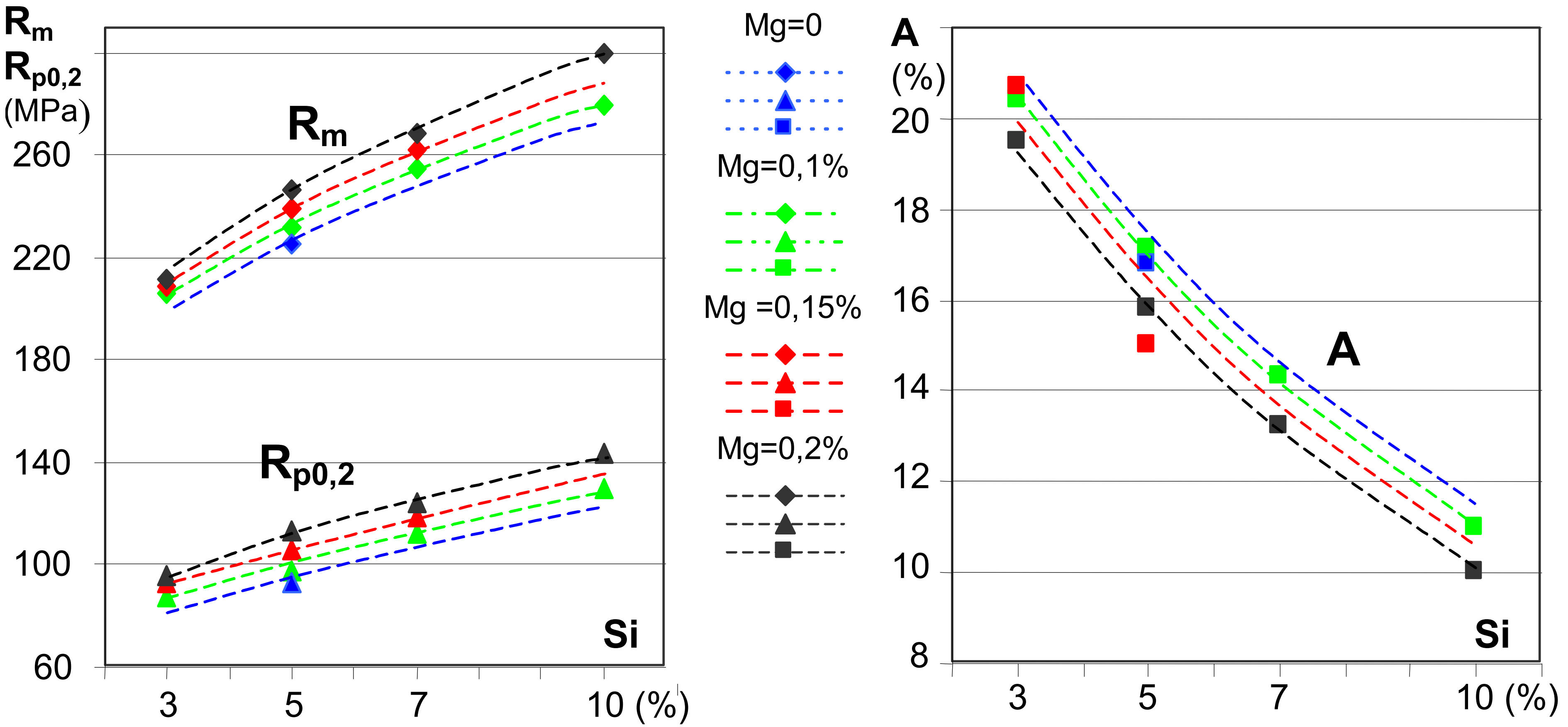


T6



Alloys for high integrity diecastings

The influence of Si and Mg on mechanical properties in the F temper



Mercalloy 362

Alloy 362.0											
Alloy 362.0–Chemical Composition Limits											
Si	Fe	Cu	**Mn**	**Mg**	Cr	Ni	Zn	Ti	**Sr**	Other Elements Each	Other Elements Total
10.5-11.5	0.25	0.20	**0.25-0.35**	**0.50-0.7**	--	0.10	0.10	0.20	**0.05-0.07**	0.05	0.15

Typical Mechanical Properties at 0.60% Mg*

Casting Process and Temper	Aging Time and Temperature	Tension: Ultimate Strength ksi (MPa)	Tension: Yield Strength ksi (MPa)	Tension: Elongation (%)	Endurance Limit Ksi (Mpa)
Die Cast 362.0--F	as cast	38-40 (260-275)	18-20 (125-140)	9-11	21 (145)
Die Cast 362.0--T6	6 hr at 320 F	43-46 (295-315)	33-36 (230-250)	14-16	20 (140)

* These properties are for separately cast tensile specimens

Alloys for high vacuum high integrity HPDC

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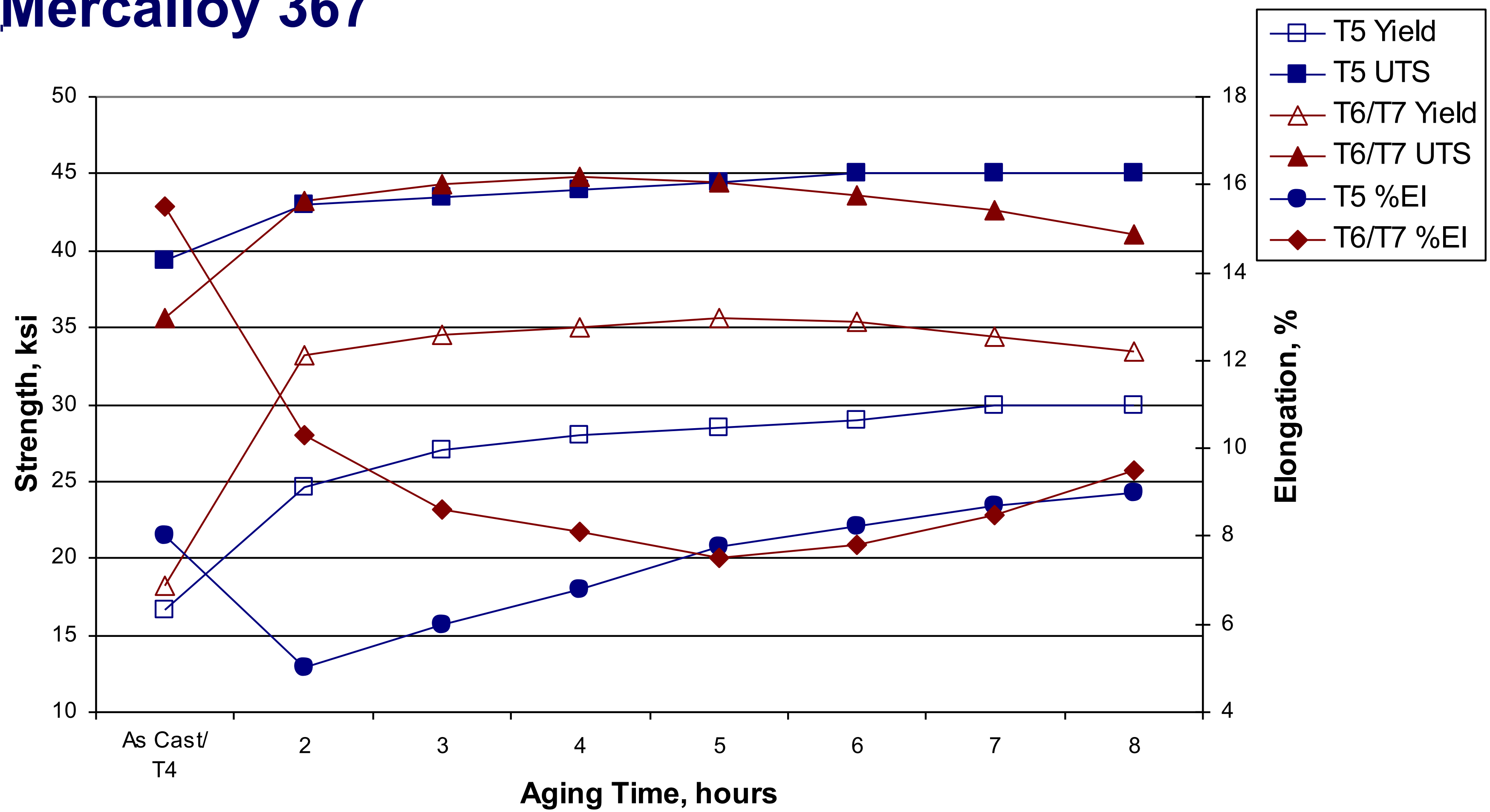
Mercalloy 367

Alloy 367.0											
Alloy 367.0–Chemical Composition Limits											
Si	Fe	Cu	**Mn**	**Mg**	Cr	Ni	Zn	Ti	**Sr**	Other Elements	
										Each	Total
8.5-9.5	0.25	0.25	**0.25-0.35**	**0.30-0.50**	--	--	0.10	0.20	**0.05-0.07**	0.05	0.15

Typical Tensile Properties at 0.40% Mg				
Casting Process and Temper	**Aging Time and Temperature**	**Ultimate Strength ksi (MPa)**	**Yield Strength ksi (MPa)**	**Elongation (%)**
Die Cast 367.0—F	as cast	39.3 (270)	16.6 (115)	8.1
Die Cast 367.0—T5	2 hour at 170C	42.8 (295)	24.5 (170)	5.0
Die Cast 367.0—T5	4 hour at 170C	43.9 (300)	27.8 (190)	6.7
Die Cast 367.0—T5	6 hour at 170C	45 (310)	29 (200)	8.2
Die Cast 367.0—T5	8 hour at 170C	45 (310)	30 (205)	9.0
Die Cast 367.0—T4	3 hr at 490C + water quench	35.6 (245)	21.6 (150)	15
Die Cast 367.0—T6	2 hour at 170C	43 (295)	33.2 (230)	10.3
Die Cast 367.0—T6	4 hour at 170C	45 (310)	35 (240)	8
Die Cast 367.0—T6	6 hour at 170C	43.4 (300)	35.3 (245)	7.8
Die Cast 367.0—T6	8 hour at 170C	41.4 (285)	33.4 (230)	9.5

Alloys for high vacuum high integrity HPDC

Mercalloy 367



Alloys for high vacuum high integrity HPDC

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SENSE, MONITOR, CONTROL

Mercalloy 368

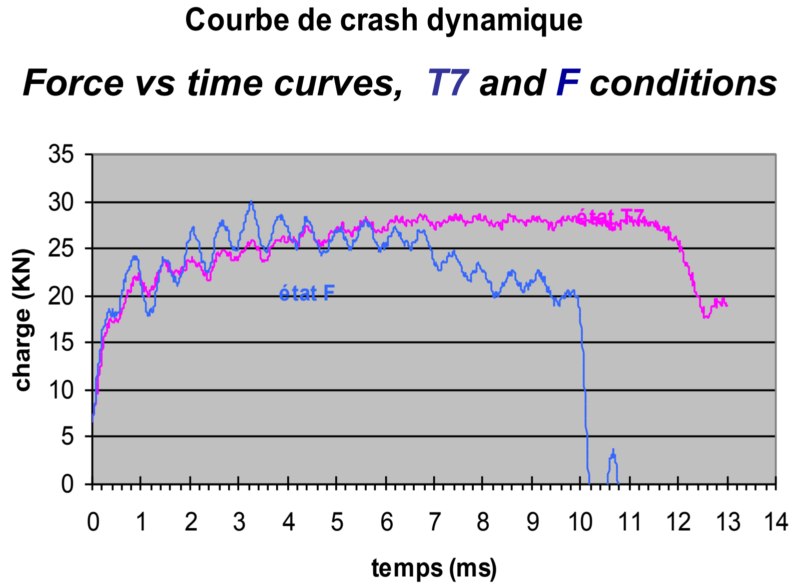
Alloy 368.0											
Alloy 368.0–Chemical Composition Limits											
Si	Fe	Cu	**Mn**	**Mg**	Cr	Ni	Zn	Ti	**Sr**	Other Elements	
										Each	Total
8.5-9.5	0.25	0.25	**0.25-0.35**	**0.10-0.30**	--	--	0.10	0.20	**0.05-0.07**	0.05	0.15

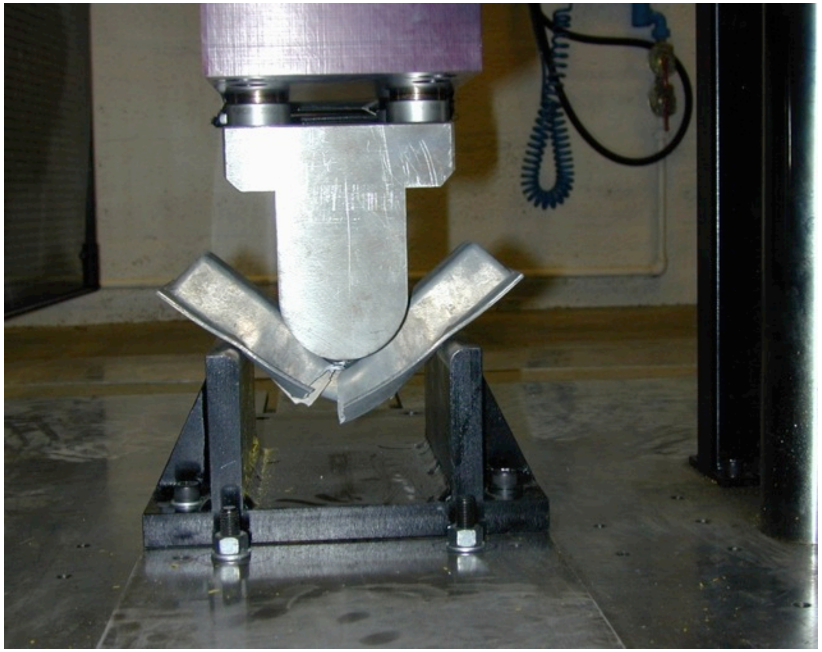
Typical Mechanical Properties at 0.20% Mg*					
Casting Process and Temper	**Aging Time and Temperature**	**Tension**			**Endurance Limit Ksi (Mpa)**
		Ultimate Strength ksi (MPa)	**Yield Strength ksi (MPa)**	**Elongation (%)**	
Die Cast 368.0--F	as cast	38-40 (260-275)	18-20 (125-140)	10-12	21 (145)
Die Cast 368.0--T6	6 hr at 320 F	41-43 (280-295)	27-29 (185-200)	14-16	20 (140)

* These properties are for separately cast tensile specimens

Alloys for high integrity diecastings

Example: CALYPSO 61D (Al Si10MgMnFe) :
Difference between crash behaviors in T7 and F





Condition	*YS*	*UTS*	*Elongation %*
F	*120 ~ 140*	*270 ~ 290*	*10 ~ 12*
T7	*155 ~ 165*	*215 ~ 225*	*14 ~ 18*

Alloys for high integrity diecastings

Example: CALYPSO 61D (Al Si10MgMnFe) :
Difference between crash behaviors in T7 and F

T 7

F

Alloys for high vacuum high integrity HPDC

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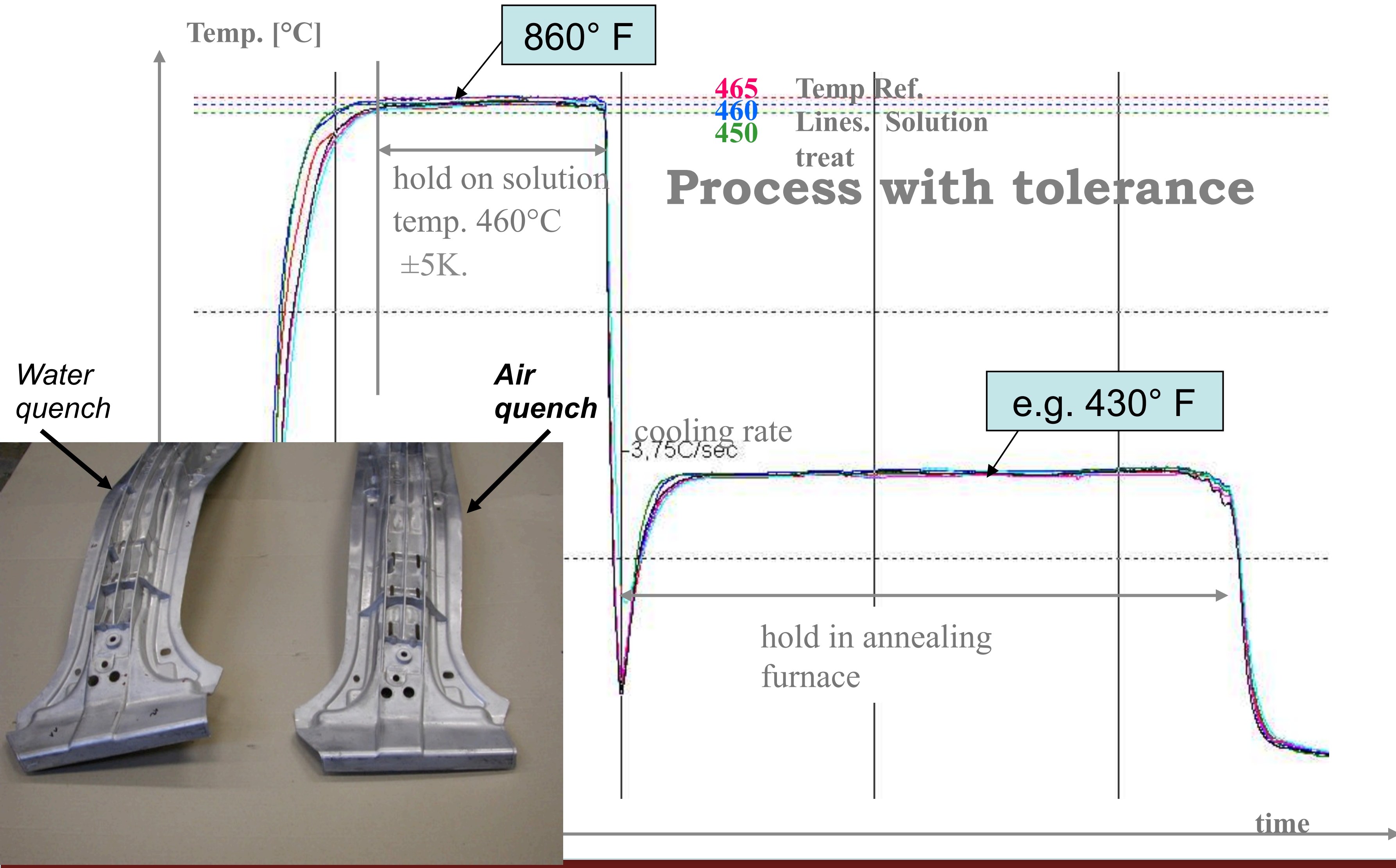

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- Summary and Q & A

Products offered

- Per Die-casting Machine
  - Process Monitoring
  - Process Control
  - Thermal monitoring of die
  - Metal Treatment Specifications
  - Alloy and Heat Treatment specification
  - Production Start-up Support
  - Additional Support on Demand

Services offered

- Alloy and process selection, optimization and sourcing
    - Chemical composition of alloy (specification)
    - Guidelines for melting, melt treatment, melt transfer, etc.
    - Diecasting process improvement/optimization
- Casting simulation and optimization
- Heat Treatment for minimized distortion
- Guidelines (Temperatures, Times, quenching, etc.)
- Engineering Support

  - DCM-Set-up, HT-Process, Melting,…

  - Project Management
- Training for engineers, operators, managers, ...

Outline

- Aluminum content in automotive - The opportunity for diecasters
- Requirements of High Integrity Aluminum HPDC
- Success factors for high integrity HPDC with technological solutions & case studies
- Alloys and tempers for structural diecastings
- Products and services for you
- **Summary and Q & A**

Summary

- Traditional diecasting processes had difficulty in achieving high integrity (low porosity) castings and were therefore unusable for structural applications
- Traditional diecasting has relied upon high levels of Fe in Al to reduce die soldering. As known, Fe also destroys mechanical properties (especially elongation)
- New diecasting processes applying process control, vacuum, proper die design, etc. and new alloys allow production of castings with high quality / mechanical properties (heat treatable, weldable, crash worthy, etc.)
- The inherent advantages of diecasting (high freezing rate, thin walls, high precision, etc.) can now be used to produce high quality structural castings at competitive costs

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Thank You