A Design Study in Aluminum Casting

Aluminum Cylinder Block for General Motors Truck/SUV Engines

Chevy Trailblazer

Design Study Outline

Start the Design Study ! Next

Acknowledgment --

The metalcasting design studies are a joint effort of the American Foundry Society and the Steel Founders' Society of America.

Project funding was provided by the American Metalcasting Consortium Project, which is sponsored by the Defense Logistics Agency, Attn: DLSC-T, Ft. Belvoir, VA, 22060-6221

Return to AFS Home Page

Address comments to: jss@afsinc.org

Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Engines for GM SUVs and Trucks

The Application -- In 2002 General Motors introduced a new family of Sport Utility Vehicles (Chevy Trailblazer, Buick Rainier and GMC Envoy). In 2004 a family of mid-sized trucks (Chevy Colorado and GMC Canyon) was introduced.

- **With the higher vehicle weight and additional load capability, the engineering challenge was to upgrade the powertrain with improvements in power, torque, fuel economy, emissions, and NVH (noise, vibration, harshness) performance, while keeping the vehicle cost affordable and the weight down.**
- **A comprehensive engineering study was done to select the best engine configuration, considering V-8, V-6, and Inline 6 designs. The study determined that the Inline design had the following advantages -- simplest design, lowest number of parts, inherently balanced, lowest cost, and best manufacturing flexibility.**
- **The Inline 6 was designed to have the power and torque of a V-8. The inline 5 was designed to match the performance of a V-6. Both engines provide improved fuel economy without sacrificing performance**

Inline 5 Cylinder 3.5 liter Engine

GMC Canyon

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Engine Design

The inline design is applicable to 6, 5, and 4 cylinder *(4.2, 3.5 and 2.8 Liter displacement)* engine configurations.

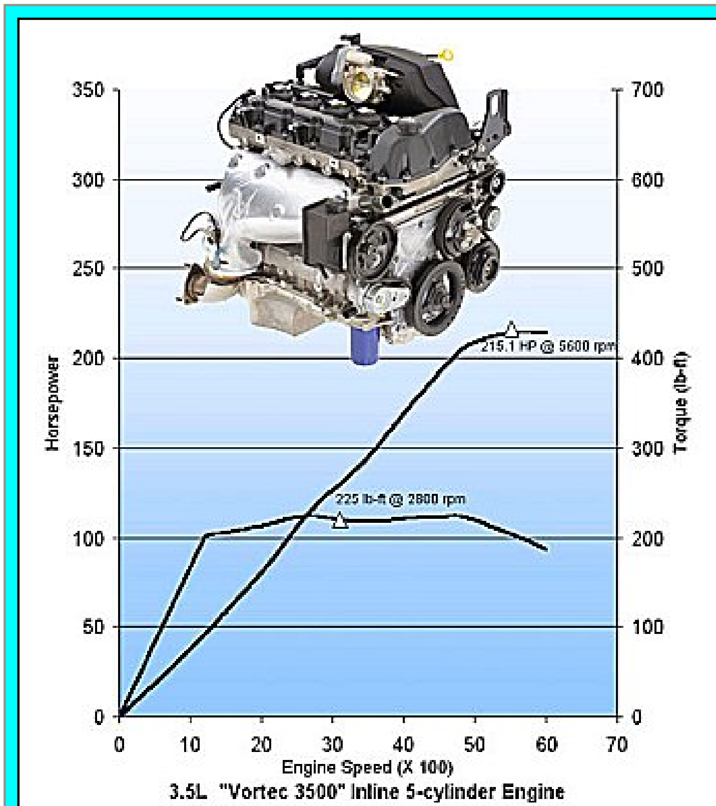
- **The SUVs come equipped with the six cylinder version and the mid-size trucks are equipped with the four or five cylinder versions of the engine family.**
- **All three inline engines use the Vortec cylinder design and have a 93mm bore x 102mm stroke with a double overhead cam using 4 valves per cylinder.**
- **The engines operate with a 10:1 compression ratio, but still use regular unleaded fuel (87 RON).**
- **The three inline engines have 75% part commonality.**

GM Vortec Inline Engine

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Engine Specifications



The performance specifications for the three engines are --

Cylinder Count & Displacement	6 Cylinder 4.2 Liter	5 Cylinder 3.5 Liter	4 Cylinder 2.8 Liter
Peak Horsepower	275 HP @ 6000 RPM	215 HP @ 5600 RPM	170 HP @ 5600 RPM
Peak Torque	275 FT-LB @ 3600 RPM	225 FT-LB @ 2800 RPM	175 FT-LB @ 2800 RPM
Base Engine Weight	184kg	178 kg	150 kg

The newly designed inline engines are significantly lower in weight than previous truck engines with the same performance specifications.

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Aluminum Castings for the Engine

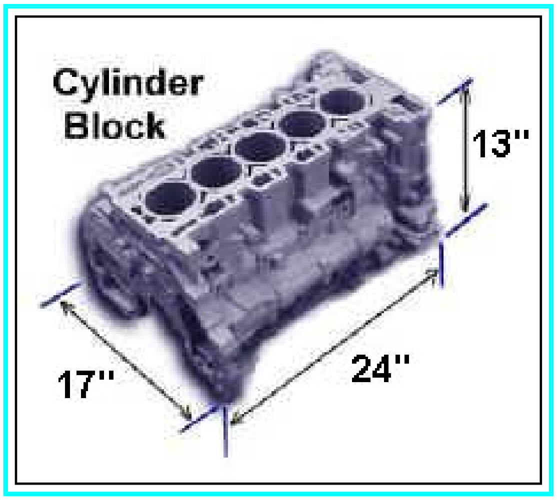
One of the key weight saving features in the engine design is the use of a cast aluminum cylinder block with cast iron cylinder liners.

- **The cast iron liners (with ground outside-diameter) are press-fit into the precision bored aluminum cylinder block. This provides optimal heat transfer into the cylinder block.**
  - **The iron liners provide the wear resistance needed for improved durability.**
- **The installation process for the liners includes chilling the liner prior to placement and sophisticated precision force monitoring to ensure proper installation.**
- **After installation, the ID of the iron liner is bored to a mass-saving 1.5 millimeter wall thickness.**

In cooperation with
GM Powertrain Casting Development

Cylinder Block Description

As an example, the cylinder block for the inline 5 cylinder engine is 24" x 17" x 13" *(61 cm x 43 cm x 33 cm)* **in block dimensions and has a cast weight of 86 pounds.**



- **The cylinder block casting incorporates many unique cast-in internal features which reduce machining costs, including: high pressure oil passages, oil drain-backs, the crankcase air passages, and coolant jackets and channels.**
- **On the exterior of the block there are numerous ribs, pads, channels, and holes for strengthening, weight reduction, and accessory attachment.**

Back Next

Return to AFS Home Page

Page 1

In cooperation with
GM Powertrain Casting Development

Cylinder Block Performance

The cylinder block has to withstand high cycle fatigue stresses, thermal strains, and aggressive wear conditions over the full life of the engine.

The typical performance requirements for the cylinder block cast in lost foam with aluminum are --

- **Ultimate Tensile Strength = 35 ksi / 245 MPa**
- **Yield Stress = 31 ksi / 215 MPa**
- **Elongation = 1.6%**
- **Brinell Hardness = 80 BHN**
- **Fatigue Strength (10^8 cycles) = 8.5 ksi / 60 MPa**
- **Pressure tightness = Excellent**
- **Machinability = Good**

Power Train with Engine and Transmission

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Lost Foam Casting

All of the aluminum blocks and heads in this family of engines are produced by using the "lost foam casting" process

The lost foam casting process uses a expanded polystyrene replica of the part being cast.

- **The coated replica/pattern is placed in a flask and loose sand is placed around the pattern and shaken into its voids.**
- **Molten aluminum is then poured through a foam sprue, or funnel, into the sand where the hot metal melts and displaces the foam of the pattern.**
- **The metal cools in the shape of the part.**

Unlike conventional sand casting, the lost foam process allows more complex and detailed passages and other features to be cast directly into the part. The lost foam process:

- *Forms complex internal passages and features without cores.*
- *Reduces part mass with near net shape capability.*
- *Eliminates parting lines.*
- *Reduces machining operations and costs.*
- *Provides for tight tolerances in critical areas and features.*

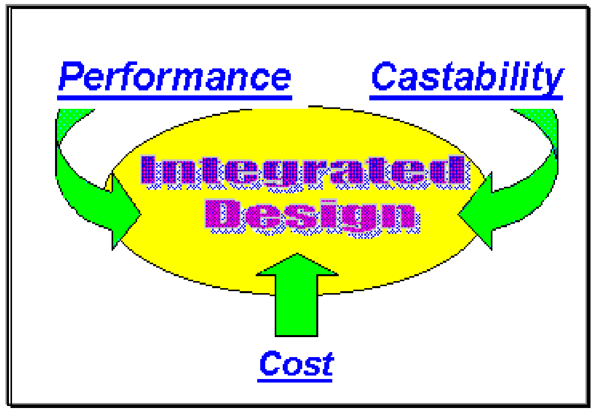
Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

The Casting Design Issues

The casting design engineers at the GM Powertrain had three imperatives for an integrated casting design.

- ***Design for Performance***
- ***Design for Castability***
- ***Design for Cost***



Critical Casting Design Issues --The requirements for performance, castability, and cost are closely interconnected. Four casting design issues played a major role in meeting the three design imperatives --

- **Select the *aluminum alloy* that meets the strength and fatigue strength requirements.**
- **Design the *casting and the pattern* to insure part quality and control costs.**
- **Control the *pattern production process* to produce accurate and uniform patterns.**
- **Manage the *metal pouring* to optimize metal flow and avoid casting flaws.**

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Aluminum Alloy Selection

Aluminum is the metal of choice for weight savings in the cylinder block, but the performance requirements and manufacturability issues will drive the choice of a specific aluminum alloy.

- **There are a range of different alloys that are commonly used for aluminum castings.**
- **The engine designer has to select the aluminum alloy that offers the best combination of mechanical properties, castability, and machinability.**

Aluminum being poured into the mold

Here are three aluminum alloys which can be considered for this application --

242 aluminum alloy with a T77 heat treat	*319 aluminum alloy with a T5 heat treat*	*A356 aluminum alloy with a T6 heat treat*

NOTE -- While published alloy properties may state levels of mechanical performance, actual performance can vary due to section size, porosity and gating design in the casting.

-- Thick section sizes (vs. thin section sizes) cool slower generating somewhat lower properties.

-- Porosity is a function of hydrogen content, oxides and metal composition. Higher porosity levels give lower properties.

-- The gating needs to optimize directional solidification and maintain head pressure through the solidification of the metal.

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Aluminum Alloy Selection

Which aluminum alloy (242-T77, 319-T5, A356-T6) would you choose for the cylinder block based on performance and manufacturability requirements and the nominal alloy properties listed below?

Alloy	Requirement	Choose 242 - T77	Choose 319-T5	Choose A356-T6
Performance				
Ultimate Tensile Strength	35 ksi / 245 MPa	30 ksi /205 MPa	30 ksi /205 MPa	40 ksi/ 280 MPa
Tensile Yield Strength	31 ksi / 215 MPa	23 ksi / 157 MPa	26ksi / 178 MPa	31 ksi / 215 MPa
Ductility (% Elongation)	1.6%	2%	1.5%	6%
Brinell Hardness (BHN)	80	75	80	80
Fatigue Strength 10^8 cycles	8.5 ksi / 60 MPa	10.5 ksi /74 MPa	11 ksi / 77 MPa	8.5 ksi / 60 MPa
Pressure Tightness (1= Excellent, 5= Poor)	1	3	2	1
Manufacturability				
Castability/Fluidity (1= Excellent, 5= Poor)	1	3	2	1
Machinability (1= Excellent, 5= Poor)	3	2	3	3

Back

Choose an alloy!

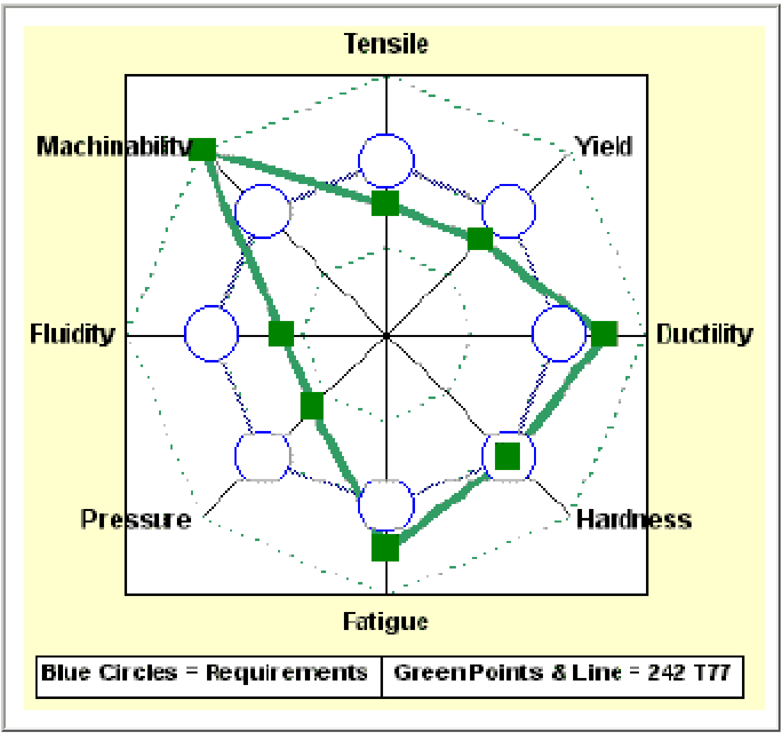
Return to AFS Home Page

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

Page 1

In cooperation with
GM Powertrain Casting Development

Aluminum Alloy 242 T77



- **Alloy 242 is a 4Cu-2Ni-2.5 Mg alloy. The T77 heat treatment is an solution- annealed alloy with a 650F aging.**
- **Alloy 242 is used extensively for applications where strength and hardness at high temperatures are required.**
- **Typical applications include: heavy-duty pistons motorcycle, diesel and aircraft pistons; and aircraft generator housings.**
- **Not suitable for complex, heavy section parts (blocks/heads) because of low fluidity and misruns.**

The Alloy 242 has good ductility, hardness, fatigue strength, and machinability, but the alloy fails to meet the requirements for tensile strength, yield strength, pressure tightness, and castability/fluidity.

Go back to the alloy table and select another aluminum alloy

Back

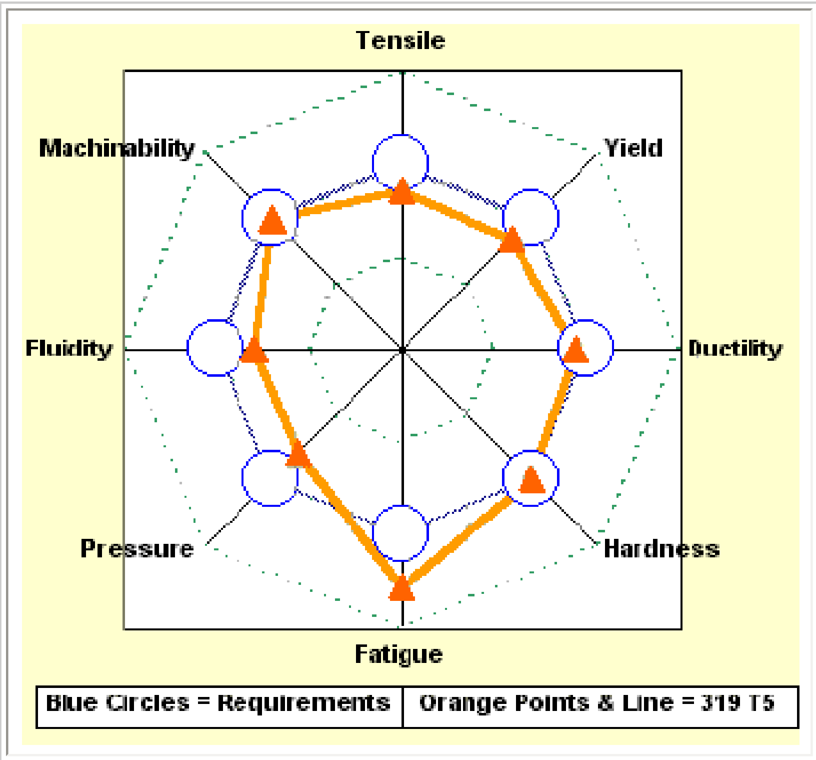
Return to AFS Home Page

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

Page 1

In cooperation with
GM Powertrain Casting Development

Aluminum Alloy 319 T5



- **Alloy 319 is a 6Si-3.5 Cu alloy with 1.0 Fe (max) and 1.0 Zn (max). The T5 heat treatment is a thermal aging at 310F .**
- **Alloy 319 has good casting characteristics and machinability.**
- **Typical applications for sand castings of 319 include internal combustion and diesel engine crankcases; gasoline and oil tanks; and oil pans.**

The Alloy 319 has good ductility, hardness, fatigue strength, and machinability, but the alloy fails to meet the requirements for tensile strength, yield strength, pressure tightness, and fluidity.

Go back to the alloy table and select another aluminum alloy

Back

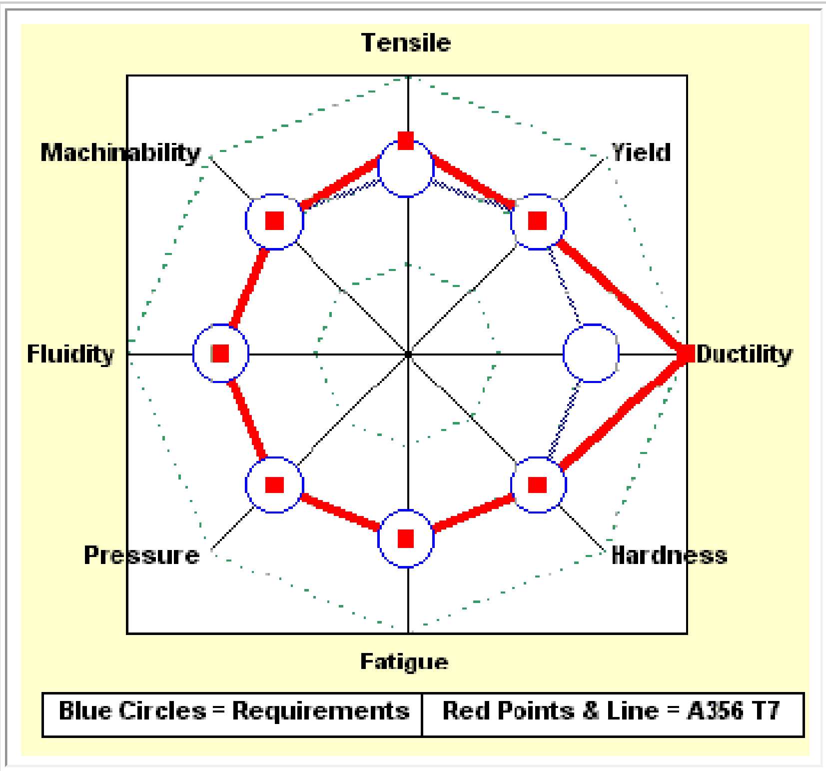
Return to AFS Home Page

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

Page 1

In cooperation with
GM Powertrain Casting Development

Aluminum Alloy A356 T6



- Alloy A356 is a 7Si-0.3 Mg alloy with 0.2 Fe (max) and 0.10 Zn (max). The T6 heat treatment is a solution-anneal heat treat followed by a 320F aging.
- Alloy A356 has greater elongation, higher strength and considerably higher ductility than Alloy 356.
  - A356 has improved mechanical properties because of lower iron content, compared to 356.
- Typical applications are airframe castings, machine parts, truck chassis parts, aircraft and missile components, and structural parts requiring high strength

The A356 alloy meets or exceeds all the requirements for mechanical strength, ductility, hardness, fatigue strength, pressure tightness, fluidity, and machinability.

The A356 alloy is the best choice. Go on to the next design decision.

Back Next

Return to AFS Home Page

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

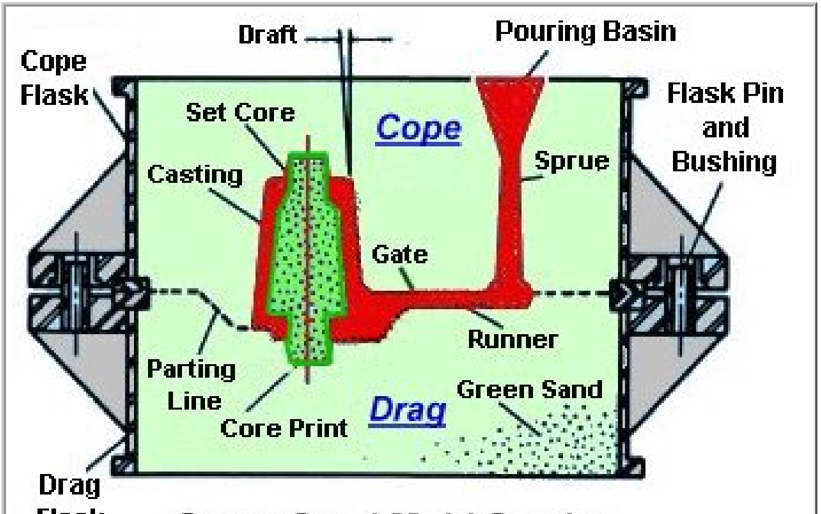
Page 1

In cooperation with
GM Powertrain Casting Development

Green Sand versus Lost Foam

The traditional method of casting cylinder blocks is green sand casting, where the mold cavity is formed in sand with a wood or metal pattern and multiple sand cores to form the internal passages.

A comparison of green sand casting to lost foam casting shows a number of distinct advantages for lost foam.



Green Sand Mold Section

Property	Green Sand Casting	Lost Foam Casting
Complex Internal Features and Part Consolidation.	Complexity determined by sand core limitations -- geometry, strength, and cost.	Extensive and complex internal features (as small as 0.20") available in lost foam, based on detail duplication and pattern assembly in foam.
Dimensional Tolerances	+/- 0.030" is typical depending on part size, complexity, and geometry	+/- 0.005"-0.010" is typical depending on part size, complexity, and geometry.
Surface Finish Capabilities	250-600 microinches typical. Depends on grain fineness of sand.	60-250 microinches typical. Depends on bead size and ceramic coating grain fineness.
Feature Accuracy	Core movement and shift between mold halves across the parting line limit feature accuracy.	No cores or mold halves to shift and degrade feature accuracy.
Parting Line and Draft Angles	Parting lines and draft angles are necessary for molding.	No parting lines in the mold and minimal draft on tools.
Environmental Costs	Sand recovery requires binder removal and time consuming sand clean-up	Sand is binder free, so it can be easily and rapidly recovered at low cost.
Tool Life	Wear on wood and metal tools from sand abrasion	Low wear and long life with aluminum tool

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Lost Foam Casting for Fine Features

The lost foam casting process allows more complex and detailed passages and other features to be cast directly into the cylinder block.

- **In the cylinder block, oil galleries, crank case ventilation channels, oil drain back passages, and coolant passages are cast into the block.**
- **These features would otherwise require drilling or external plumbing (with a potential for leaks).**

Lost Foam castings have tighter dimensional tolerances compared to sand castings, because variations caused by core shift and core variability are eliminated and there is much less tool wear over the production life.

The direct result is a significant reduction in machining costs and infrastructure investment and fewer opportunities for errors in machining and assembly.
Lost Foam Casting is a highly efficient and reliable process for producing complex castings for the new GM high performance engines.

Back Next

Return to AFS Home Page

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

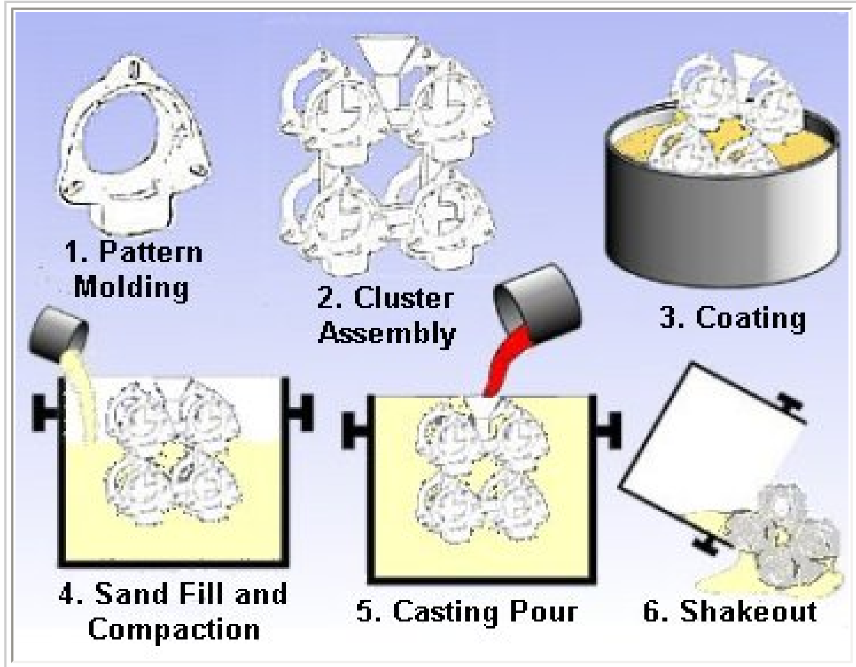
Page 1

In cooperation with
GM Powertrain Casting Development

Lost Foam Casting

The basic steps of the lost foam casting process are:

1. Pattern Molding -- Bead Preexpansion and Conditioning, Tool Preheat, Pattern Molding, Pattern Aging
2. Pattern/Cluster Assembly
3. Pattern Coating and Drying
4. Sand Fill and Compaction
5. Metal Casting and Cooling
6. Shakeout, Clean-up, and Finishing



Back Next

Return to AFS Home Page

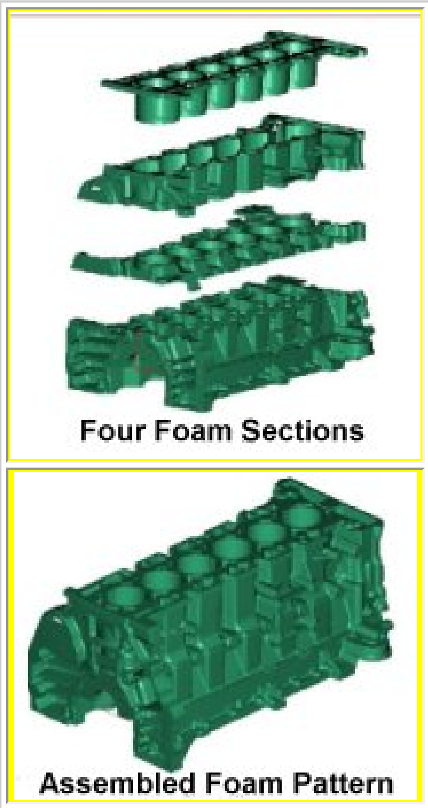
Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

Page 1

In cooperation with
GM Powertrain Casting Development

Pattern Design by Assembly

Complex internal features are produced by assembling and gluing multiple foam sections together to form a single complex foam pattern.



The cylinder block uses four separate foam sections assembled into a single pattern. With these four sections, the following detailed features are cast directly into the cylinder block --

- **A 580-mm long and 12 mm diameter main oil passage to feed high-pressure oil to the balance shaft and crankshaft bearing surfaces and the cylinder head. This eliminated three long drilling operations.**
- **Six 75-mm long, 7-mm diameter oil feed holes from the main oil passage to each crankshaft bearing surface, eliminating drilling.**
- **Four 75-200 mm long, 7-mm diameter oil feed holes from the main oil passage to both balance shaft bearing surfaces, eliminating drilling and four sealing plugs.**
- **Cast-in-place balance shaft covers eliminate the need for two separate covers, two gaskets and eight mounting bolts for each cover as well as eliminate machining for the cover mounting face and bolt and dowel holes.**
- **Four oil holes of varying size are cast-in for the oil filter, eliminating two drilling operations.**

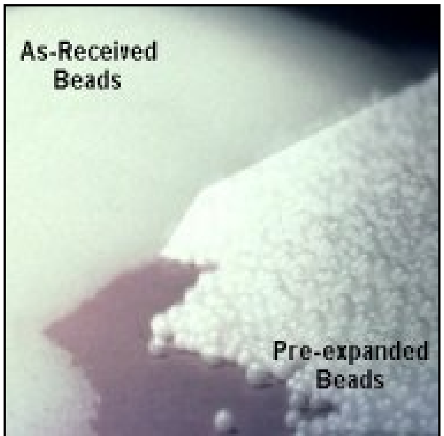
Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

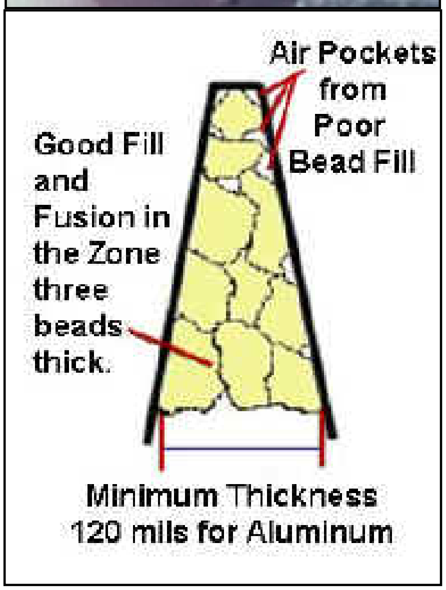
In cooperation with

GM Powertrain Casting Development

Expandable Polystyrene Beads

The foam pattern is formed from expandable beads (commonly polystyrene) which contain pentane (5-7 wt%) as a blowing/expansion agent.





The raw EPS beads (EPS= expandable polystyrene) are delivered at a density of about 38 #/cubic foot in a wide range of initial sizes (10 to 80 mils diameter)

- **The smallest beads give the best fill into the tool and surface finish, but they are more difficult to control for uniform density.**
- **As a rule of thumb, the thinnest wall section in the casting should allow at least a three (3) bead fills wide after curing. This generally limits wall sections to sizes greater than 3 mm (0.120 inches) for aluminum.**

The polystyrene beads are formed into a final pattern in a 4-step process --

- **Preexpansion** by heat and conditioning of the beads to control and stabilize the bead size and density for molding
- **Preheating** the metal tool to the desired cure temperature
- **Injection** of the beads into the tool
- **Heat and cooling** the tool to expand the beads and fuse the pattern.

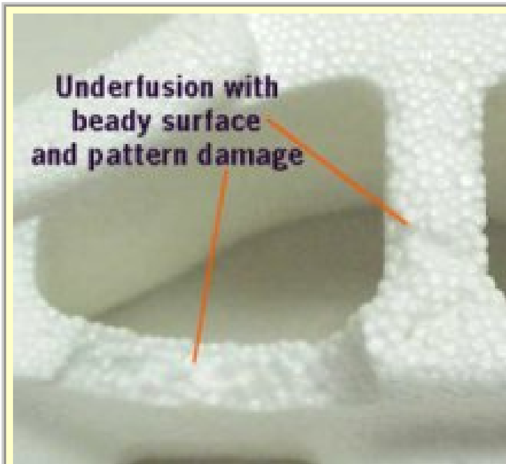
In cooperation with
GM Powertrain Casting Development

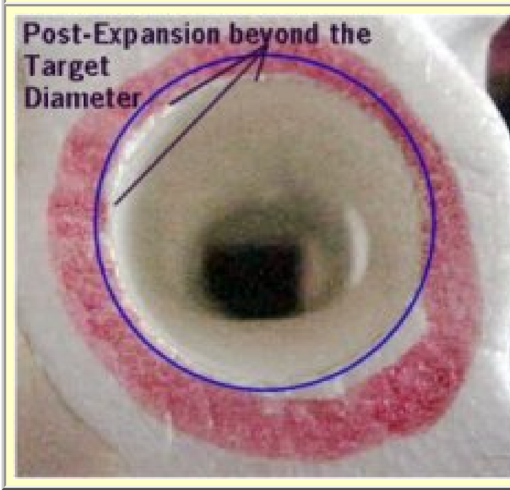
Pattern Molding

The pre-expanded EPS beads are injected into the pre-heated tool cavity and the tool is steam-heated and water cooled to expand, soften, fuse, and cool the polystyrene to form a finished pattern.

Proper design and control of the steam-cool cycle is critical for strong, smooth- finish, and dimensionally-accurate patterns.

- **A cold tool surface or a short steam step produces "underfusion."**
  - **Underfusion fails to fully expand and bond the beads, producing a rough "beady" surface and low strength sections in the pattern.**
- **Extended steam exposure or inadequate cooling produces "overfusion."**
  - **Overfusion collapses the beads on the surface producing surface waviness.**
- **Inadequate cooling in the tool can produce "post expansion."**
  - **In post expansion, the soft, warm beads can locally expand after removal from the tool, producing dimensional variations.**





After ejection from the tool, the foam pattern is aged to release residual pentane & water and to stabilize the pattern to the final dimensions.

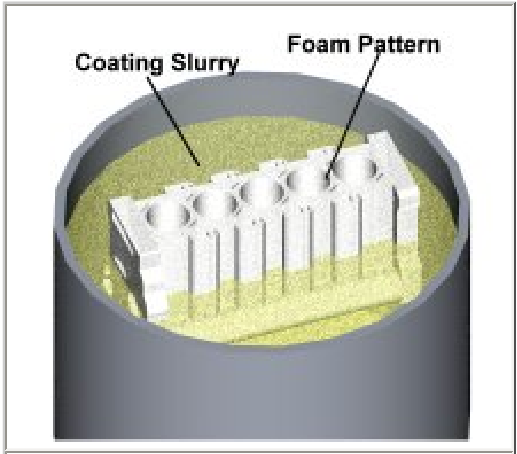
Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Pattern Coating

The different pattern sections are assembled and glued together with the pouring sprue to form the pattern cluster   The pattern cluster is coated with a water-based ceramic slurry which is oven-dried to form a rigid coating over the foam.

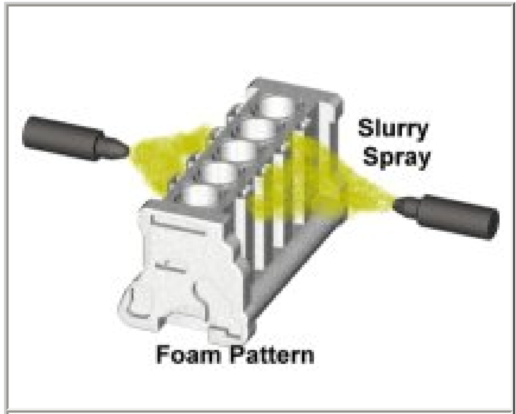
- **The coating acts as a barrier to metal penetration into the sand, provides an escape path for foam decomposition products, stiffens the foam cluster, provides a smooth surface finish to the casting , and affects the heat transfer into the sand during casting.**
- **The coating process must be carefully controlled for thickness, uniformity, and permeability. This is done by monitoring the solids content and viscosity of the slurry and checking the weight and thickness of the dried coating on the pattern.**



Option A -- Dip coating

Two procedures are often used for coating the foam pattern -- dipping and spraying.

- **Option A - Dipping -- Dip the pattern in a tank with the stirred, viscosity- controlled ceramic slurry.**
- **Option B - Spraying -- Spray the pattern with the viscosity-controlled slurry. Used for thin, buoyant, or fragile patterns with few internal features.**



Option B -- Spray Coating

Choose the process (Option A-Dipping or Option B-Spraying) which provides the best coating coverage for the cylinder block.

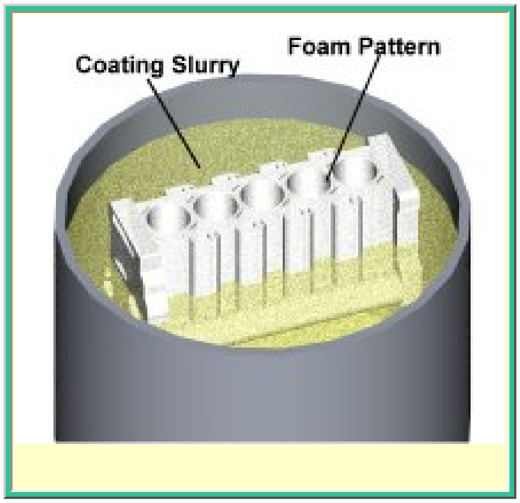
Back *Choose an Option*

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Option A -- Dip Coating

Dipping is the better method for coating the cylinder block foam pattern



- **The foam block is large enough and rigid enough to withstand the buoyant forces in the tank without distortion.**
- **Dipping insures that all the internal passages in the foam block will be well coated with a uniform layer of ceramic.**
- **Dipping this large foam block is faster than spraying.**

***Dipping is the** preferred coating approach*

Go to the next design issue

Back Next

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

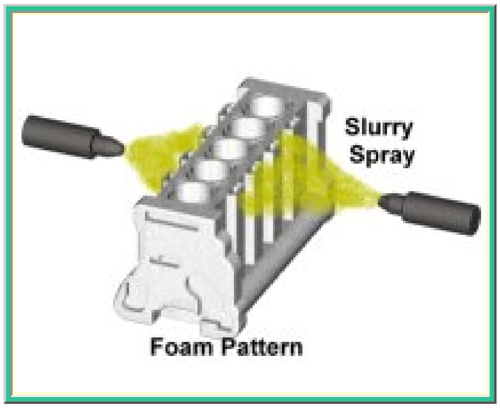
Return to AFS Home Page

Page 1

In cooperation with
GM Powertrain Casting Development

Option B -- Spray Coating

Spray coating is not the best method for coating the cylinder block foam cluster.



- **It will be difficult to develop uniform and complete coating coverage in all the internal passages of the cluster.**
- **Spraying will take longer than dipping.**
- **The cylinder block foam cluster is sturdy enough to be coated by dipping.**

Spraying is not the preferred coating approach.

Go Back to the Coating Page

Back

Return to AFS Home Page

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

Page 1

In cooperation with
GM Powertrain Casting Development

Sand Fill and Compaction

The lost foam process uses sand as it primary molding media. Unbonded sand is used to support and rigidize the coated foam pattern in the flask during casting.

- **The permeability of the sand is important to allow gasses and foam residue to escape from the cavity during pouring. The sand size and the compaction density are controlled to give the desired permeability in the sand.**
- **The cylinder block pattern is positioned horizontally in the flask. Loose silica sand is back filled into the flask and compacted by vibration on a 3-stage horizontal shaker table.**
- **The sand must be loaded and compacted uniformly in the flask to prevent cluster distortion and deformation.**

Sand Fill into the Flask

(Courtesy of LostFoam.com)

In cooperation with
GM Powertrain Casting Development

Metal Pouring

The cylinder block and head castings are produced at dedicated GM casting facilities in Saginaw, Michigan and Defiance, OH.

- **Three melt systems support casting production in five casting cells. Each melt system contains a receiving furnace, a holding furnace, and a ladling furnace.**
- **Metal is poured in each cell by a robotic pouring system.**

These precision production facilities ensure that molten motel is poured at the correct temperature and the correct pour rate.

24,000 lb Electric Ladling furnace in Saginaw

The aluminum is poured into the lost foam mold at a temperature of ~ 1015C / 1500F.

In cooperation with
GM Powertrain Casting Development

Foam Pattern Decomposition

As the metal is poured into the mold, the heat of the advancing melt front progressively collapses, melts, depolymerizes, and vaporizes the polystyrene foam.

Collapse -- 100C / 212 F >>>	**Melt -- 165C / 330 F >>>**
Depolymerize -- 315C / 600F >>>	**Vaporize -- 576C / 1069F**

	
Movie of Metal Flow into Low Fusion Foam	Movie of Metal Flow into Full Fusion Foam

The density and fusion condition of the foam affect how the foam decomposes.

--- If the foam is underfused, it will decompose non-uniformly and metal flow into the mold will be fast and turbulent, trapping residue and causing fold defects and pores.

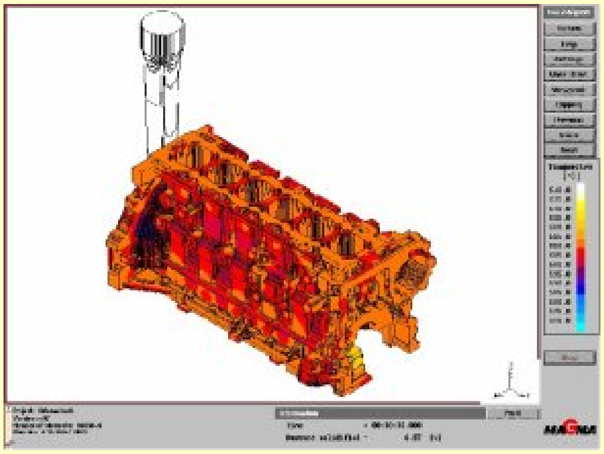
--- Fully fused foam will decompose evenly and produce smooth, uniform metal flow with no defects or trapped residuals.

Flaw-free castings require controlled metal flow and consistent foam density and bead fusion.

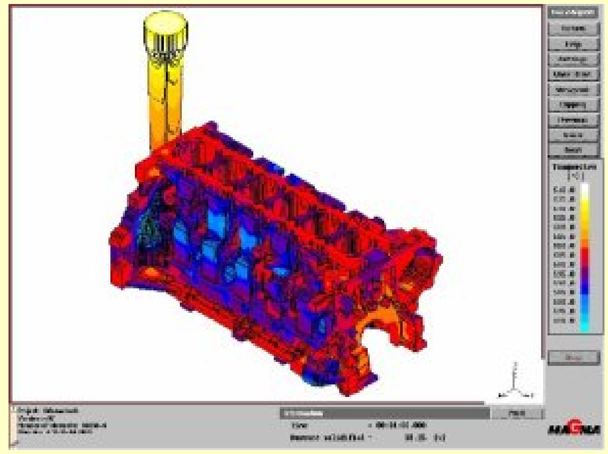
In cooperation with
GM Powertrain Casting Development

Solidification Modeling

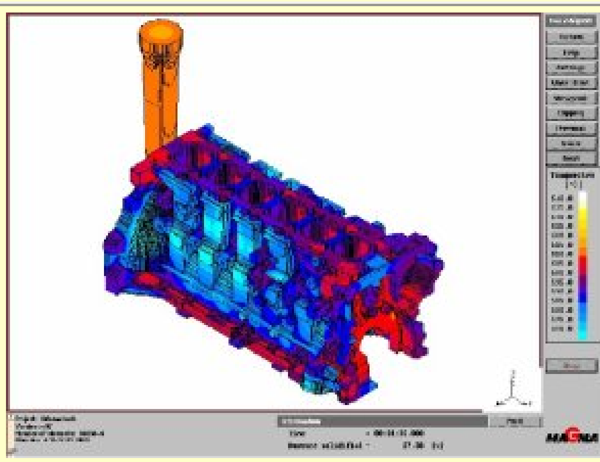
Flow modeling and solidification modeling are invaluable tools for producing high quality castings with rapid first-article cycle times.



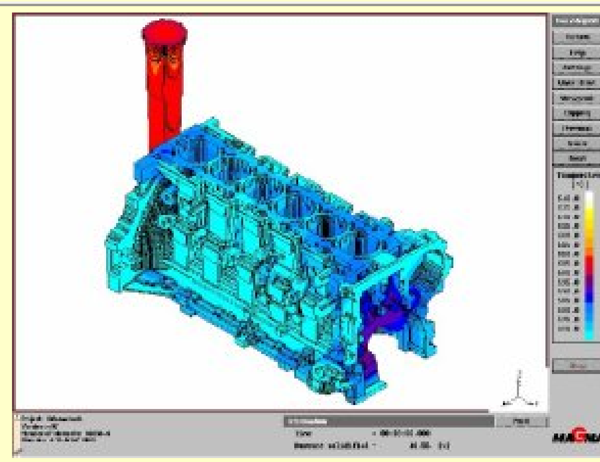
Solidification Model - **30 seconds** after pour



Solidification Model - **60 seconds** after pour



Solidification Model - **90 seconds** after pour



Solidification Model - **180 seconds** after pour

Modeling of metal flow in the gates and complex cavity ensures uniform fill and smooth flow into all sections of the casting.

Modeling of metal solidification ensures good metal feed into all sections during cooling and avoids solidification shrinkage.

In cooperation with
GM Powertrain Casting Development

Heat Treatment and Machining

Cylinder Blocks Exiting the Heat Treat Furnace at Alfe Heat Treat, Defiance, OH

After shake-out, cutting, and cleaning, the aluminum engine block is heat-treated.

- **The A356 aluminum alloy requires a three step heat-treatment (T6 = solution-heat-treat, quench, and artificial aging) to develop the controlled microstructure which gives the alloy its high mechanical strength and ductility.**
- **Heat treatment is done at Alfe Heat Treat, Defiance, OH.**
- **After heat-treatment the cylinder block is premachined and internal coolant and oil passages are leak tested to assure pressure tightness.**

After heat-treatment, the cylinder block is machined.

- **The primary machining operation is the precision boring of the cylinders to tolerance.**
- **Mating surfaces are finished machined to tolerance and bolt holes are drilled and tapped.**

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Quality Assurance

The quality targets (performance and production) for the cylinder block require a flaw-free, controlled microstructure, precision dimensioned casting.

Precision Metal Pour in GM Plant

Quality is engineered into the cylinder block through the entire design and production process.

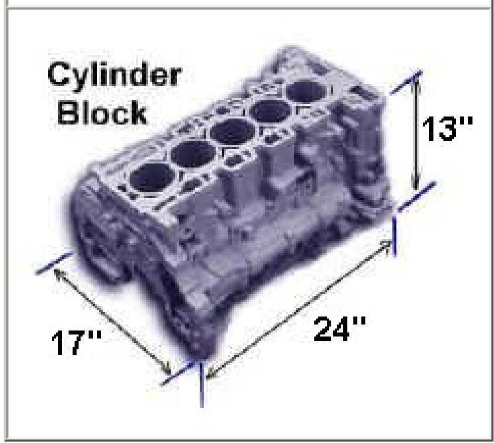
- **Engineered design for performance and manufacturability.**
- **Precision process control at each production step -- EPS bead preparation, pattern forming and assembly, cluster coating, sand fill, melting, casting, cleaning, heat treating, and machining.**
- **Detailed measurement and recording of critical properties (dimensions, weights, pressure tightness, hardness, etc) at the different production steps**

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Lessons Learned

The use of Lost Foam Casting for this cylinder block required detailed, collaborative design work and process optimization from initial concept to full production.



Major lessons learned were --

1. Lost Foam Casting is most advantageous for complex components with extensive internal features and the potential for component integration.

- **The advantages of lost foam casting are best used when the component is designed for lost foam casting from the start with careful considerations of castability requirements, capabilities, and limitations.**

2. Control of the pattern molding is a critical process parameter to ensure a sound casting that meets tolerance requirements.

- **80 to 90 % of the final casting quality is determined during the "white side" steps of the lost foam casting process.**

3. 3D computer aided design (finite element analysis and solidification modeling) is essential to rapidly optimize the design for mechanical performance and castability and to reduce the "first part" time.

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development

Summary

Aluminum Cylinder Block for General Motors Truck/SUV Engines

GM Powertrain has been producing the cylinder blocks and heads for almost 5 years. The benefits of the lost foam casting process in aluminum are:

- **Lower weight and more power in the engine.**
- **Reduced production and machining costs.**
- **Improved dimensional tolerances.**

Buick Rainier

For further information on the production of this and other engine castings, contact

Edward Genske at General Motors Powertrain

Phone-- 989-757-9858 **E-mail:** edward.genske@gm.com

Web Site = http://www.gm.com/automotive/gmpowertrain/

Acknowledgment --

The metalcasting design studies are a joint effort of the American Foundry Society and the Steel Founders' Society of America.

Project funding was provided by the American Metalcasting Consortium Project, which is sponsored by the Defense Logistics Agency, Attn: DLSC-T, Ft. Belvoir, VA, 22060-6221

Address comments to: jss@afsinc.org
Last Modified:August, 2004 by STG

In cooperation with
GM Powertrain Casting Development