

Designing
Zinc Castings
for
Electronic Applications

INTERZINC

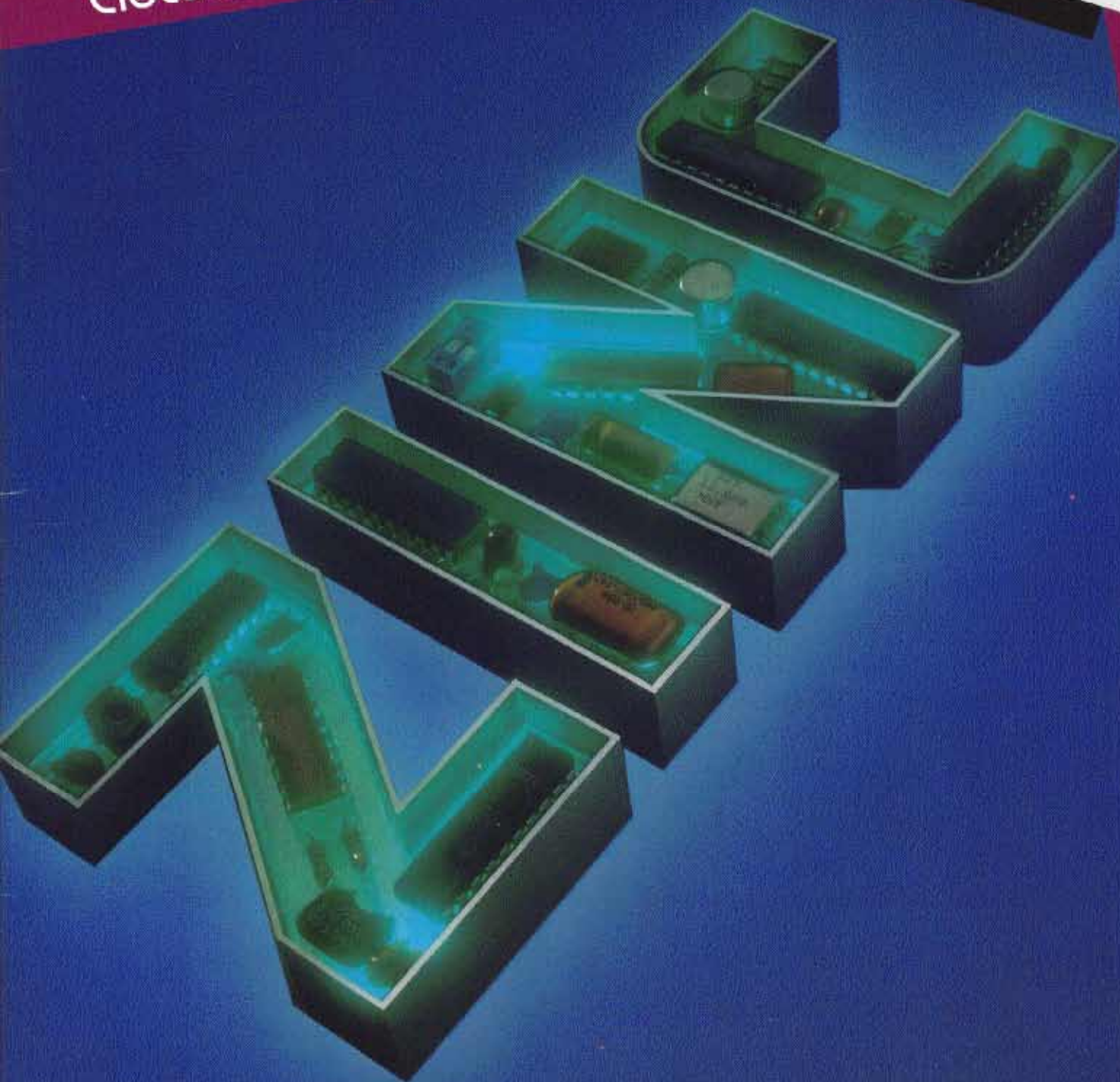


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Designing with zinc

Imagine a process capable of transforming a shapeless fluid into a finished three-dimensional component in only a few seconds. Now imagine a material which will give this component strength rivaling malleable cast iron, stiffness roughly 50 times greater than nylon, and thermal and electrical conductivity superior to 380 aluminum. All this, while providing precision tolerances of less than 0.001 in. in some cases, less than 0.005 in. in almost all cases, and wall thicknesses down to 0.030 in. (.75 mm) or less.



Now imagine this process and material combined, providing engineers an almost limitless range to design components and products. This combination is *zinc alloy die casting*. Die cast zinc alloys have been specified by design engineers for nearly 80 years for components ranging from automotive carburetors to fighter aircraft components. Zinc is an inexpensive and commonly available material. Best of all it is a material which is ideally suited for virtually all types of electronic applications, including:

- Heat sinks
- Components
- Enclosures
- Connectors

A versatile material

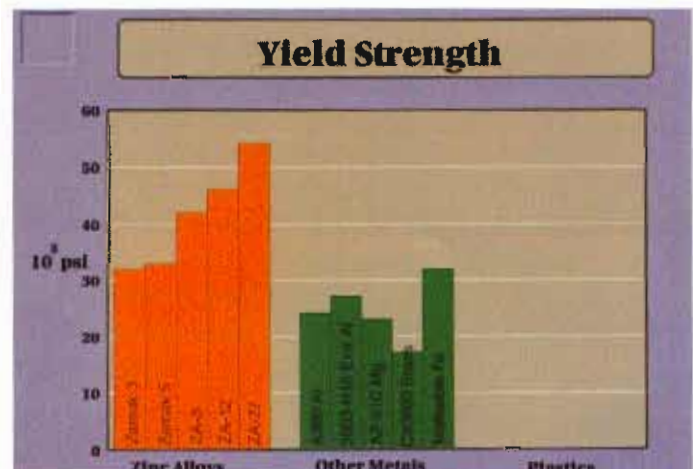
Zinc casting alloys are stronger, stiffer and tougher than molded plastics, extruded aluminum or die cast aluminum and magnesium. Zinc die castings can be produced with thinner wall sections than aluminum or magnesium castings and with lower or sometimes zero draft angle. Dimensional consistency is better and in many cases trimming and machining is eliminated, even where tight tolerances are specified.

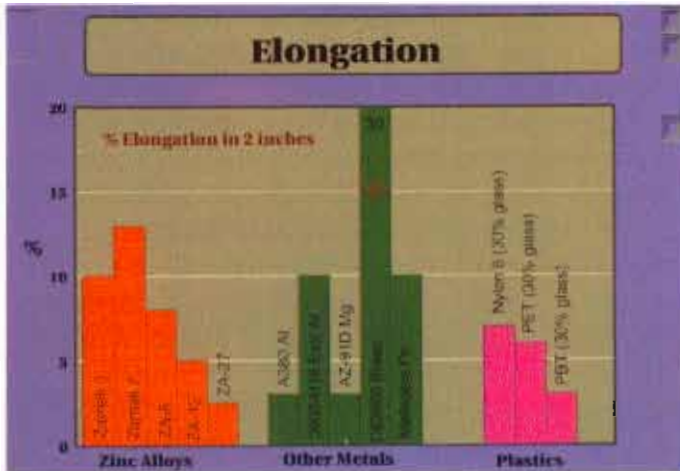
Consider these facts:

- All of the zinc alloys have higher yield strengths than any of the commonly specified metals and plastics, including malleable cast iron.
- Zinc alloys have the highest impact strengths: up to 15 times higher than 380 aluminum.
- Zinc alloys have up to 20% higher torsional stiffness and bending stiffness than 380 aluminum and are about 10 times stiffer than most reinforced plastics.
- Zinc alloys have up to 13% elongation, the highest of any die cast material

by a wide margin. This allows easy assembly through crimping, staking, swaging and spin riveting.

- Zinc offers three times higher damping capacity than 380 aluminum at 20°C (1.5% SDC) and 20 times higher at 100°C (10% SDC).
- Zinc alloys are non-magnetic which allows for their use in applications such as magnetic-proximity switches.
- Seven different zinc casting alloys are available providing a wide range of properties and abilities to match individual design requirements.





- Zinc can be die cast with greater accuracy than any other material.
- Zinc can be die cast with the lowest draft angle of any metal, sometimes even zero draft.
- Zinc can be cast with the smallest cored holes of any material.
- Zinc alloys machine faster and with less tool wear than 380 aluminum and even free machining brass.
- Zinc die casting dies last at least ten times longer and with less maintenance than dies for 380 aluminum.

Zinc die casting is a combination of the right material and process. Imagine designing an enclosure or component providing:

- More internal volume than your current non-zinc design due to zinc's thin wall casting capability.
- Superior EMI and ESD shielding without gaskets due to zinc's electrical conductivity and die casting's ability to produce complex three-dimensional shapes.
- Pressure tightness ensuring that, where required, atmosphere is kept out or inert gases are retained.
- Excellent VHF reflectivity for applications such as waveguides and radar horns.
- The ability to mount a thermally conductive circuit board right in the housing which incorporates thin, complex and efficient cooling fins or cooling pins.

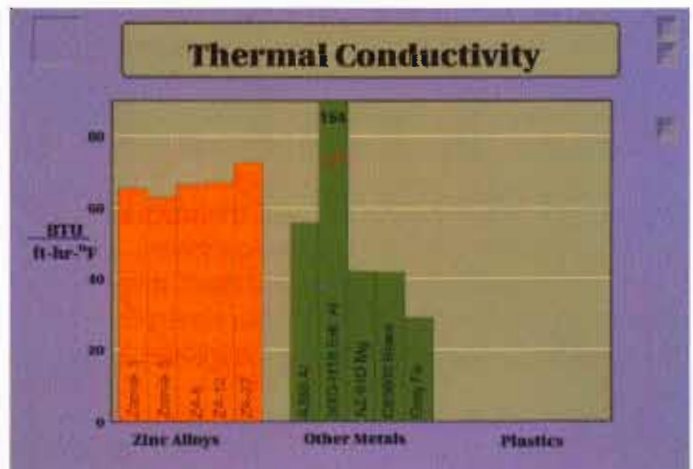
- Unmatched physical strength and dampening properties for unsurpassed reliability in rough environments. And if circumstances really push the intended design envelope, enough ductility is provided to keep the enclosure and the internal electronics in one piece.
- Tolerances so tight that secondary machining is eliminated and solid contact is provided between components and mounting surfaces.
- A surface which has very good corrosion resistance properties in the unfinished form and can accept virtually any finishing process in existence.
- The ability to cast logos and instructions right into the housing.

Thermal conductivity

Electrical and electronic equipment generates heat. If the heat is not removed the electronic circuits develop faults and eventually the electronics fail. As a rule of thumb, each 20°C rise in operating temperature doubles the failure rate of semiconductor devices.

Extruded aluminum sections make good heat sinks; however, they have two main drawbacks:

First, they are basically two dimensional and not easily made into enclosures. This introduces an interface in the thermal path which reduces thermal efficiency. Second, fin spacing is generally large and limited by the extrusion process. The result is physically large heat sinks.



Designing with zinc

The thermal conductivity of all seven zinc casting alloys is superior to that of 380 aluminum. Zinc's excellent fluidity permits designs of complex shapes containing more and thinner fins providing a larger radiating surface with less metal and therefore greater heat dissipation.

While pure aluminum used for extrusions has roughly two times greater thermal conductivity than zinc alloys, the total heat dissipating performance of a heat sink is dependent on several other factors, including:

Surface area of the fins: Zinc can be cast thinner than any other metal. Thinner walls mean that more cooling fins can be designed on the surface of a heat sink.

Air flow patterns through the fins: Zinc allows the designer much greater freedom in the configuration and positioning of the fins.

Contact efficiency of the heat sink to the heat source: Extruded aluminum heat sinks can only be mounted on the surface of a heat generating component. A zinc die casting can be designed to actually fit or screw into the heat source, thereby eliminating an interface in the heat flow path and increasing the contact surface area and contact efficiency. Close flatness tolerances achievable with zinc die casting ensure superior contact between the semiconductor devices and the heat sink.

Electrical conductivity and EMI shielding

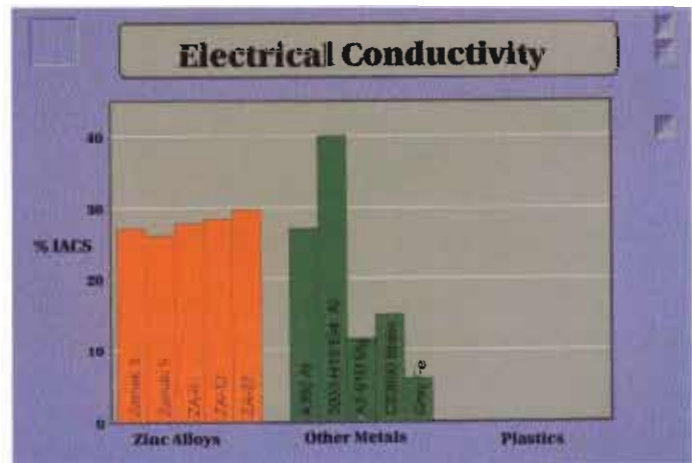
EMI shielding is a critical material property for virtually all of today's electronics applications. Today's electronics packaging designer is faced with two EMI shielding problems.

One, externally generated electromagnetic interference (EMI) must be blocked from infiltrating the product and degrading performance be it a TV set, medical instrument, aircraft equipment or computer system. Second, EMI generated by the product itself must be blocked from escaping into the environment. New regulations in many countries set limits

on electromagnetic interference radiated by products such as home computers, office equipment and radios.

Unlike metals, ordinary plastics are completely transparent to electromagnetic radiation. In order to provide shielding, enclosures must either be made in conductive-filled plastics, which are expensive, hard to mold, and have poor surface quality, or the plastic must be given a conductive coat, usually a thin coating of zinc. While these coatings will reflect high frequency electric waves, their thickness will be ineffective in reflecting low frequency EMI radiation. Fabricated metal stampings contain joints through which EMI radiation can leak. Joints can be sealed but that is both difficult and expensive.

Zinc alloy die castings, featuring good



electrical conductivity (27% IACS), have inherent shielding and can be produced in "leak-tight" one-piece shapes. Where joints are required, such as on a removable cover, the flatness, accuracy, stiffness and good surface finish produced by die casting means that efficient seals can be achieved by good joint design, eliminating the need for gaskets.

Additionally, zinc provides good surfaces which can be easily nickel plated without the use of special equipment or techniques, providing even greater surface conductivity, or tin plated to allow soldering of ground connections directly on the casting.

Design considerations

Small electronic components may be produced as multiple impressions in a conventional die casting machine or as a single impression in a multi-slide miniature die casting machine. Design tips for parts cast in conventional die casting or graphite mold dies are provided in INTERZINC's *Zinc Casting, a Systems Approach*.

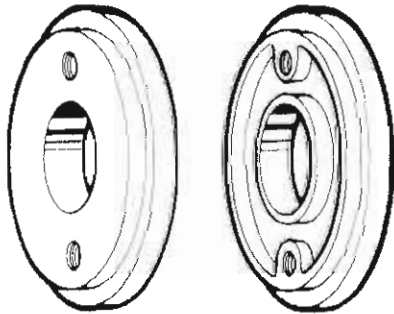
Multi-slide, miniature die casting provides multiple benefits to the designer, including:

- Precise, close dimensional tolerances.
- Thin wall construction.
- Opportunity to incorporate multi-part items into a single casting.
- Ability to produce small cored holes, with minimum or no side wall draft.
- Long lasting, low maintenance dies.
- The elimination of secondary operations.

Weight reduction

Component weight can be minimized by reducing the cross-sectional area or by designing pockets in solid sections. Thinner sections can be

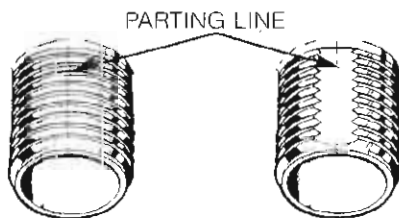
strengthened where needed with ribs, which also improves metal flow. The size and location of weight reduction



pockets should be reviewed with a die cast engineer to avoid irregular shrinkage and dimensional inaccuracy. Weight reduction also decreases casting cycle time, which is a cost factor.

Threads

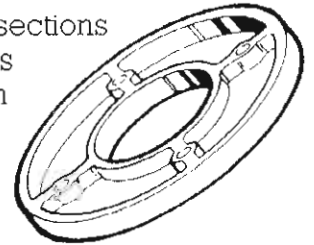
Most external threads can be die cast. Wherever possible, flats should be designed



on the thread root diameter at the parting line. Full diameter threads are possible, but require very precise tooling.

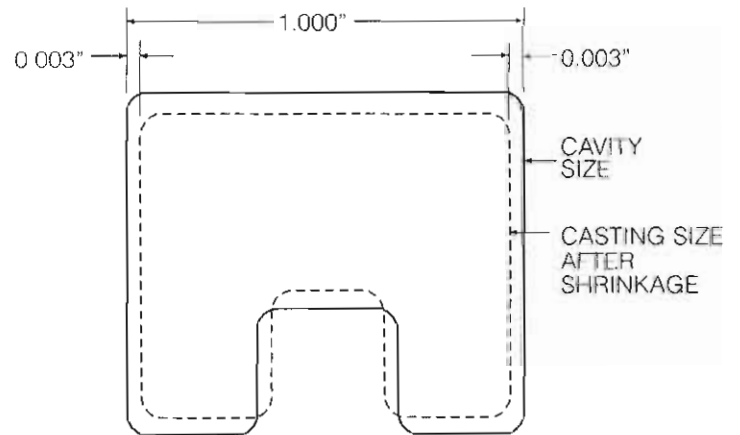
Ribs

Ribs are added to thin wall sections to increase part strength. It is preferable to blend ribs with fillets and radii to eliminate sharp corners and rapid changes in cross sections.



Shrinkage

The Zamak casting alloys shrink approximately 0.006 in./in. As metal cools, it shrinks towards

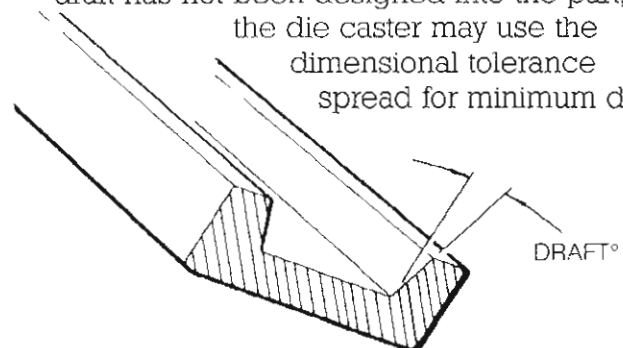


the theoretical center. This phenomenon permits the casting to pull away from the outside cavity walls but causes the part to lock onto any die section that projects into it.

Draft

Draft is the slight taper on a die casting's internal walls, offsetting the effects of shrinkage. Draft makes it possible for the ejector pins to push the casting out of the cavity. In certain cases where

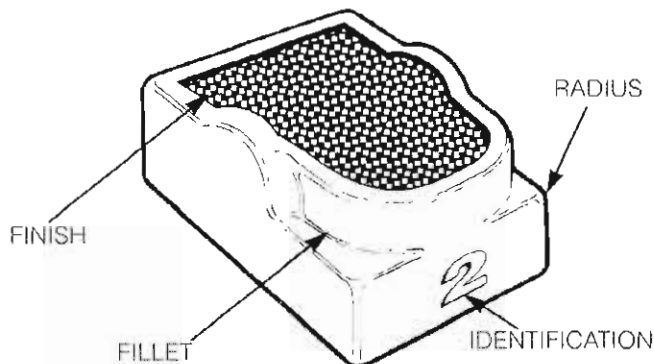
draft has not been designed into the part, the die caster may use the dimensional tolerance spread for minimum draft.



Designing with zinc

Fillets & radii

Sharp corners, especially when they're associated with a rapid change in cross section, should be avoided. It is desirable to design inside corners with fillets and outside



corners with radii. Fillets and radii as small as 0.005 in. can strengthen the casting and improve metal fill through reduced turbulence.

Surface finish

The surface finish of a die casting is derived from the casting die's finish. Highly polished tooling provides good surface finishes, while texture dies are used to impart a textured finish to the casting. Smooth die cast finishes are generally in the range of 16 to 64 microinches. In select cases, center bores can be cast to a 4-8 microinch finish. A matte finish is usually the easiest textured finish to cast.

Part identification

The designer should consider what identification marks are to be cast into the part and where they can be accommodated. It is easier and less costly to cast raised letters than recessed letters.

Tolerances

Miniature zinc die castings can be produced to very close dimensional tolerances, with almost no part-to-part variation. Many castings

produced on multi-slide machines are clean, flash-free and ready-to-use without secondary operations.

Typical Zinc Casting Tolerances*

Miniature die castings

Wall thickness: 0.010 in. minimum

Cast holes: up to 1.5 in. long & within 0.001 in. of true position. Center bores cast parallel within 0.005 in. Minimum diameter approximately 0.020 in. for lengths up to twice the diameter.

Linear tolerances: ± 0.001 in./in.

Straightness, roundness and perpendicularity within 0.001 in.

Flatness and parallelism within 0.0005 in.

Concentricity within 0.002 in. T.I.R.

Conventional die castings

Wall thickness: 0.020 in. minimum

Cast holes: approximately 0.090 in. minimum thickness with maximum diameter depth 3 to 8 times diameter.

Linear tolerances:

non-critical linear dimensions:

first inch: ± 0.010 in.

additional inches: ± 0.001 in./in.

critical linear dimensions:

first inch: ± 0.002 in.

additional inches: ± 0.001

Across parting line: add ± 0.0045 in.

Flatness: within 0.005 in.

Graphite mold casting

Wall thickness:

small parts: 0.10 in. minimum.

larger parts:

nominal 0.180 in., 0.25 in. maximum preferred.

Cast holes:

cored holes should be oriented perpendicular to the parting line.

Linear tolerances:

critical dimensions:

first inch: ± 0.005 in.

additional inches: ± 0.002 in./in.

across parting line: add ± 0.005 in.

non-critical dimensions: ± 0.005 in./in.

* The tolerances provided here are meant as guidelines. Exact specifications are dependent on the the specific application. For more information consult the zinc caster of your choice.

Plating for electronics

Metallic coatings provide zinc castings with enhanced appearance, corrosion resistance, wear resistance and electrical properties. Both electroless plating and electroplating are used to plate zinc castings for electronics, the vast majority being electroplated.

Electroless deposition

Copper and nickel can be applied to zinc with an electroless deposition process. This process deposits a coating in a 1:1 ratio, providing very tight dimensional control. Compared to electroplating, electroless plating improves coating hardness, wear resistance, corrosion resistance, and dimensional tolerances. The electroless process is especially useful when there is a need to plate low current-density areas such as recesses and holes. Disadvantages include higher chemical costs, lower deposition rates, and less ductile deposits.

Electroplating

The most common methods of electroplating are rack plating for large parts and barrel plating for small parts. Parts with complicated geometry may be difficult to barrel plate. However, plating distribution can be optimized through dimples, grooves, or other configurations incorporated into the casting which prevent parts from nesting together.

Zinc castings usually require a thin deposit or strike of copper to begin the plating process. This protects the zinc substrate from acid

solutions used in subsequent plating. Metals such as nickel, chromium, silver, gold, brass, and bronze are then plated over the copper layer.

Chemical milling

In certain critical applications, such as fiberoptic connectors, the use of chemical milling should be considered to enhance the durability and quality of electroplated nickel.

In a standard chemical milling process, 75 microns of material is removed from the die cast surface and replaced with 7.5 microns of copper. Chemical milling has been successful in the removal of up to 40 microns while holding a 10 micron bore dimension. Gage sizes for internal and external threads can also be controlled.

Design summary

Zinc alloys combined with the versatility and capabilities of the die casting process presents designers with the opportunity to produce higher quality parts at lower costs. To ensure that this is achieved, the die caster and tool designer must be involved very early in the design stage. This involvement will also secure additional benefits, including:

- The required tolerances will be met and machining often eliminated.
- Reduced tooling costs and shortened lead times.
- Maximized production rates and lower manufacturing costs.

Metallic coating service properties for zinc die cast components

Finish	Appearance	Electrical Conductivity			Wear and Abrasion Resistance				Corrosion Resistance		
		Excel.	Good	Fair	Excel.	Good	Fair	Poor	Excel.	Good	Fair
Cadmium	silver gray		●			●	●		●		
Copper	copper	●						●			●
Copper/Nickel	silver (with yellow cast)		●			●			●	●	
Chromium (direct)	blue white		●		●	●				●	
Copper/Nickel/Chromium	blue white		●			●			●	●	
Gold	gold	●				●	●		●		
Silver	silver	●				●	●		●	●	
Tin	silver gray		●					●		●	
Zinc (bright)	bright gray		●					●			●

Engineering properties

ALLOY PROPERTY	ZINC														ALUMINUM			MAGNESIUM	BRONZE/BRASS		IRON	
	ZAMAK 2**	ZAMAK 3**	ZAMAK 5**	ZAMAK 7**	ZA-8***			ZA-12***			ZA-27***				380	319	356-T6	AZ-91D	SAE 660 (C83200)	SAE 40 (C83600)	Class 30	32510
	Die Cast	Die Cast	Die Cast	Die Cast	Sand Cast	Perm Mold	Die Cast	Sand Cast	Perm Mold	Die Cast	Sand Cast	Sand Cast HT*	Perm Mold	Die Cast	Die Cast	Sand Cast	Sand Cast	Die Cast	Sand Cast	Sand Cast	Gray Cast Iron	Malleable Iron

MECHANICAL

Ultimate Tensile Strength	psi x 10 ³ MPa	52 359	41 283	46 331	41 283	38 263	35 240	54 374	43 299	48 328	59 404	61 421	46 318	64 441	62 426	47 324	27 196	33 228	34 234	35 241	37 255	31 214	50 345
Yield Strength 0.2% Offset	psi x 10 ³ MPa	NA	32 221	33 228	NA	29 198	30 208	42 290	31 211	39 268	46 320	54 371	37 257	56 376	54 371	24 165	18 124	24 165	23 159	18 ¹ 124	17 ¹ 117	18 124	32 221
Elongation (% in 2in.)		7	10	7	14	17	13	8	15	22	5	4.6	9.4	2.5	2.5	3.0	2	3.5	3	20	30	nil	10
Young's Modulus	psi x 10 ⁶ MPa x 10 ³	≥124 ≥855	≥124 ≥855	≥124 ≥855	≥124 ≥855	124 855	124 855	124 855	120 827	120 827	120 827	113 779	113 779	113 779	113 779	103 710	107 736	105 724	65 44.8	145 100	120 827	13-16 89.6	25 172.4
Torsional Modulus	psi x 10 ⁶ MPa x 10 ³	≥4.8 ≥331	≥4.8 ≥331	≥4.8 ≥331	≥4.8 ≥331	4.8 331	4.8 331	4.8 331	4.6 317	4.6 317	4.6 317	4.3 296	4.3 296	4.3 296	4.3 296	3.9 26.9	4.0 276	3.9 26.9	2.4 16.5	NA	NA	NA	93 64.1
Shear Strength	psi x 10 ³ MPa	46 317	31 214	38 262	31 214	NA	35 241	40 275	37 253	≥35 241	43 298	42 292	33 225	NA	47 325	27 186	22 152	26 179	20 138	NA	NA	43 293	45 310
Hardness (Brinell)		100	82	91	78	85	87	103	95	95	100	113	94	114	119	80	70	70	63	65	60	170-269	110-156
Impact Strength	ft-lb J	35 ¹ 47	43 ¹ 58	48 ¹ 65	43 ¹ 58	15 ¹ 20	NA	31 ¹ 42	19 25	NA	21 ¹ 29	35 ¹ 48	43 ¹ 58	NA	9 ¹ 13	3 ¹ 4	4 ¹ 5	8 ¹ 11	27 ¹ 37	6 ¹ 8	11 ¹ 15	nil	40-65 54-88
Fatigue Strength Rotary Bend (5 x 10 ⁶ cycles)	psi x 10 ³ MPa	8.5 58.8	6.9 476	8.2 56.5	6.8 46.9	NA	7.5 51.7	15 103	15 103	NA	17 117	25 172	15 103	NA	21 145	20 138	10 69	8.5 58.8	14 97	18 110	11 76	14 97	28 193
Compressive Yield Strength 0.1% Offset	psi x 10 ³ MPa	93 ¹ 641	60 ¹ 414	87 ¹ 600	60 ¹ 414	29 199	31 210	37 252	33 230	34 235	39 269	48 330	37 257	NA	52 359	NA	19 131	25 172	23 159	46 ¹ 317	375 ¹ 259	109 ¹ 752	NA

PHYSICAL

Density	lb/in ³ Kg/m ³	0.24 6600	0.24 6600	0.24 6700	0.24 6600	0.227 6300			0.218 6030			0.181 5000			0.098 2713	0.101 2796	0.097 2685	0.066 1827	0.322 8913	0.318 8802	0.25 6920	0.26 7198
Melting Range	°F °C	715- 734- 379- 390	718- 728- 381- 387	717- 727- 380- 386	718- 728- 381- 387	707-739 375-404			710-810 377-432			706-903 376-484			1000- 1100- 538- 593	960- 1120- 518- 604	1035- 1135- 587- 613	875- 1105- 468- 596	1570- 1790- 854- 977	1570- 1850- 854- 1010	> 2150 > 1177	> 2250 > 1232
Electrical Conductivity (% IACS)		25	27	26	27	277			283			297			27	27	39	115	12	15	NA	6
Thermal Conductivity	Btu/ft-hr-°F W/m K	605 104.7	65.3 1130	62.9 108.9	65.3 1130	69.3 114.7			67.1 116.1			72.5 128.5			55.6 96.2	65.5 1134	87 151	41.8 73.3	34 59	41.8 72	28-30 48-52	NA
Coef. of Thermal Expansion (66-212°F)	1/°F x 10 ⁻⁶ 1/°C x 10 ⁻⁶	154 277	15.2 274	15.2 274	15.2 274	12.9 23.3			13.4 24.2			14.4 26.0			11.8 21.2	11.9 21.4	11.9 21.4	1.4 25.2	10 18	10 18	6.7 12.1	6.6 11.9
Pattern Shrinkage in/in.		0.006	0.006	0.008	0.006	0.010		0.007	0.013		0.0075	0.013		0.008	0.006	NA	NA	NA	0.018	0.016	0.010	0.010

* 3 hrs at 610°F and furnace cooled

** Complies with ASTM specification B98

*** Complies with ASTM specification B669

¹ 10mm unnotched Charpy

² 1/4 in unnotched Charpy

³ at 1/2 in along

⁴ Izod

⁵ notched Charpy

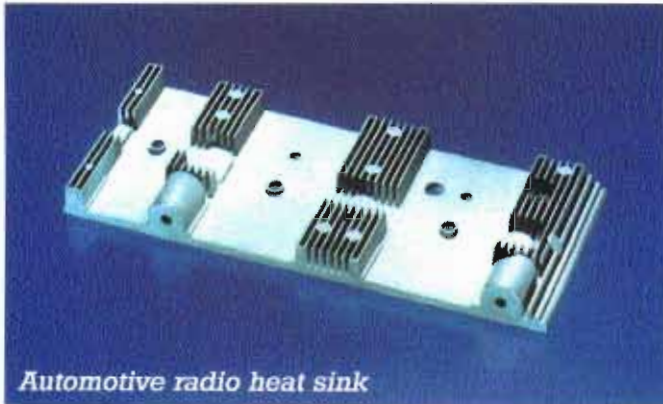
⁶ compressive strength

⁷ at 10% permanent set

NA - Not Available

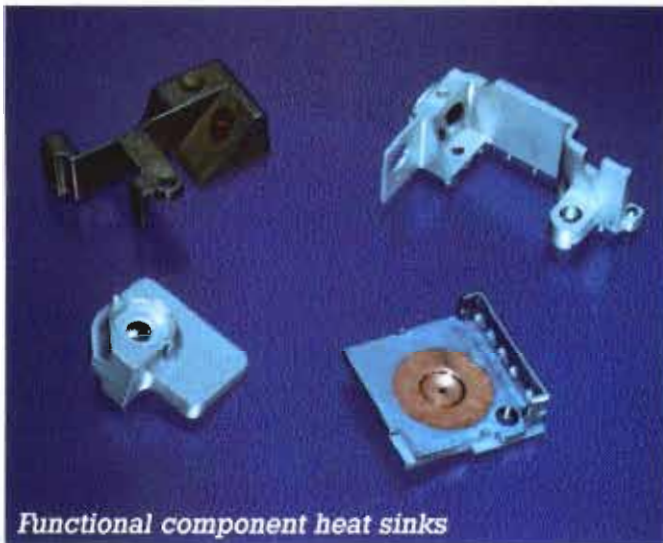
Heat Sinks

Removing heat from an electronic device and consequently enabling it to run cooler is a very important design criteria. Product reliability is dependent on components functioning in an environment below their maximum operating temperatures.



Automotive radio heat sink

Zinc die cast heat sinks can be designed with relatively large flat areas, thin-wall fins, cored holes, bosses and other integral features. The heat sink pictured here is designed for use in an automotive radio, one of the first areas of electronics where space was considered a premium.



Functional component heat sinks

Heat sinks are not always designed with cooling fins. They can also be functional

components of an assembly allowing zinc's natural thermal conductivity to remove heat. Pictured are various die cast zinc components which also double as heat sinks. One of the pictured heat sinks incorporates a copper insert to accelerate heat dissipation.

Cast-in heat sink/switch assembly

An electronic furnace thermostat utilizes a cast-in assembly process for a more efficient method of joining a heat sink to a bimetal strip. By casting the heat sink directly onto the bimetal strip, it becomes an integral part of the switch assembly with good heat transfer properties. A hole in the strip allows the molten zinc to flow through, forming a hub on the



Cast-in switch assembly

under side. Shrinkage during solidification locks the heat sink tightly into place.

Two configurations are used, both cast in the same tool with a simple change of inserts. The cast assembly method combines two components into one, with total part-to-part consistency. It also produces a net shape assembly, ready for the next operation.

Radial-fin heat sink

A radial-fin heat sink was developed specifically to cool densely spaced PC cards in a down-sized mainframe computer. Miniplenums channel air directly into the center of the highly efficient ZA-8 alloy heat sinks which are positioned on the PC cards.

The heat sink is designed with tightly spaced vertical fins mounted radially on the base. The thin-walled fins, 0.020 in. thick at the tip with a one degree draft, provide the heat sink an exceptionally large surface area

for heat dissipation. Maximizing the heat sink's efficiency is ZA-8's excellent thermal conductivity—higher than either traditional zinc or aluminum die casting alloys. ZA-8 also adds strength to the fins, helping them to withstand



Radial-fin heat sink

packing, shipping and handling prior to the PC board assembly.

After the component is cast, the back plate is machined to a 0.0005 in. flatness tolerance. Additional secondary operations include chromate finishing, identification stamping and inspection.

Housing/heat sink

A heavy-duty safety flasher utilizes a zinc die casting for a heat sink as well as a housing. The flasher is a completely electronic unit operating on 12 or 24 volts and rated for continuous service at 35 amps.

Engineers elected to die cast the housing rather than ejection mold it with a non-conduc-



Flasher housing/heat sink

tive polymer material. Additionally, Zamak 3 alloy was chosen over aluminum because of its ability to produce thinner fins and its 175 percent greater thermal conductivity over 380 aluminum. Zinc die casting provides the housing efficient heat removal with a minimum amount of material.

The 4.250 in. L x 2.375 in. W x 1.625 in. D die cast-and-trimmed housing goes directly to assembly without any secondary machining or finishing.

Halogen lamp housings

Quartz halogen lamps are specified in automotive lighting for their concentrated light output. But high illumination from a small package leads to increased bulb temperatures. These high temperatures need to be dissipated through bulb mounts and the housing. Low thermal conductivity of the common injection-molding resins caused the plastic housings to suffer heat distortion, warping, and even melting under some test conditions.



Halogen lamp housing/heat sink

Zamak 3 die cast housings provided similar product geometry with substantially better thermal conductivity. Additionally, separate parts required by the plastic housing are now cast in-place, simplifying assembly. Tooling based on optimum gating principles and thin-walled product design concepts provide high productivity and yield, allowing a cost-effective solution to the tail lamp design.

Consumer microwave collector

Graphite permanent mold is often used to produce lower volume components. Such was the case with an LNB/feedhorn device for a



Permanent mold ZA-12 components

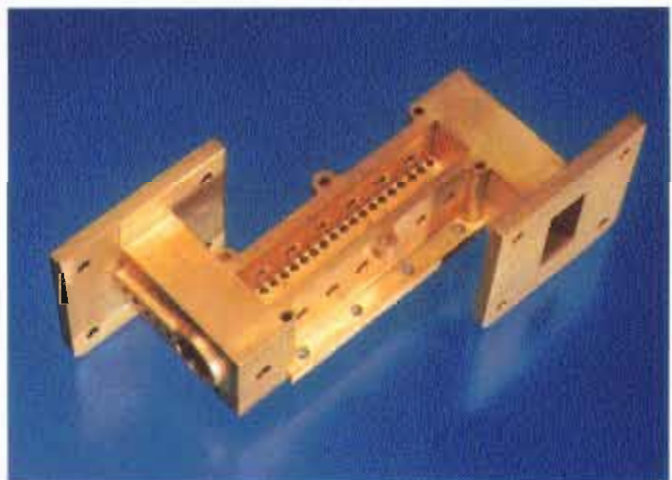
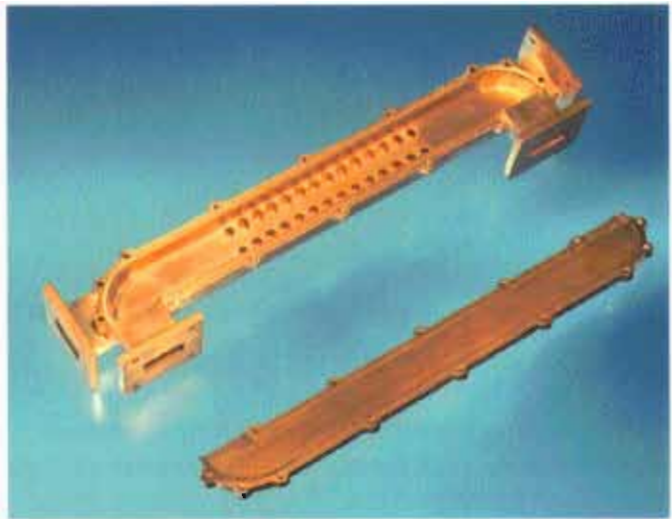
home satellite system. The LNB/feedhorn is an assembly of six ZA-12 graphite mold castings: the end cap, the housing (which holds the circuit boards), the feedhorn, the cover (used for shielding) and two mounting probes.

The components are cast to net shape, with secondary operations limited to hole drilling and tapping. After assembly the castings are finished with an epoxy coating for an aesthetic, highly durable finish.

Commercial microwave guides

Microwave guides are built to exacting specifications. The slightest irregularities in dimensional accuracy, straightness and flatness can set up wave patterns that effectively reduce signal strength. For ground-based microwave systems, die cast zinc wave guides offer a number of compelling advantages. Flatness tolerance on die cast commercial wave guides is held to within 0.002 in. over entire lengths. Dimensional tolerances for TV and communications are ± 0.002 to 0.003 in.

In certain circumstances the zinc wave guide serves as a heat sink, dissipating some of the heat as the signals pass through it. Die casting wave guides is the most cost effective process available. Die cast zinc results in an approximately 80 percent cost savings over a finished, machined set. Casting the wave guides in zinc rather than aluminum eliminates post-casting straightening while small holes and under cuts are cast-in using sliding cores. The zinc die cast wave guides provide additional cost savings after they are delivered to the electronics lab where the microwave circuits are tuned. Even though machining produces tight tolerances, dimensions may vary from part to part. Die casting produces tight

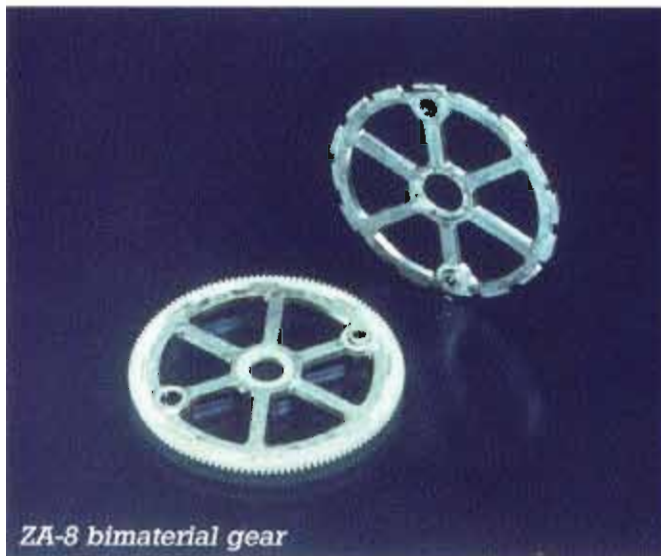


Two examples of die cast Zamak 3 microwave guides

tolerances not only within one part, but also part to part. Where it might take hours, even days, to tune a single microwave system utilizing machined wave guides, once parameters are set for the zinc wave guide system, tuning can be accomplished in as little as 15 minutes.

Tape drive gear

Designers satisfied multiple objectives with a bimaterial main drive gear for a high performance tape drive. Requirements for the gear include minimum envelope size, strength,



rigidity and quiet operation. Neither plastic nor zinc could do the job alone; plastic wasn't rigid enough and zinc wasn't quiet enough. Combining the two proved successful.

Outer and inner plastic rings are molded onto a 2-1/2 in. ZA-8 alloy hub to form the main gear. The plastic inner bearing and gear teeth provide smooth, quiet operation while the ZA-8 hub provides the overall strength. The gear thickness is a compact 0.080 in., easily fitting into the tight space available.

Capstan retainer

This capstan retainer is actually two separate components cast together. The first component is a 5/8 in. x 0.105 in. Torx head screw with an

integral retainer sleeve. The second part is a 0.060 in. x 0.320 in. x 1-3/8 in. wing.

A two-step "intercasting" process substantially



reduces costs by combining four parts of a prototype (screw, washer, arm and sleeve) into one part ready for further assembly.

The die cast Zamak 5 component is finished in a yellow chromate coating for additional corrosion resistance.

Antenna

A hand held radio antenna is a good example of insert casting. A plastic washer is first positioned on an antenna cable and then both ends are die cast at the same time. The one-piece assembly is then rubber



overmolded. After molding, the threaded end of the zinc casting is nickel plated and the antenna is ready for market.

Miniature housings

A diode shield for a smoke detector circuit board is zinc die cast for a low cost, precision fit. The diode uses the shield's precise window



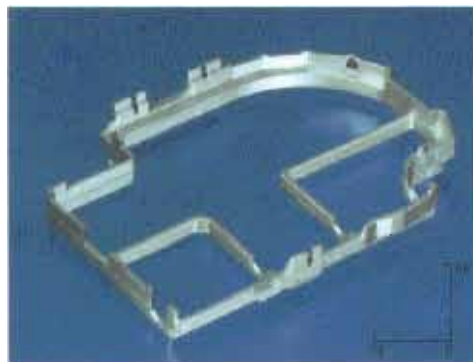
opening to sense change in light. The shield is tin plated and wave soldered in place.



These 0.325 in. x 0.200 in. x 0.230 in. coaxial housings have 0.030 in. cast legs which plug into a PC board and are wave soldered. The critical I.D. is held to within 0.001 in. tolerance. The housings are normally tin plated for solderability. Pictured are electroless nickel and gold-plated examples.

Telephone shield frame

A shield frame, designed for a cordless phone, also functions as part of the chassis, supporting internal switches. The frame measures



Zinc shield frame weighs 0.35 oz.

2.06 in. L x 1.94 in. W x 0.35 in. D and weighs just 0.35 ounces (after plating).

Die cast Zamak 3 was chosen to produce the frame for the following advantages:

- Designers wanted frame rigidity with the thinnest possible wall sections. Since the exterior shell envelope was fixed, the thinner the walls, the more interior space available. The zinc die cast wall dimensions are 0.035 in. or less. A die cast aluminum component would be significantly thicker.
- The material requires good electrical conductivity and ease of plating.

After casting, the shield frame is copper/nickel/tin plated. In a key assembly step, the zinc frame is placed into an opening on the circuit board where the entire peripheral surface is soldered. The shield frame is flat within ± 0.007 in. ensuring a 100 percent soldered surface.

Radio chassis

A Zamak 3 die casting provides a "space frame" for a two-way FM mobile-communications radio and supports the internal components.

Squareness and torsional rigidity are critical, as are surface finish and heat dissipation.

Produced to net shape, the chassis contains four holes, one a large rectangular opening in a thin-walled side.

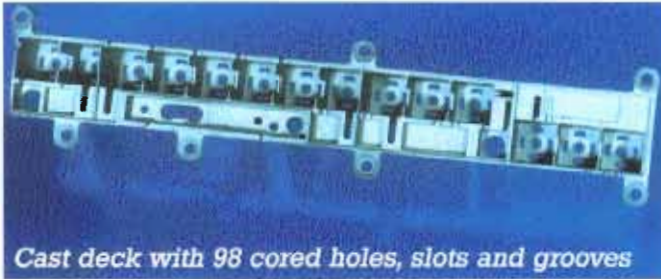
Additionally, the component includes nine bosses on one side and seven on the other, all cast to size. To eliminate secondary machining, the 16 bosses accept self-tapping screws.



Frame contains 4 holes and 16 bosses

Radio RF deck

Zinc die casting enabled engineers to design an elaborate RF deck for a high-frequency



radio. The casting is made with 98 cored holes, slots and grooves. Secondary machining is limited to tapping of selected holes. The casting is divided into 14 individual cells by a network of 0.019 in. ribs running perpendicular to the length of the casting, which provides the necessary RF shielding.

Prohibited costs ruled out a light-gauge metal stamped assembly as an alternative process.

Radar detector horn

The radar detector waveguide horn, formally called a linearly-polarized, double-ridged



waveguide horn, is a complex zinc alloy die casting providing detail, net shape and thin wall construction. The latest design replaced three separate pieces utilized in earlier models. One component now performs four distinct functions—a horn antenna, a microwave cavity, RF shielding for the circuit board, and electronics mounting.

A unique microwave design element is the double ridge located on the top and bottom of the horn interior. The ridges enable the horn to work across a broad range of microwave frequencies. This eliminates the

need for two separate horns, enabling a single unit to collect both X and K signals.

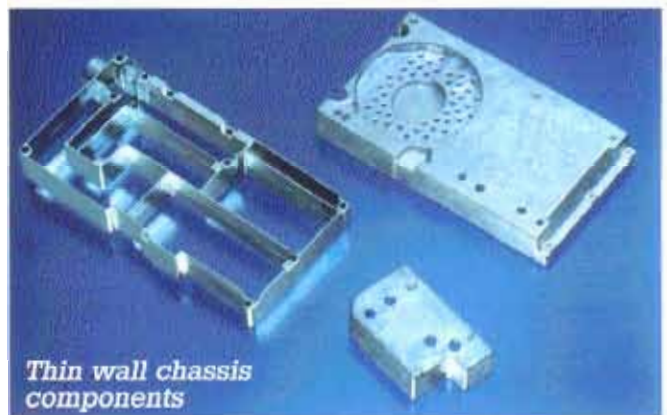
The casting is produced with a nominal wall thickness of 0.040 in. with an 0.018 in. tapered edge at the mouth of the horn. Other intricacies of the casting include 19 through holes, two blind holes, two bosses and two major cavities.



All of this is incorporated into a casting measuring 1-1/2 in. x 3-1/4 in. x 9/16 in. The horn weighs approximately 1-1/2 ounces.

Radio chassis components

A commercial hand-held, two-way radio incorporates three Zamak 3 die castings as chassis components. The three include the chassis frame, the chassis shield and the synthesizer housing. All three components provide strength, stiffness, vibration dampening and EMI and RFI shielding. In addition, the chassis also serves as a ground for the enclosed electronics.



To maximize space and minimize weight, the chassis is cast with very thin walls, 0.032 in. maximum at the parting line and 0.024 in. at the taper. By designing the parting line in the

Enclosures

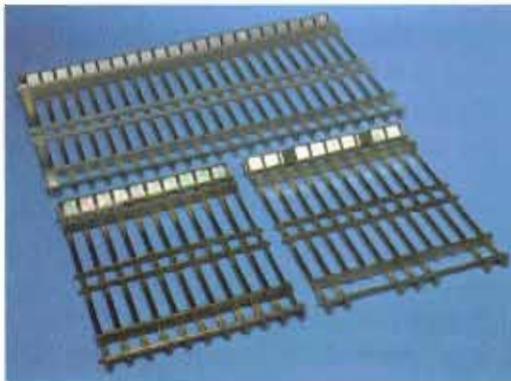
center of the walls, draft was cut in half. The exception to this are several outside walls which are cast with the parting line on the outside corner and are produced with zero draft.

The 0.031 in. chassis shield provides a mounting for the radio speaker. In addition, it shields the internal electronics from magnetic interference waves generating from the speaker. The shield also protects the circuitry from outside EMI and RFI which may pass through the speaker.

Logic module frame & bulkhead

Minicomputer logic module frames are grill-like components containing parallel rails, insertion guides, and separators. The frames function as top and bottom guides (slots) that separate banks of vertically-mounted logic modules. The original fabricated module frame

consisted of 1/4 in. diameter wire weldments requiring as many as 144 welds per frame. The steel units were heavy



Logic module bulkhead

and dimensionally unstable. They were also susceptible to heat distortion during welding.

Conversion of the frame to a Zamak 3 zinc casting is credited with reducing component cost by one-third, improving dimensional accuracy, providing JIT delivery, decreasing weight by 35 percent, and eliminating incoming component inspection and assembly problems.

Maintaining the large part's flatness is accomplished by designing the guide rails as oval channel shapes with concave backs. This design has greater surface area and stability than a solid shape. The zinc components



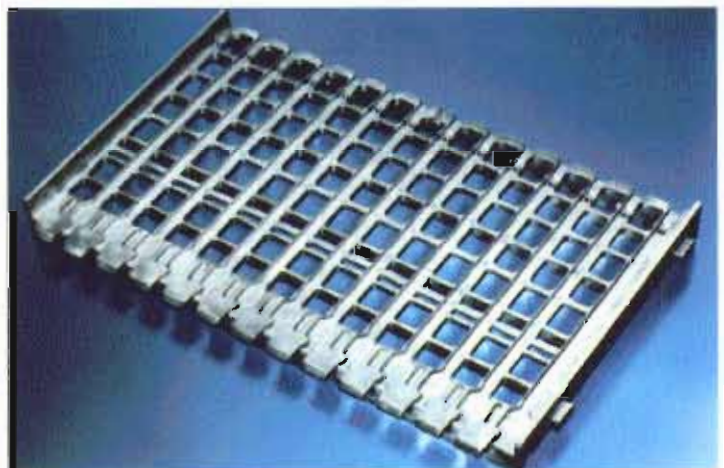
Logic module frames

achieve strengths comparable to the steel frames they replaced.

Die casting also replaced stamped steel bulkhead modules. The parts were previously stamped and brake formed, but this process proved too labor intensive. The net shape castings have openings to accommodate different I/O connectors for a flexible configuration of the computers. Tabs and slots are cast in various sizes close to and along the edges of the modules, accomplished with inexpensive tooling inserts. Zinc casting technology achieves excellent dimensional accuracy and thin walls down to 0.025 in., as well as excellent internal soundness and tool life.

Mainframe computer rack

Prototypes and initial production runs of a mainframe computer rack took advantage of graphite mold casting and ZA-12 alloy and achieved low tooling cost and relatively short development time. The graphite mold castings



Graphite mold computer rack

are produced to die casting standards with the critical flatness tolerance held to 0.020 in. across the entire grid, which is 10-1/4 in. x 16-3/4 in.

Graphite mold casting provided the computer manufacturer with two distinct benefits. First, the production method, including tooling, provides a cost savings over an all-machined grid. Second, because the ZA-12 grids are molded to die cast dimensional standards, the development of steel die-cast tooling can be delayed until engineers are comfortable that there are no further changes. During early stages of its life cycle, tooling changes can be quickly and economically made in graphite. An engineering change can be completed in three to four days compared to weeks with steel tooling.

Optical drive decks

ZA-12 and graphite permanent mold casting satisfied three important design requirements for the manufacture of an optical drive

deck-high mechanical properties, near-net shape and economical low-volume production. Previous experience with aluminum investment casting did not produce the sought after stiffness. Additionally, ZA-12's high zinc content provides the deck with excellent sound and vibration dampening characteristics.

The drive deck, measuring 7-3/4 in. x 5-3/8 in. x 2 in. and weighing approximately 1-3/4 lbs., is cast square along all planes.



Top side of drive deck



Under side of drive deck

The whole process is controlled to the point where the decks are ready for finish machining right out of the mold, eliminating preparatory machining. Three as-cast pads on the deck's underside serve as machining locator points.

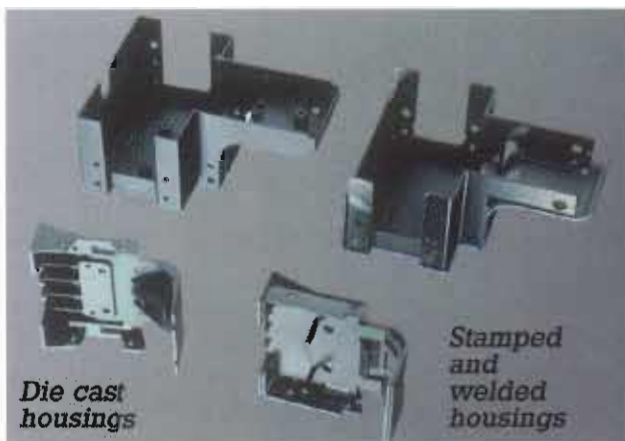
Cooperation between designers and the caster in the initial stages of the design process permitted close attention to dimensions critical to fit, while leeway was granted to non-critical dimensions. In this manner an easy-to-cast component requiring minimal machining was produced, maximizing the total value of the casting.

Sensor housings

The top and bottom sensor plates for a dollar bill changer houses the unit's sensor and circuit board. Both components were originally designed as two-piece stamped steel weldments. However, dimensional stability varied, causing poor fits and high rejection rates.

Both components were redesigned as zinc die castings, achieving close dimensional tolerances, ± 0.005 in. versus ± 0.020 in., and the reduction of the part rejection rate from 30 percent to less than one percent. In addition to tight dimensional control, the spot welding operations were eliminated, resulting in substantial cost reductions.

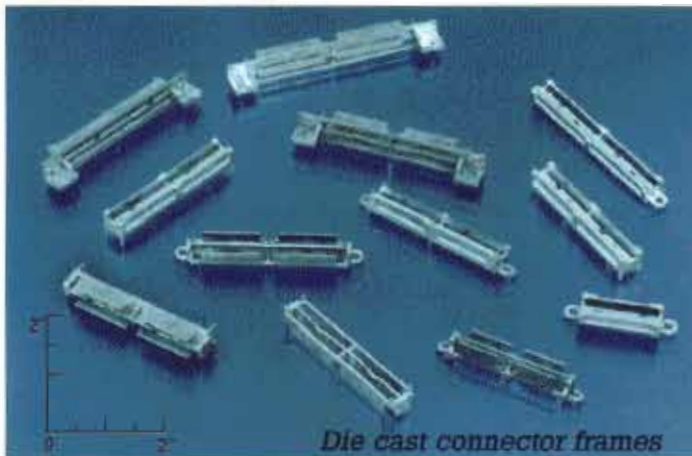
Die casting allows designers to combine functions into a single component. In this case, the sensor plate includes bosses, mounting areas, windows and holes. The only machining performed is hole tapping.



Connectors

High density connectors

High density connectors encompass a wide range of receptacles and plugs in various printed circuit board mounting configurations. The central area of the connectors—where the male pins and female receptacles fit together—is common. Variation occurs in the different mounting schemes.



Die cast connector frames



High density connector

What all the connectors have in common are requirements for thin-wall construction, extreme flatness and precise dimensional control. A complete connector may be quite complex, featuring 40 to 200 pins. Designers utilize zinc die casting to accommodate the following connector requirements:

- Flatness across the mounting plane within ± 0.005 in.
- Projecting blades with 0.035 in. wall thickness tapering to 0.028 in.
- Cast-in mounting holes of 0.040 in. diameter.
- Openings with Y-shaped lead-in grooves to guide the mating parts to a precise fit. The tolerances on all the grooves are $+0.000$ in. / -0.001 in.
- Bright tin plate finish.

Die cast zinc offers designers five distinct advantages over aluminum for this application:

- Capability to design intricate shapes and configurations.
- Thin-wall construction.
- Ease of plating.
- Faster production cycle times.
- Longer die life.

Video jacks

To accommodate the need for numerous cable connections and minimum space, one company developed a miniature video jackfield half the size of a standard jackfield. What made this possible is the miniature jack design. Jacks are used with BNC connectors, which have 5/8 in. centers. By staggering the connections 1-1/4 in., the miniature jack reduces the center spacing to 1/2 in.

A one-piece zinc die casting is now used for the jacks, replacing the original six-piece brass assembly. The assembly required nine separate operations including spot facing, soldering, plating, straightening, assembling and grinding. Quality problems included soft solder, non-concentric bodies and bad solder joints.

Zinc die casting eliminates brass soldering, machining and body assembly time. Durability, appearance and performance are also improved. Production cost savings more than offset amortized tooling costs.

Before final assembly the video jack body is copper and electroless nickel plated. The



Original brass jack

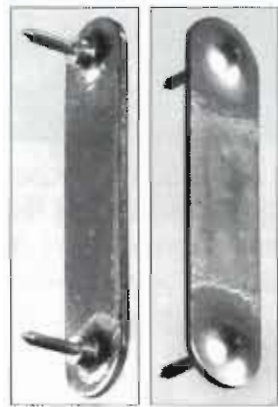


Die cast jack

electroless nickel is applied through barrel plating. This combination provides two major benefits: a 1:1 deposition without build-up and process control of 0.0001 in. Electroless nickel offers both wear and corrosion resistance and provides a degree of lubricity for easier assembly.

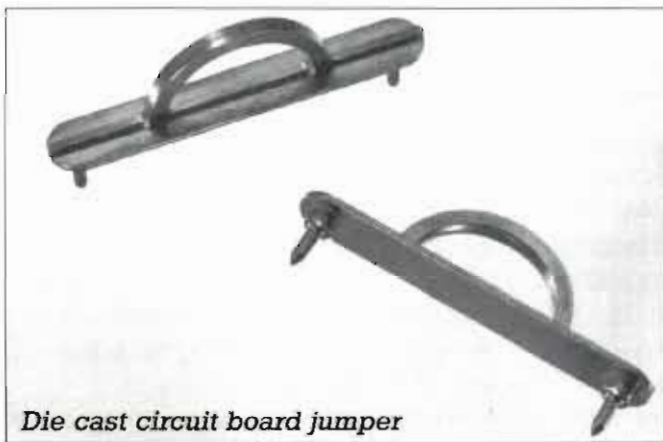
Cable circuit board jumper

A cable circuit board jumper is a simple device enabling current to bridge voids in a circuit board. This small component, 1/4 in. x 1-5/8 in., provides uninterrupted current in the absence of plug-in accessories. The jumpers provide a 75 ohm impedance match.



Soldered jumper assembly

The jumper was originally designed as a fabrication consisting of two screw machined pins soldered to a stamping and silver plated. The jumper was redesigned as a single-piece zinc die casting with an added design feature. A loop was designed into the



Die cast circuit board jumper

top surface to function as a finger grip. This made it easier to remove by spreading the retracting force and also adding rigidity to the jumper, minimizing pin breakage.

The cost savings before tooling totaled 68 percent.

Coaxial/RF cable connectors

The typical coaxial cable connector is a screw machined brass or stainless steel component. However, die cast zinc is replacing brass and stainless connectors with increasing frequency. Reported savings are in the 30 to 40 percent range, with improved turnaround times.

One example involves a three-piece connector assembly. Two of the subcomponents were relatively simple conversions to zinc die casting. The third subcomponent, a body assembly with slots, required modification.

Die casting enables engineers to incorporate extra detail into a component.



3-piece coaxial connectors

With the slotted body connector, it was the addition of internal ribs used to firmly hold a plastic insert. Previously, the plastic had to be pinned in place. To assure proper fit, the automated assembly process includes an additional step to size the connector opening, correcting any deformation.

Grounding contact

A grounding contact for a trunk amplifier used in the cable industry is die cast for low cost manufacturing. The cross hole is as-cast with the center hole tap the only secondary operation. The base of the contact is plugged into a board and soldered.



Zinc grounding contacts

Connectors

Fiberoptic connectors

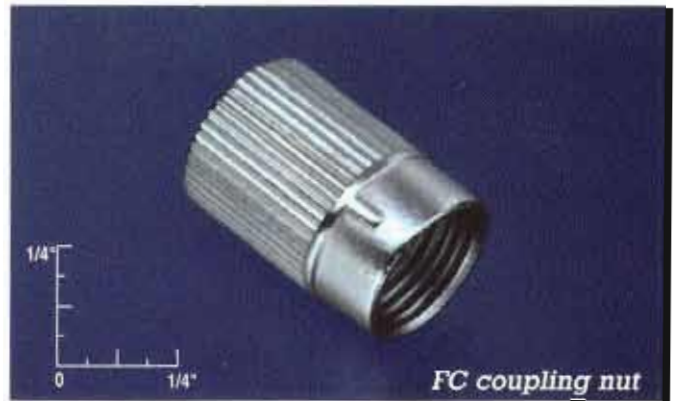
Three important characteristics are considered when designing fiberoptic connectors—the level, durability and performance reliability. Zinc die casting plays a role when considering durability. Zinc permits the design of strong,



thin wall backbones with tight dimensional tolerances. Zinc holds up better than plastic in automatic assembly operations and resists warpage under normal operating temperatures.



ST connectors - Nickel-plated zinc die casting has become the standard in the manufacture of ST connectors. Standard tolerances can be held to ± 0.001 in. For the critical backbone



component, tolerances can be tightened. For best results, less than standard dimensional tolerances should be reviewed with an appropriate die caster before the design is finalized. *FC Connectors* - The round coupling nut is designed to withstand 1000 insertions with zero



failure, the standard set by the imported screw machined version. A criteria for the die cast nut is that it be indistinguishable from the machined version. The parts are electroless nickel plated for wear, shielding and aesthetics.

The FC backbone pictured above was specially developed for press fitting with the ferrule. The part ID is held to a 0.0004 in. as-cast tolerance. There are no secondary operations. Parts are normally electroless nickel plated for internal throw. The sample pictured illustrates a blackened electroless nickel finish.



INTERZINC is a market development and technology transfer group, dedicated to increasing awareness of zinc casting alloys among engineers, designers and specifiers. It aims to accomplish this mission through technology transfer, technical services and designer education programs.

Casting technology is not a process frozen in time. Ongoing advancements in zinc casting technology greatly benefit those who select materials for industrial and consumer products. INTERZINC'S programs are structured to assist manufacturers in determining how zinc can be cost-effectively employed for a wide range of end uses.

Since its formation in 1986 by three zinc producers and two zinc alloyers, INTERZINC has participated in national and international exhibitions; presented technical sessions at these exhibitions and conducted its own technical seminars. Through these activities INTERZINC has provided potential end-users of zinc castings with the following services:

- Technical literature
- Alloy and process selection help
- Casting design and prototyping assistance
- Product feasibility studies.

For information and assistance contact INTERZINC:

Phone: 1-800-247-6265

Fax: (313) 794-3940

P.O. Box 455

Algonac, MI 48001-0455