Metalcasters and engineers have joined forces to adapt to a new legislative measure that decreased the amount of lead allowed in copper plumbing.

Shea Gibbs, Assistant Editor

California Gov. Arnold Schwarzenegger has a history of throwing weights around. Prior to entering politics, he was a 13-time world bodybuilding champion. Now, he has turned his world famous brawn on the metalcasting industry.

Since he was elected to office, Schwarzenegger has passed numerous bills aimed at cleaning up the environment. One of the more recent may affect the way in which copper metalcasters operate in the coming years. California bill AB 1953, signed into law Sept. 30, 2006, reduced the state’s allowable lead content in potable water-bearing copper pipe and other plumbing fixtures from 8% to 0.25%.

“I signed this bill to reduce the amount of lead exposure in California’s drinking water,” said Schwarzenegger. “We need to make sure that the water we consume is safe for everyone, especially our children.”

Existing pipes and fittings will not be removed or replaced, but all future installations must adhere to the new limits. The two most common alloys currently used to cast such components, C84400 and C83600, contain higher lead concentrations than are allowed under the new law. What’s more, currently no plumbing

California Gov. Arnold Schwarzenegger signed AB 1953 on Sept. 30, 2006, bringing the allowable lead content in potable water-bearing fixtures down to 0.25%.
manufacturers can meet the new limits. With the changeover scheduled for Jan. 1, 2010, some are concerned that the timeframe is too tight.

Others in the metalcasting industry question whether the lead in copper plumbing even contaminates the water supply. Nevertheless, the state law should be considered a national issue, as all casting shipments to the state will have to comply with the law. Also, according to state legislative experts, environmental bills that originate in California often proliferate throughout the union.

In response, metalcasters and copper plumbing designers have come together to find the ideal metallurgical alternatives, which must be used in all components made for California on or after the Jan. 1, 2010, deadline.

"You currently have two predominant, [leaded] copper alloys," said Robert Beard, Sloan Valve Co., Franklin Park, Ill., who chairs a subcommittee of the AFS no-lead copper alloy consortium (a copper alloy research group) that is looking for alternatives to leaded copper alloys other than copper-bismuth. "Those are going to be replaced by as many as six to eight different alloys. Each company is going to have to determine for their application which of the available options fits them best in terms of price, machinability and what their customers are demanding. We think the more alternatives we can offer, the better off you are."

The Leader in the Clubhouse
As early as 1990, industry researchers began testing metalcasting alloys that could replace coppers that rely on lead for castability and machinability. Copper-bismuth emerged as the leading candidate. Research then stalled, until recently.

The no-lead copper alloy consortium, which includes metalcasters, alloy producers, potable water fixture manufacturers, a research lab and trade associations, has posted several possible alternatives in addition to copper-bismuth—copper-silicon alloys and tin-based alloys. Manufacturers also are free to develop proprietary alloys, though that process has not been conducted publicly.

Current research indicates that the greatest challenge in developing bismuth as the primary alternative to lead will be coming up with enough of the material. The first problem, though, is coming up with enough information on the material.

"Even the U.S. government is frustrated with trying to come to terms with the global availability and annual production figures for [bismuth]," said Jim Mallory, executive director of the Non-Ferrous Founders' Society and chair of the copper consortium’s Material Availability and Cost subcommittee, which is exploring the most well-known alternative to leaded copper, copper-bismuth. "They rely on information provided from other countries, and the accuracy or validity is always called into question."

Only three global mining outfits currently are known to contribute to the world's supply of bismuth, and they don't even mean to do so. Miners in China, South Africa and Canada produce the metal only as a byproduct in the mining of another material—lead. To further deepen the irony, if the world-wide demand for lead decreases, those miners will produce less bismuth.

There could be more bismuth production going on elsewhere on the globe, but those three main producers combine for only 6,000 metric tons of the metal per year, which will not be enough to support an industry-wide changeover to copper-bismuth alloys in potable water applications. That's not to say that the supply will simply dry up, but such a rapidly increasing demand will drive bismuth costs (already 100% greater than lead) through the roof, and it may be difficult for miners to keep pace.

"We estimate that if all lead in plumbing brass in the U.S. needed to be replaced, it could add as much as 2,000 metric tons, increasing global production by 33%," Mallory said. "Is that something that can happen quickly? We don’t know."

Holding It Back
Inadequate production notwithstanding, bismuth will encounter some problems when and if it makes its way...
"We're looking to help OEMs of plumbing products make intelligent business decisions."—Geary Smith, Manufacturer's Brass and Aluminum

into metalcasting and machine shops. While for the most part the metal demonstrates good castability, machining it is turning out to be a challenge.

“The problem is that the legislation is enacted based on political considerations, not the feasibility or availability of the materials,” Mallory said.

Lead-coated copper has long served the plumbing industry, largely due to its unsurpassed machinability. Significant ductility and elongation make the alloy capable of rapid machining without the use of coolant. Bismuth alloys, when machined in a similar manner, tend to crack.

“People have made castings with [bismuth] alloys, but they have made significant changes to the machining process, changing the type of tooling they use and adding the coolant, which slows the whole process down,” said Geary Smith of Manufacturer’s Brass and Aluminum, Blue Island, Ill., a member of the consortium’s Machining subcommittee, which is exploring the machinability of all alternatives to leaded copper.

Elevated hardness in bismuth alloys, which is tempered by selenium, also will induce an eventual price increase in the machining process, as tool wear is greater than with the leaded material. The use of coolant also adds another step in the process when a component must be brazed; the metal must be more thoroughly cleaned to remove the coolant prior to brazing.

**Copper Alternatives Go Unleaded**

The two leading copper alloys in potable water applications, C84400 and C83600, exceed California’s new low-lead regulations, which stipulate that no alloy may contain more than 0.25% of the metal. Metalcasters and engineers are therefore on the hunt for viable alternatives.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Lead Content</th>
<th>Casting Processes</th>
<th>Machinability</th>
</tr>
</thead>
<tbody>
<tr>
<td>84400</td>
<td>6-8%</td>
<td>S, C</td>
<td>Excellent</td>
</tr>
<tr>
<td>83600</td>
<td>4-6%</td>
<td>S, C, I</td>
<td>Excellent</td>
</tr>
<tr>
<td>91000 (Tin-Bronze)</td>
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<td>S, C, PM, I</td>
<td>Unknown</td>
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<tr>
<td>Copper-Bismuth</td>
<td>0%</td>
<td>S, C</td>
<td>Moderate</td>
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<tr>
<td>Copper-Silicon</td>
<td>0%</td>
<td>S, C</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

S = Sand, C = Centrifugal, I = Investment, PM = Permanent Mold

Copper Alternatives Go Unleaded

If the world’s bismuth mining can’t ramp up quickly, alternatives to the bismuth alternative must be found, or the metal castings necessary for plumbing production just won’t be there.

“There are plastic pipes or fittings,” Mallory said. “But there are some things that cannot be done with plastic pipe.”

Luckily, several additional alternatives currently exist. One of them has been around for a long time, but it will require some tweaking before it can step into leaded copper’s role.

“We’re down to 90300 (a tin-bronze copper alloy) and a couple modifications,” Beard said. “You’re going to have to have parts in the pipeline by 2009 to have them in distribution by 2010. So we took a known alloy. It will be easier to get that approved if we need it approved.”

Fresno Valve Co., Selma, Calif., poured several castings out of the tin-based copper alloy in January; the castings are due to be machined and tested for their compatibility with potable water applications in the coming months. Early indications are that the alloy is castable, and visual inspection shows a sound casting. However, machining results could render the process incompetent.

“It could take some of the pressure off of other alternatives, but we don’t know how well it’s castable yet,” Beard said. “We’ve got to machine and see if we run into any defects.”

Researchers are less far along developing silicon-coppers. Private companies have taken on this task in some cases, but a spokesperson from Kohler, a leading plumbing manufacturer, declined comment on the company’s progress.

“There’s nothing out there that’s going to be a one for one replacement for the [leaded alloys],” Beard said. “There are negatives to any options we choose. It’s not good, and it’s not good for the customer.”

Shoulder the Load

When all the research is done and all the alloys are classified, it will be up to
Alternatives to leaded copper must be used in all components made on or after the Jan. 1, 2010, deadline.

the metalcaster to make the new metals his or her own. In-house testing will be a pivotal final step.

“Everyone makes their own product and uses their own processes,” Smith said. “So they will have to do some fine tuning. [Current research] will be a good guideline, but it’s not going to be the panacea that some people think it will be. This is a serious and difficult challenge for the copper industry to deal with.”

The extent of the challenge will be illuminated in the coming months. Metalcasters currently are pouring eight different plumbing castings out of the various alternative alloys. The next step will be to send the castings to machining firms to learn more about their soundness. Researchers expect that accurate, practical data will be available by 2008, at which time more will be known about the specifics of the alternatives.

“We’re constantly evaluating our progress and determining what further work needs to be done before we can reach conclusions and a consensus,” Smith said. “We’re looking for a consensus that we can put to good use to help an OEM of plumbing products make intelligent business decisions.”

For More Information