design FOR THE ENVIRONMENT

Lead-Free Solder Partnership

What Is EPA's Design for the Environment Program?

EPA's Design for the Environment (DfE) Program works in partnership with a broad range of stakeholders to reduce risk to people and the environment by preventing pollution. Partnerships focus on industries that combine the potential for chemical risk reduction with a strong motivation to make lasting, positive changes. DfE convenes partners, including industry representatives and environmental groups, who develop goals and guide the work of the partnership.

As incentives for participation and driving change, DfE offers unique technical tools, methodologies, and expertise. Partnerships evaluate the human health and environmental risks, performance, and cost of traditional and alternative technologies, materials, and processes.

DfE has formed partnerships with a range of industries including:

- Auto refinishing
- Chemical product formulators
- Electronics
  - Printed wiring board manufacturing
  - Lead-free solder
  - Computer displays
- Furniture
- Garment and textile care
- Industrial and institutional laundry
- Printing
- Wire and cable

Solders in Electronics: A Life-Cycle Assessment

Why Did the Partnership Evaluate Solders?

Solder composed of tin and lead is a fundamental material joining electronic components to circuit boards in the assembly of almost every type of electronic product. The electronics industry, however, is facing significant international legislative and market pressures to phase out the use of tin-lead solders and switch to lead-free alternatives. Such a switch will require significant capital expenditures and may have a broad impact on public health and the environment. The electronics industry, as well as public interest and governmental organizations, are concerned about the lack of research to date on the potential environmental effects of the alternatives to tin-lead (SnPb) solder.

Approximately 176 million pounds of tin-lead solder was used worldwide in 2002. Lead, a chemical known to be toxic, can be released into the air and groundwater throughout its life cycle, from mining and use to waste treatment and disposal. Once in the environment, lead is persistent (as are all metals) and bioaccumulates in the food chain.

Concerns about potential risks have led to initiatives by several nations (e.g., European Union and Japan) to mandate or encourage the electronics industry to replace lead solder with lead-free alternatives. Industry experts estimate that U.S. industry could lose approximately $240 billion over only three years if the United States does not respond to these initiatives quickly and competitively by identifying viable alternative solders that perform well, are cost effective, and pose fewer environmental risks.

Virtually all research about potential substitutes for lead in solder, however, has focused strictly on performance. Although U.S. industry needs to move ahead with alternative products to remain competitive, information about life-cycle impacts and risks of the alternatives is lacking. This has raised concerns for both industry and the public about the possible future business and environmental risks of making a wholesale switch from lead to other metals.

What Were the Partnership's Goals?

To address the information gap on the impacts of leaded and lead-free solders, EPA's Design for the Environment (DfE) Program entered into a voluntary partnership with representatives of the electronics industry and other interested parties to evaluate the life-cycle environmental impacts of tin-lead solder and four alternative lead-free solder compositions.

Project partners included electronics manufacturers and assemblers, trade associations (the Electronic Industries Alliance and IPC—Association Connecting Electronics Industries), academic and research organizations (e.g., University of Tennessee), and public interest groups. Contributing industry partners included Agilent, Cookson Electronics, Delphi Delco, Hewlett-Packard, IBM, Intel, Pitney Bowes, Rockwell Collins, Sematech, and Thomson Multimedia.

Specific goals of the project included:

- Evaluating the environmental impacts of tin/lead solder and selected lead-free alternative solders;
- Evaluating the effects of lead-free solders on recycling and reclamation at the end of the electronic product life-cycle; and
- Assessing the leachability of lead-free solders and their potential environmental effects.

What Solders Were Evaluated by the Partnership?

The partnership examined life-cycle impacts of tin-lead solder and the following lead-free solders:

- 95.5% tin, 3.9% silver, and 0.6% copper;
- 57.0% bismuth, 42.0% tin, and 1.0% silver;
- 96.0% tin, 2.5% silver, 1.0% bismuth, and 0.5% copper; and
- 99.2% tin and 0.8% copper.

These solder alternatives were selected by the industry partners because they have shown promising performance as substitutes for tin-lead solder. Solders were evaluated in both paste form, used in "reflow" soldering, and bar form, used in "wave" soldering. Wave soldering is used mostly in low-tech, low-cost applications, and reflow soldering is usually used for higher-tech applications. Using a life-cycle assessment (LCA) approach, the study has generated data to help manufacturers, users, and suppliers of solder incorporate environmental considerations into their decision-making processes.

What Were the Project's Results?

A life-cycle assesment examines the full life cycle of a product, and estimates environmental impacts from each of the following life cycle stages: raw material extraction or acquisition and material processing; solder manufacture; solder application; and end-of-life disposition.

The LCA results can be used by industry to select lead-free solders that work well for reflow or wave soldering applications and that may have fewer impacts on public health and the environment.

- For paste solders, bismuth/tin/silver had the lowest (best) impact scores among the lead-free alternatives in every category except non-renewable resource consumption.
- For bar solders, when only lead-free solders were considered, the tin/copper alternative had the lowest (best) scores.
- Three major contributors to overall life-cycle impacts include energy consumption during solder application, silver mining and extraction for silver-bearing alloys, and potential leachate from landfilling the SnPb alloy.

A detailed discussion and presentation of the results can be found at www.epa.gov/dfe.

How Can I Get More Information?

To learn more about the DfE Program or the Lead-Free Solder Partnership, or to obtain an electronic version of this fact sheet (document #EPA 744-F-05-003), visit the Office of Pollution Prevention and Toxics' DfE Program Web site: www.epa.gov/dfe.

To obtain hard copies of DfE Program technical reports, pollution prevention case studies, and project summaries, contact:

National Service Center for Environmental Publications
U.S. Environmental Protection Agency
P.O. Box 42419
Cincinnati, OH 45242
Phone: (513) 489-8190, (800) 490-9198
Fax: (513) 489-8695
E-mail: ncepimal@one.net