Removing contaminants from crushed glass containers

by Robert De Saro

Contamination from ceramics and non-ferrous metals is a serious impediment to glass container recycling. Field testing of new sorting equipment offers hope.

The container glass industry wants to use as much reasonably priced scrap glass as can be obtained. Increased cullet use results in a combination of furnace energy use reduction, furnace production increase and furnace emission reduction; the exact value of each depends on individual furnace operations. (Cullet is broken scrap glass, typically bottles and jars.)

Additionally, pressure from legislation forces container plants to use more cullet and increases scrap bottle recovery. In 1992, historically high levels of cullet use were achieved — 2.4 million tons (1) — resulting in a nationwide container plant recycling average of 22 percent.

A major impediment to high cullet levels is glass contamination, most importantly from ceramics. Ceramic contaminants enter the cullet stream when consumers mistakenly include these materials with their glass containers and also through the cullet distribution chain.

Contamination from consumers is generally pottery, porcelain and glass ceramics. Contamination from cullet distribution is typically stones and gravel that may be inadvertently picked up by front-end loaders or are residual materials in trucks and rail cars used to transport cullet.

Whichever way the contaminants get into the glass, their effect is serious — a reduction in furnace production due to an increase in bottle stone count.

Other contaminants are also present in the glass stream, though most of these can be removed with existing beneficiation equipment:

- Plastic, labels and other light materials — vacuum system
- Ferrous metals — magnetic separation
- Large contaminants — hand picker
- Non-ferrous metals — eddy current detectors.

Of these, non-ferrous metal separation, while easily accomplished, extracts the largest penalty — about 5 to 8 percent glass loss.

Glass container plants that want to boost

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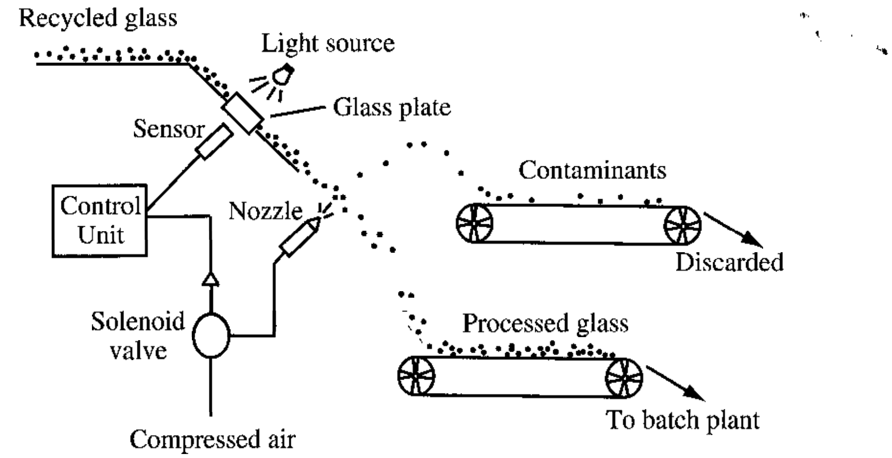
■ **Figure 1 – Ceramic separator**



ource: Energv Research Co., 1994.

eir cullet use face two problems:
removing ceramics
removing non-ferrous metals (with minimal glass loss).

These problems were addressed in an ›plied research and development program investigate and demonstrate state-of-the-t ceramic separation and non-ferrous metal ›parators. This article presents the results the engineering evaluation and the field sting of both separators (2).

Ceramic separator

Optical techniques were selected as the most suitable approach to ceramics separation since they have been commercially proven in the food and pharmaceutical industries, and more recently have been used in the European glass industry.

Glass first enters a vibratory feeder, which spreads the glass evenly over the separator's width, typically four feet (see Figure 1). The glass then slides down a metal plate, the angle

What did the tests find?

Ceramics separator
- ✔ Most of the ceramic pieces that entered the separators were smaller than ¼".
- ✔ The separation efficiency at ½" was lower than expected.
- ✔ Glass loss was variable, depending on operator-set sensitivity.

Non-ferrous metal separator
- ✔ The separator did a good job of removing all metal contaminants.
- ✔ Field test results were lower than laboratory results.
- ✔ The separator continues to operate.

of which is set to assure a continuous flow c a single layer of glass without much tumblin; At the bottom of the incline, the glass ente the detector, which consists of a pulsed ligl source on top, photodiode detectors on tl bottom and a glass plate in between. The ligl either passes through the glass and is sense by the detectors, or is blocked by an opaqu ceramic. The glass next free falls past a serie of nozzles and, if a ceramic has been detec ed, one or more of the nozzles will fire a higl pressure air jet and the offending cerami along with a small amount of glass, i removed. The glass leaves the separator as clean stream.

Anything opaque to the light will be sense and rejected by this system, including mo ceramics, aluminum coated labels, lead an crushed aluminum rings — as long as the are larger than a quarter-inch. Anythin smaller will most likely pass through unde ected.

A detailed search both in the U.S. an abroad was conducted to locate vendors th could supply the needed equipment. The tea of MSS (Nashville, Tennessee) and Siemen (Germany) was selected from a list of 56 poter ial vendors, based on the following criteria:

- low cost
- experience
- technical and sales force in U.S.

Ceramic separator field tests

MSS's ceramic separator, known as ELKE was installed at RRT's Syracuse, New Yor recycling facility in July 1992. The ELK is the final step in RRT's beneficiation proces and is preceded by vacuuming of light object non-ferrous and ferrous metal removal, an hand picking of large pieces. RRT's facilit is typical of glass recycling facilities excep that its vacuum system may have been unde sized, which resulted in copious amounts c loose plastic labels remaining in the glass.

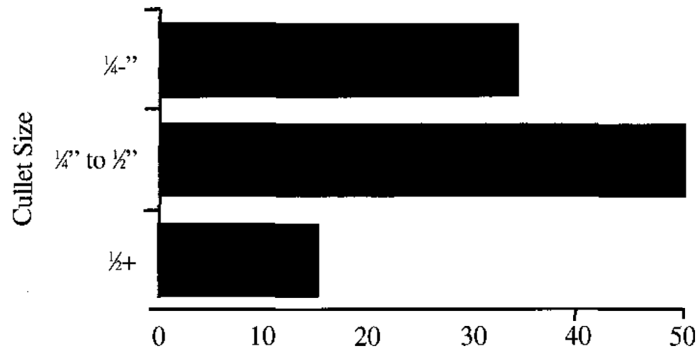
A 30-pound sample was taken alternativel downstream and then upstream of the ELKE Each sample was screened to produce three size cuts: ¼-"; ¼" to ½"; and ½+". In each size cut, the number of ceramics was counted. Statistical inference was applied to the total number of samples to determine the separation efficiency of each cut.

The data reported here were the result of manually sorting 2,624 pounds of glass for ceramic and metal contaminants over a two-month period. Glass samples were taken both before and after this period, but the data were discarded due to various equipment malfunctions.

In previous laboratory testing of the ELKE, the test results represented the ELKE performance isolated from all other influences and was, therefore, the best performance achievable. In contrast, the field tests include the effect of the upstream equipment. In a broad sense, the field test results represent the performance of the entire beneficiation process, with the ELKE simply the last step in a series of events. This is an appropriate approach, since what is of interest is not how well the ELKE works but, rather, how well the entire system performs in eliminating ceramic contaminants.

Several problems arose during the field

■ **Figure 2 — Cullet size distribution, weight in percent**



Source: Energy Research Co., 1994.

■ **Table 1 — Ceramic and metal pieces entering the separators, number of pieces by size (1)**

	Ceramic (mean)	Standard deviation	Metal (mean)	Standard deviation
½+"	4.7	0.8	8.3	0.3
¼" to ½"	4.3	0.1	1.7	0.4
¼-"	16.8	0.9	(2)	(2)

(1) Per 100 pounds of glass.
(2) Insufficient data.

Source: Energy Research Co., 1994.

tests that affected the results:

- The vacuum system did not remove all of the loose paper and plastic labels. Although the ELKE was designed to penetrate labels adhering to the cullet, clumps of loose labels caused false rejections, resulting in increased glass loss. Plant personnel often lowered the detection sensitivity to minimize the loss that resulted in reduced detector effectiveness. This was the single biggest problem encountered, and it greatly reduced the separator's performance.
- Several detector channels were damaged, which reduced the separator's effectiveness. The data taken during this period were discarded, but there may have been other periods when the channels were also malfunctioning, but undetected.
- At times, the compressor, which supplied both the ELKE and the ELPAC nonferrous metal separators (see below), had inadequate capacity, resulting in ceramic and metal pieces not being ejected due to low nozzle air pressure.
- The equipment sensitivity settings had to be adjusted continually to reduce glass loss.
- Errors in data collection were possible, since manually removing contaminants down to ¼-" was tedious.

The data for ELKE allowed a characterization of the glass and contaminant loading entering the separators. Figure 2 shows the glass size distribution, and Table 1 shows the contaminant loading.

The ceramic loading entering the ELKE was skewed toward the ¼-" size with about 17 pieces per 100 pounds of glass. This, coupled with the fact that 35 percent of the glass is the ¼-" size, results in a large number of small and essentially nonremovable ceramic particles.

Laboratory results showed that ceramic contaminants below ¼" would not be removed. With the ELKE operating at 15 tons per hour, 1,764 pieces of ¼-" ceramic contaminants pass through per hour. (Fortunately, ¼-" pieces will mostly dissolve in the

■ Table 2 — Ceramic removal rate in the ceramic separator, in percent

	Field separation(1)	Laboratory separation
½+”	52-54	100
¼” to ½”	0	0-100
¼”	14-16	0

(1) Field results given at the 95.5 percent confidence level.
Source: Energy Research Co., 1994.

furnace, unless they are glass ceramics.) The number of larger ceramic pieces entering the detector were 197 pieces per hour of ½+” and 658 pieces per hour of ¼” to ½” of ceramic contaminants. The total number of pieces of ceramic contaminants that would not be removed is 2,619 per hour.

Table 2 shows the removal rate for the ELKE compared to previously acquired laboratory data. The ½+” data separation is much lower than the laboratory results and would allow 93 pieces per hour to pass into the furnace-ready cullet. Assuming these pieces did not dissolve in the furnace and that the cullet was 50 percent of the feedstock, then the percent pack loss attributable to these pieces alone would be about 0.1 percent, a significant amount.

The disappointing results for the larger pieces, compared to the laboratory data, is due largely to the loose paper problems and the resultant reduction in equipment sensitivity, and led to the ELKE being decommissioned. However, after touring the ELKE installation, Coors is considering operating the separator in its facility, because Coors doesn’t have a problem with loose paper labels.

Non-ferrous metal separator

Although the focus of the program was ceramic detectors, the opportunity arose to test an advanced design on a non-ferrous metal separator called the ELPAC, also offered by MSS, that was installed in RRT’s facility along with the ELKE.

The advantage of the ELPAC is not that it can eliminate non-ferrous metals; there are several commercially available devices that can do that. The ELPAC, however, removes the metals with a greatly minimized glass loss — 0.5 percent compared to 5 to 8 percent for conventional devices. This is attributable to the nozzle-style removal arrangement, in contrast to the more prosaic diverter valve used by conventional separators.

The ELPAC, however, extracts a price — it costs more, is larger, and it can miss metal contaminants due to momentary air pressure lapses or solenoid valve cycling. Also, the ELPAC cannot remove heavy metal objects such as large bolts because the nozzles provide limited removal force.

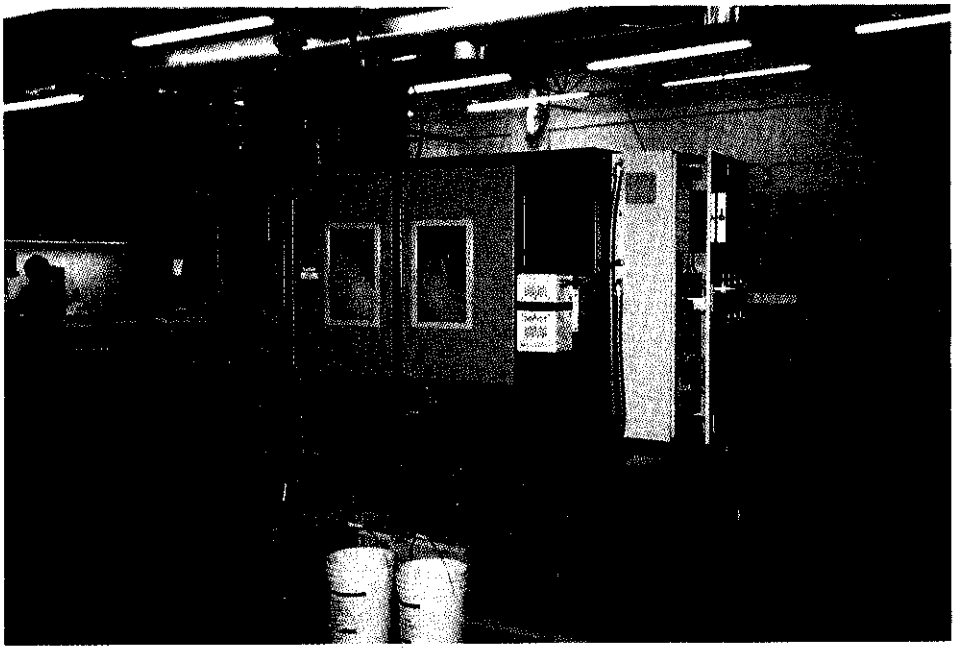
The ELPAC, installed at RRT’s Syracuse facility in July 1992, is the next-to-the-last step in the beneficiation process, immediately preceding the ceramic separator.

The problem with Vision Ware

Vision Ware is a transparent glass ceramic made by Corning. Consumers mistakenly recover it for recycling because it looks very much like amber bottle glass.

Unfortunately, none of the equipment tested could detect Vision Ware samples — not surprising, since its transmissivity is too close to amber to be discernible.

Also, glass melt crucible data show Vision Ware’s solubility to be quite low, causing repeated passage through the furnace even for small-sized contaminants. This restricts the amount of foreign cullet that can be used.



An ELKE ceramic separator was installed at the recycling facility of RRT in Syracuse, New York.

■ Table 3 — Non-ferrous metal removal rate in the metal separator, in percent (1)

	Field separation	Laboratory separation
½+"	90	100
¼" to ½"	68-73	100
¼-"	(2)	0

(1) Field results given at the 95.5 percent confidence level.
(2) Insufficient data.
Source: Energy Research Co., 1994.

Field test procedures were the same as described for the ceramic separator. The metal contaminant loading for ½+" was 8.3 pieces per 100 pounds of glass, and for ¼" to ½" it was 1.7 pieces. There were insufficient data at the ¼-" size. (See Table 1.)

At a throughput of 15 tons per hour, the number of metal contaminants entering the ELPAC would be: ½+", 348.6 pieces per hour; and ¼" to ½", 260.1 pieces per hour.

The results of the field data, compared to the laboratory results, are shown in Table 3.

The field separation, while good, was less than the laboratory data, particularly at the ¼" to ½" size cut.

Two possible reasons account for this:

- Periodic air compressor capacity limits, as mentioned previously, could allow pieces to be detected but not removed.
- Continual sensitivity adjustments by the plant personnel could have led to periods in which the sensitivity was set too low.

The separation was good enough that the ELPAC is currently operating, and RRT plans to keep it in operation. **RR**

Footnotes

(1) "Recycling Update," *American Glass Review*, May 1993.

(2) New York State Research and Development Authority, *Automatic Separation from Recycled Glass: Final Report*, prepared by Robert De Saro, July 1993.