Digital Equivalent Data System for XRF Labeling of Objects

Conventions for XRF labels and converting XRF spectra to alphanumeric data leads to new identification method.

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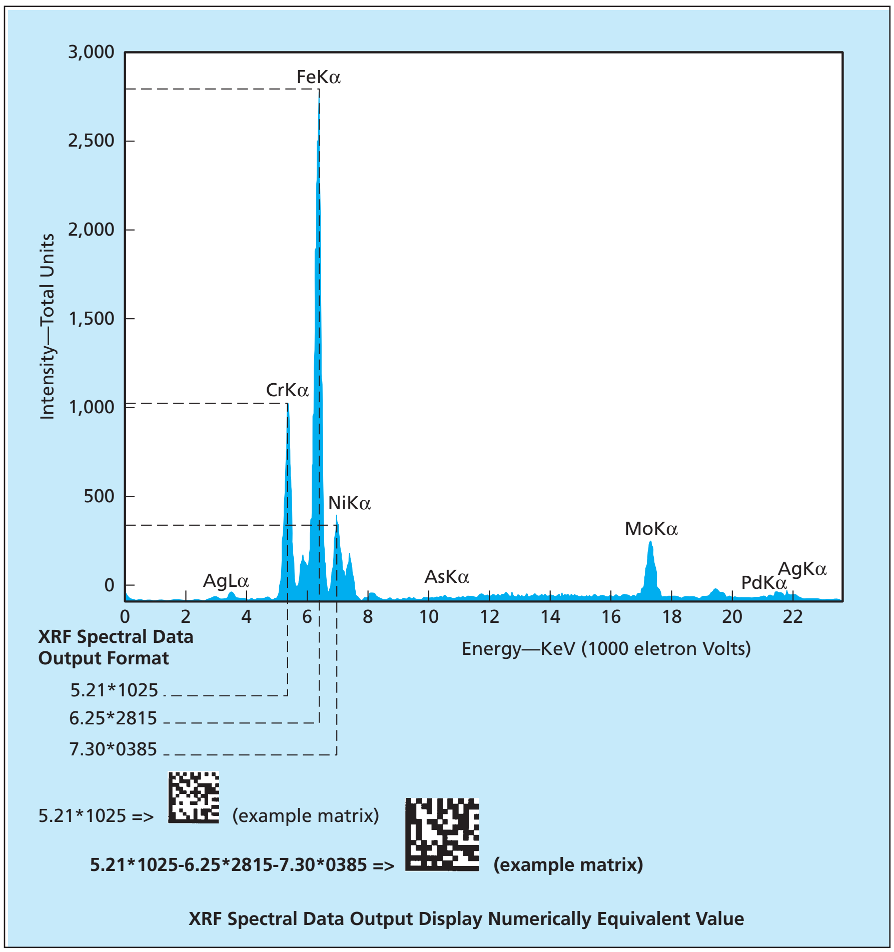
A digital equivalent data system (DEDS) is a system for identifying objects by means of the x-ray fluorescence (XRF) spectra of labeling elements that are encased in or deposited on the objects. As such, a DEDS is a revolutionary new major subsystem of an XRF system. A DEDS embodies the means for converting the spectral data output of an XRF scanner to an ASCII alphanumeric or bar-code label that can be used to identify (or verify the assumed or apparent identity of) an XRF-scanned object.

A typical XRF spectrum of interest contains peaks at photon energies associated with specific elements on the Periodic Table (see figure). The height of each spectral peak above the local background spectral intensity is proportional to the relative abundance of the corresponding element. Alphanumeric values are assigned to the relative abundances of the elements. Hence, if an object contained labeling elements in suitably chosen proportions, an alphanumeric representation of the object could be extracted from its XRF spectrum. The mixture of labeling elements and for reading the XRF spectrum would be compatible with one of the labeling conventions now used for bar codes and binary matrix patterns (essentially, two-dimensional bar codes that resemble checkerboards). A further benefit of such compatibility is that it would enable the conversion of the XRF spectral output to a bar or matrix-coded label, if needed. In short, a process previously used only for material composition analysis has been reapplied to the world of identification. This new level of verification is now being used for "authentication."



The **Coordinates of Each Peak in an XRF Spectrum** of a label would contribute information on the contents of the label: The horizontal coordinate would indicate a photon energy and, hence, the identity of an element; the vertical coordinate would indicate the spectral intensity and, hence, the abundance of the element.

The DEDS as described thus far would be used to process XRF spectral data output only. In one of several alternatives, an object could be labeled with both a conventional bar or matrix code and an XRF tag, so that the XRF tag could be used to provide redundant, additional, or confirmatory information. In that case, the DEDS would analyze the XRF tag and convert the readings to alphanumeric data in a recognized format. In yet another alternative, the XRF scanner would be used to acquire an XRF spectrum of not only the XRF tag but also the substrate material surrounding the tag. In that case, the spectral data output from the substrate would constitute an additional set of data that could be combined with the XRF label data and the bar-code or matrix readout to obtain an alphanumeric label unique to the labeled object or to the class that it represents.

Authentication is the natural evolution of the identification process as security technologies are combined with it. The XRF DEDS provides a unique set of methods to determine if an object is genuine. The respective sets of information cannot be duplicated and answers the question "is that the original object."

Authentication using XRF DEDS is expected to have no negative impact on existing networks as its conversion is in ASCII format, and convertible to bar code or other symbology formats. In fact it is expected to simply "fit in" with other members of the identification technology family. It is intended as a process to eliminate counterfeits and knock-offs, enabling the routine data collection in the downstream process using bar codes and matrix codes to be much more secure. Finally, it is expected to find its way into the courtroom, having the unique insight as to which object is genuine and which is not. Authentication using XRF DEDS may well be the next-generation expert witness in product liability cases.

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In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MFS-31886, volume and number of this NASA Tech Briefs *issue, and the page number.*

Identifying Objects via Encased X-Ray-Fluorescent Materials — the Bar Code Inside

XRF spectra would be used as labels, similarly to bar codes, inside a product.

Marshall Space Flight Center, Alabama

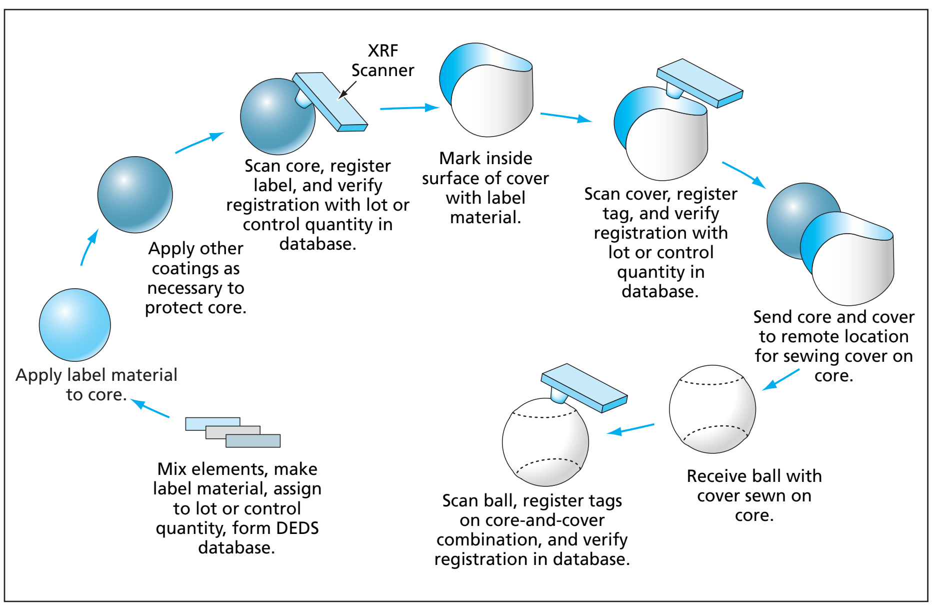
Systems for identifying objects by means of x-ray fluorescence (XRF) of encased labeling elements have been developed. The XRF spectra of objects so labeled would be analogous to the external bar code labels now used to track objects in everyday commerce. In conjunction with computer-based tracking systems, databases, and labeling conventions, the XRF labels could be used in essentially the same manner as that of bar codes to track inventories and to record and process commercial transactions. In addition, as summarized briefly below, embedded XRF labels could be used to verify the authenticity of products, thereby helping to deter counterfeiting and fraud.

A system, as described above, is called an "encased core product identification and authentication system" (ECPIAS). The ECPIAS concept is a modified version of that of a related recently initiated commercial development of handheld XRF spectral scanners that would identify alloys or detect labeling elements deposited on the surfaces of objects. In contrast, an ECPIAS would utilize labeling elements encased within the objects of interest.

The basic ECPIAS concept is best illustrated by means of an example of one of several potential applications: labeling of cultured pearls by labeling the seed particles implanted in oysters to grow the pearls. Each pearl farmer would be assigned a unique mixture of labeling elements that could be distinguished from the corresponding mixtures of other farmers. The mixture would be either incorporated into or applied to the surfaces of the seed prior to implantation in the oyster. If necessary, the labeled seed would be further coated to make it nontoxic to the oyster. After implantation, the growth of layers of mother of pearl on the seed would encase the XRF labels, making these labels integral, permanent parts of the pearls that could not be removed without destroying the pearls themselves. The XRF labels would be read by use of XRF scanners, the spectral data outputs of which would be converted to alphanumeric data in a digital equivalent data system (DEDS), which is the subject of the previous article. These alphanumeric data would be used to track the pearls through all stages of commerce, from the farmer to the retail customer.

In another potential application (see figure), an ECPIAS would be used to track softballs. Softball cores and covers are typically manufactured in the United States and shipped offshore where the covers are sewn on. At present, in order to verify the origin of a shipment of assembled softballs returning to the United States, it is necessary to take some balls as samples, cut their covers off, and examine their cores. In contrast, the ECPIAS would make it possible to verify the origin of the balls quickly and nondestructively. The ECPIAS concept could also be applied to other products in which XRF labels could be permanently encased. Examples include balls used in high-profile sports, tires, printed-circuit components, layered clothing items (e.g., shoes), and critical aircraft components.

The ECPIAS is a "next logical step" technology that gives an OEM a new safeguard for product liability. With the bar code inside the part or even mixed with the material of the



Softball Cores and Covers Would Be Labeled by mixtures of elements having unique XRF spectra. The balls would be tracked through the stages of manufacture and transport by using the spectra to verify their identities.