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A Demonstration of the Cleaner Technology Substitute Auditor and Advisor, a Prototype Expert System for Small Printing Businesses

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Abstract

Small businesses, because they do not possess the resources of large businesses, may experience a disproportionate exposure to compliance and enforcement actions by government regulatory agencies. I believe, in many cases, that information technology solutions such as expert systems can help level the playing field. This demonstration illustrates the potential usefulness of expert systems in the small business environment having a potentially large number of users. This system is a field-tested prototype expert system for small printers, as a proof of concept. That system has been commended by both environmental agencies and potential users alike as a dramatic conceptual improvement in environmental compliance.

Introduction

We received a grant from the Environmental Protection Agency to build an expert system, called Cleaner Technology Substitute Auditor and Advisor (CTSAA), that provides small printers with advice on choosing substitute environmentally-desirable printing chemicals and products--a pollution-prevention strategy. Its features will help these small businesses: 1) select the least environmentally-hazardous production materials, 2) evaluate the amount of hazardous materials released into the environment, 3) use an alternative source of information to state and federal regulatory agencies, 4) do private and confidential on-site planning without regulatory inspectors, 5) minimize risk liability due to environmental violations.

Businesses are expected to comply quickly and completely (Toxic Substances Act 1994). The EPA Policy on Compliance Incentives for Small Businesses gives firms up to six months to remedy the first violation and correct any damage. If pollution-prevention technologies are used, they may receive an additional six months. However, depending on the agency interpretation, businesses may be liable for punitive civil and criminal penalties, as noted above, in addition to payment of any economic benefit determined to have resulted from the violation. Even environmentally- conscious businesses can experience unpleasant surprises, since unexpected retooling for EPA-approved processes and materials can be both expensive and debilitating. Environmental agencies maintain that retooling, despite the initial cost, can result in increased business efficiencies and better care of the environment (Federal Legislation 1996). Still, the retooling schedule imposed is that of the agency and not of the small business.

CTSAA Sources of Expert Knowledge

We developed the Cleaner Technology Substitute Auditor and Advisor prototype with the close collaboration of project experts that included an environmental chemist, an environmental engineer, several area printers, a vendor and supplier of printing materials, and members of the project advisory board. All experts provided their expertise free of charge, and on a time-available basis. The chemist provided parameters for development of the hazard index used by the system, while the engineer provided feedback on the realism and usefulness of the index and fuzzy calculations for each material. The printers and vendor provided extensive feedback on the user interface, including the GUI design, usability features, and even terminology used by the system itself.

We obtained critical data outlining environmental responsibility of lithographic printers from EPA documents, from EPA Internet information, from EPA individuals, and from project experts. Material Safety Data Sheets (MSDS) contained critical information about each material to be compared by the system, including a list of toxic chemicals used to formulate each material, but also company and other material information. Our printing industry experts first helped us acquire MSDS sheets, which were not readily available. They then classified each material into a material group, so we could compare substitute materials within each group. Finally, we used the SARA Title III toxic chemicals list to calculate the relative toxicity, or environmental hazard, of each material.

CTSAA System Description

Initially, we used a well-known expert system shell for development. Although this shell provided excellent rule-based and cased-based features, it manifested a number of flaw that made us change development tools mid-stream. For instance, the GUI features proved unacceptable to our users, the shell was very "buggy," and its generated run-time executable was too large and too slow for most client computers. Consequently, we converted to Microsoft Visual Basic and Access, implementing forward-chaining algorithms ourselves, along with the fuzzy logic features of the system. The inherent stability of VB and its seamless interface with the Access database environment facilitated rapid development and helped us meet user GUI expectations.

The resulting CTSAA system provides user-friendly Windows access to a comprehensive list of substitute materials for each stage of the lithographic printing process. Using push buttons that are presented analogous to diagrams in EPA documentation for printers, the user can navigate through a maximum of three screens before reaching a materials-selection screen that contains functional substitutes. Each material is listed by company, name, catalog code, and quantity used per year. The user is free to compare substitutes and vary the quantities at his discretion.

After selecting a list of materials to compare, the system calculates a "hazard index," based on the number of Federally-defined hazardous chemicals (SARA Title III 1993) listed on each item's Material Safety Data Sheet, the percentage of these chemicals in the material, the quantity of material that the printer uses, and other factors. Materials with the lowest "hazard index," a number derived and based on EPA guidelines, are ranked more preferable to other materials. The system applies fuzzy logic to deal with content ranges (e.g., 5 percent to 12 percent of the material may contain isopropyl alcohol--and other chemicals with similar ranges), and compensate for inconsistencies or incomplete information in the database.

Because both EPA and manufacturer information may currently be incomplete (a condition that is gradually changing), the system uses available information and applies a confidence factor in formulating the index. It then graphs the index set as triangular distributions on a another panel. In addition, the graph provides pop-up information boxes that explain the characteristics of each material, as well as information used in the computations and comparisons. All base data is table-based, and hazard criteria may be changed as federal regulations change. The system also contains a database-driven form facility for completing the Environmental Worksheets required by the EPA. This form facility integrates with the Materials Substitute Advisor.

For example, a printer wishing to investigate a substitute material for a particular blanket wash would be guided by the system to a list of blanket wash materials, which are displayed on the computer screen. After selecting any or all of the materials with the mouse and typing in the estimated quantity of material used per year, the CMIT system would provide list the materials ranked according to a "hazard index." Those materials with the smallest hazard index number would appear at the top of the list, and the printer could both save this information on a diskette and print it out for later reference.

Conclusion

Small businesses, because they do not possess the resources of large businesses, may experience a disproportionate exposure to compliance and enforcement actions by government regulatory agencies. In situations where small businesses need advisory assistance from policing agencies and are simultaneously deterred from contacting them because of heightened regulatory risk, expert systems can be socially and financially beneficial. We believe, in many cases, that information technology solutions such as expert systems can help level the playing field. Initial results from our federally-funded expert system prototype appear to verify this concept. The expert systems can distribute the agency wisdom to many businesses reliably, continually, and concurrently. In time, these systems can reduce the agency funding burden borne by small businesses and other taxpayers.

References

Federal Pollution Prevention Legislation, http://es.inel.gov/nppr/nppr_leg.html, 1996.

The Federal Register (FR) Environmental Subset, http://www.epa.gov/fedrgstr, 1996.

Guidance for Conducting a Pretreatment Compliance Inspection, Order Number: EPA300R92009, National Center for Environmental Publications and Information, Cincinnati, Ohio, 1992.

Guides to Pollution Prevention: The Commercial Printing Agency, Order Number: EPA62579008, U.S. EPA, Office of Research and Development, Washington, D.C., 1995.

Pollution-Prevention Information Questionnaire for Small Nebraska Printers, conducted by Nebraska Business Development Center and the Center for Management of Information Technology, University of Nebraska at Omaha, March, 1995.

Sara Title III Fact Sheet: Emergency Planning and Community Right-to-know Act, Order Number: EPA550F93002, EPCRA Hotline, Washington, DC, 1993.

Toxic Substances Control Act (Public Law 94-469), Order Number: EPA745K93005, Environmental Assistance Division, TSCA Assistance Information Service, Washington, DC, 1994.