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COMPUTER-INTEGRATED KNOWLEDGE SYSTEM (CIKS) NETWORK: REPORT OF THE 2ND WORKSHOP

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Knowledge For The Coatings Industry: Needs and Progress

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1. Introduction

Knowledge and Information are in vogue these days. We are said to be in the "information age." For example, this conference is about knowledge systems. The Society for Protective Coatings (SSPC) developed a strategic plan in 1996. One of the primary goals is to develop a knowledge center, although, it has not yet been clearly defined. It is important to determine what the market will be for this knowledge based on the potential uses and users.

The objectives of this paper are:
- To describe the needs of the industrial coatings industry for knowledge, and
- To describe how SSPC and others are working to fill that need.

The first part of the paper addresses the following:
- Defining the coatings industry and its needs
- Examining knowledge components for the coatings industry
- Identifying desired capabilities of the knowledge delivery system
- Comparing knowledge sources versus knowledge needs.

The second part of the paper reviews the following programs to address the above needs:
- Computer compatible data formats for paint data sheets
- Expert systems
- Websites
- Training on the use of electronic products and services.

2. Defining the Coatings Industry and Its Needs

The first step is to define the groups who will benefit by coatings knowledge, these are the "customers."

A. "Customers"

In the coatings industry, SSPC distinguishes two types of customer groups.

- Primary customers are users, specifiers and applicators of protective coatings. These are the organizations with a direct responsibility to achieve a successful coatings project.
- Secondary customers are organizations that provide services and products to the primary customers (e.g., coating materials, application equipment, failure analysis, waste disposal).

B. Partners

It is noted that coatings are not a stand-alone product. They serve a function by enhancing the value of other engineering and construction materials and processes. This fact highlights the need for the coatings industry to partner with other groups and associations such as:

- Those who represent specific industry segments such as bridge (e.g., AASHTO) and petrochemical (e.g., API);
- Those who represent segments based on materials of construction such as concrete (ACI) or steel (AISC);
- Those who represent segments based on service to professionals such as industrial hygienists (AIHA), specifiers (CSI) or painting contractors (PDCA).

C. Customer Needs

The next step is to identify the needs of the customer. For this paper we focus on the primary customers. Their general needs of the owners are:

- To solve problems;
- To earn or save money;
- To protect structures.

Knowledge is of interest to these customers because it can help customers meet these general needs. There are also other means to address these needs (e.g., increased budgets, or higher prices).

3. Knowledge Components for the Coatings Industry

This section discusses knowledge as it relates specifically to the coatings industry for the primary customers.

A. Types of Knowledge Needed

Some examples of coating-related activities which require knowledge are:

- Selecting and specifying coating systems;
- Tests and other measures to ensure performance;
- Tests and other measures to ensure conformance with standards and regulations;

- Procedures for managing coatings programs;
- Evaluating and correcting deficiencies and failures;
- Assessing short term and life cycle costs.

B. Examples of Components of Knowledge

Recall the distinction by Richard Wright at the 1996 CIKS Workshop on data information and knowledge.

- Data: basic building blocks in the form of numbers, words, sounds, and images.
- Information: data that has been arranged into meaningful patterns (e.g., database, plans, specifications).
- Knowledge: application and productive use of information (e.g., models, expert systems).

Examples are given for each of these using coatings as the subject.

- Data: (numbers, descriptions, images)
  - Rust spots on a bridge;
  - Paint film thickness recorded in numerous locations;
  - Surface salts observed and measured.
- Information: (patterns of data)
  - Rust clustered around bridge bearing areas;
  - High salt levels measured around bearing areas;
  - Film thickness relatively uniform over entire bridge surface.
- Knowledge: (application and productive use of information)
  - Early rusting was caused by failure to remove salt and not by improper film thickness.

C. Additional Knowledge Concepts

- Wisdom
  Daniel Burrus, a self-styled "futurist" suggests adding wisdom as a 4^{th} tier beyond knowledge. He defines it as "universal truth that enriches and enhances life."

  Possible examples of wisdom based on the previous analysis are:
  - Remove salt to a designated level (e.g., 10 micrograms per sq cm) before painting;
  - Use a coating which can tolerate salt.
- Sharing of knowledge
  Burrus also emphasizes the need to share knowledge to achieve wisdom. An example is as follows:
  - User A has knowledge of coatings, A, B, C in exposure X over salt level Y for 48 months.
  - Supplier B has knowledge of the ability of methods A, B, C, D to remove salt prior to painting.

Sharing such knowledge could produce a knowledge base of the performance of different paints over various salt levels in various exposures. This shared knowledge would lead to more informed decision making.

4. Desired Capabilities of a Knowledge Delivery System

A. General

So far, we have discussed the need for knowledge (including information and data) by the coatings industry. The next issue is how can this knowledge be imparted to these individuals to meet the primary goals (i.e., protect structures, save money, solve problems.). What is needed is a knowledge delivery system. A discussion of how the knowledge will be acquired and delivered is, to a large extent, the focus of this conference as a whole and beyond the scope of this paper. It is, however, useful to identify what the user desires from such a system. Later, we will compare current mechanisms against these derived attributes.

B. Acquisition

One cannot use knowledge unless it exists and is available, so perhaps the first step is to acquire the knowledge. Obviously, for the knowledge to be most useful, it would need to be comprehensive in scope, subject matter and depth with continual updating.

C. Accessibility

The user will not benefit if there is an enormous comprehensive up-to-date body of knowledge if that knowledge is not accessible to that user. Important factors affecting accessibility include the complexity and cost of the hardware and software, the level of expertise to operate, and the speed and ease of access. Again, many of these items will be discussed at this conference.

D. Validation

An important concern is the validity and credibility of knowledge from divergent sources. For example, a supplier's "knowledge" may be biased by his desire to promote his own product. The facility owner may not be knowledgeable in what constitutes good performance (e.g., by not recognizing the need to inspect in certain critical locations).

In the past, the development of consensus standards and reports and peer-reviewed papers helped provide a degree of credibility. In the electronic age new approaches are needed because information is often transmitted without such "filters."

The user also needs evidence of the process used to validate the knowledge. This could consist of a "good housekeeping seal of approval" by a recognized professional body or by a "paper" trail of how and by whom the review and validation were conducted.

E. Consolidation

Another concern is the vast, often intimidating quantity of information and knowledge available. The primary customers who use the technology are able to devote less and less time to acquiring, and evaluating knowledge. The demands of the job are being stretched thinner and thinner. There are less time and funds available for testing or evaluating candidate coatings in specific exposures. The users are seeking immediate answers. They often appear less concerned with the quality of the answer than with their timeliness. There is greater reliance on suppliers and contractors to make decisions that had been previously made by in-house materials, corrosion, and coatings specialists.

F. Cost

The customer wants to pay as little as possible (at least in direct costs) for the knowledge. In some cases, engineering firms and contractors are hired to undertake major portions of the engineering and construction. However, within these firms there often is little expertise or experience in coatings technology and an unwillingness to expend resources to acquire this knowledge. Coatings are considered a minor part of the project, like the color for your house. These owners and their consultants often do not recognize the overall value of coatings. In addition, those who regularly use the Internet are accustomed to a lot of knowledge and information without paying for it.

G. Summary of Desired Capabilities of Knowledge Delivery System

The customers, therefore, have the following needs with regard to coatings knowledge:

- Availability of comprehensive base of knowledge to solve problems
- Quick access to knowledge
- Validated knowledge
- Consolidated knowledge which is easy to understand/apply
- Inexpensive process

Inevitably, in a wish list such as this there are inconsistencies and contradictions.

5. Comparing Knowledge Sources Versus Knowledge Needs

In this section, we identify the most common sources of knowledge for coatings users and compare them against the attributes identified previously.

A. Sources of Knowledge

We divide the sources into non-electronic and electronic.

- Non-electronic
  - Hire a paid consultant
  - Contact a supplier (non-paid)
  - Contact a colleague (visit, letter, fax, phone)
  - Read technical literature (books, periodicals, standards)
  - Attend training or conferences

- Computer sources
  - Use CD-Roms containing searchable knowledge base
  - Use expert system on-line
  - Access chat rooms or on-line forums
  - Send email to colleagues, suppliers
  - Send email to consultant who provides on-line services
  - Access a searchable on-line database

B. Ranking Different Types of Knowledge for Desired Attributes

Table 1 ranks the various sources listed above based on the desired attributes identified previously. Rating are 1 to 5, where 5 is best. These are discussed below.

	Able to acquire knowledge	**Able to validate knowledge**	**Provide quick access**	**Inexpensive**	**Easy to understand/ apply**
Paid consultant	3	3-4	4	2	5
Supplier	3	1	3	5	5
Colleague	2	2	2	5	5
Reference books	4	3-4	2	3	2
Conferences/training	3	3-4	1	2	3
CD-Rom	5	3	4	3	2
Expert system	3	4	2	2	4
Chat room/forum	1-2	1	3-4	5	3
On-line data base	5	3	5	1-2	2
E-mail colleagues	1-2	2	2	5	2-3
E-mail consultants	2	3-4	4	3	4

Table 1: Rankings for various knowledge sources .

- Adequacy of sources in acquiring knowledge – The Electronic products (on-line and CD-ROM databases) furnish the greatest quantity of information potentially. Of the non-electronic sources, the conventional media of standards, books, and journals also provide, collectively, a large body of data.

- Adequacy of sources in validating knowledge – An expert system if designed properly can furnish reliable validated data and information. The information from a paid consultant should be reliable if the consultant is competent. Standards provide valid data as do information derived from training. Information derived from colleagues, suppliers or from chat rooms tend to be based on personal experience and do not necessarily represent a balanced perspective.
- Adequacy of sources in providing quick access On-line databases and CD-ROMs can provide extremely rapid access if the user is knowledgeable in these applications. Consultants, when pressured, can provide relatively quick access if they have the right tools and expertise. Other conventional methods (e.g., books and journals) can provide quick access if one is very proficient, but otherwise can be very time consuming. For courses and conferences the timing is based on the offerer's needs and not the user, so they rate low in this category.
- Adequacy of sources for minimizing expense – Information from suppliers and colleagues is often given free as is access to chat rooms. On-line databases and CD-ROMs may require relatively high investments in equipment along with service charges. Books and other hard copy reference materials are relatively inexpensive individually, but collectively can add up to a sizeable investment. Consultants typically charge for their services, but for relatively easy questions, these may be provided without charge.
- Adequacy of sources in providing information that is easy to understand and apply – The responses of consultants, colleagues and suppliers are typically the easiest to understand and apply, because they are acquired from an individual from direct conversation. On-line databases and CD-ROMs are often the least user friendly because the user is limited by the sophistication of the database engine and the way it has been constructed. Expert systems are often designed to give pragmatic answers (i.e., knowledge rather than information or data). This depends significantly on the quality of the expert system.

C. Discussion of Rankings

- Analysis of rankings – It is clear that no single source meets all the stated user needs. Overall, the electronic products have high rankings in access to knowledge, and the comprehensiveness of the knowledge. The validation of the data may be difficult and the data may be of limited use for direct application to a field problem. Finally, the cost may be relatively high. The conventional (non-computer) sources as a rule are relatively easy to use. A large quantity of data is typically available, but it may not be as readily retrievable to a novice and there are often contradictory and inconsistent treatments of technology among the diverse sources when validated data (e.g., standards, training programs) are available. Direct costs for acquiring this information may be low, but the time involved can significantly increase the cost to the customer.
- Guidance in developing electronic products – In some instances, it is necessary to develop products or protocols that will not be useful or available to more than a small fraction of the user community for one or more years. It is important, however, to

recognize this up front. Otherwise, the supplier of electronic products may run out of resources because the return is not what was anticipated. A risk in over zealous marketing of computer products is that the user may become frustrated or discouraged because the "hype" has not been delivered. The user may then find other sources or may be content to make decisions without the best knowledge. This latter could hurt the entire industry, resulting in loss of market to other technologies or to overseas competition. Overall, it is necessary to focus on the areas where the electronic-based sources have strengths and to recognize the deficiencies.

6. Current Programs Addressing Knowledge Needs

The SSPC currently has several programs focused on development and transmitting of knowledge through electronic means.

- Computer compatible data format and paint data sheet
- Expert systems on protective coatings
- Websites
- Training on use of electronic products and services

A. Format for Paint Data Sheet

An SSPC committee has developed a proposed format for industrial paint technical data sheets. These data sheets are used by paint manufacturers to describe technical properties of coating materials including application instruction, physical properties, and performance properties. There is no standard format in use by the industry. Each manufacturer tends to emphasize different features, sometimes depending on the coating's strength and the perceived needs for user information. In addition, the documents have been developed for hard copy distribution, so their adaptability to computer formats is inconsistent.

The Task Group developed a document which addresses the above deficiencies. It includes sections on mandatory data (required of all producers) and supplementary data (optional). The major categories are: product description; intended use; physical properties; mixing and application; and key performance parameters (including test methods and results).

The draft standard has been posted at the NIST list server and Web site and made available electronically to the Task Group. A revised draft was sent to a larger group (SSPC Unit Committee) electronically as well as by hard copies for the committee ballot.

B. Expert Systems

An additional project of the CIKS – SSPC Task Group was to identify and characterize expert systems of coatings knowledge. Expert systems are available for the following applications:

- Maintenance painting planning – Programs allow a user to follow a defined procedure to assess the condition of coatings on a structure. This is based on a systematic inspection and rating of various structure elements at a facility. The condition is rated on a scale of 1 to 7 or 1 to 10, based on previously determined criteria (e.g., percent of rust or percent of paint breakdown).
- Life-cycle cost analysis – With these systems, the user is able to determine the cost of one or more coating systems over a period of years. The input to the model consists of costs incurred at various times due to initial painting, maintenance painting, minor touchup or steel repair. The cost of these activities is derived from estimates of the cost of labor and materials. The intervals between painting are a more subjective area. These are based on charts and other data on coating lifetimes and degradation rates. The level of surface preparation, the type or thickness of the paint and the severity of the exposure environment influence these lifetimes.
- Failure analysis – Expert systems are also being developed to guide the user in analyzing coating failures. The users are asked a series of questions to help describe the failure by comparison to photographic or written descriptions. The user is pointed to one or more probable causes and advised on means to determine the specific cause and appropriate remedy.
- Selecting a specification – Under this system, the user is asked to select parameters for products and specifications for a painting project. The user is asked questions about the type of substrate, the type of exposure, restrictions on surface preparation, esthetics (e.g., gloss, color) other performance requirements, limitations on volatile organic compound (VOC) content, other performance parameters and the anticipated design life of the structure. The expert system can be limited to the products of a single manufacturer or directed to include multiple manufacturers. The expert system then can produce a complete specification which can be used to procure a contract for applying the coating system selected. Input from coating manufacturers is needed to furnish specific application instructions for the proprietary materials specified and to verify that these products meet the identified performance requirements.

C. Websites

In the coatings area as in other technologies, websites of all kinds are proliferating. SSPC and Technology Publishing Company (TPC) have agreed to actively develop two complementary websites. The TPC side includes current technical articles from coatings journal and news stories as well as substantial information on products. SSPC's site includes frequent updates on regulatory information, data on research projects and information and standards. Both sites include industry forums for presenting and responding to questions. In addition, these sites identify other sites for linking to more specialized information on regulations, products and services and technology.

D. Training

The SSPC committee on coatings knowledge recognizes the need for training and orienting novices as well as regular Internet users. A few brief articles have been published in the Journal of Protective Coatings and Linings (hard copy for the non-web

literate). In addition, tutorials have been developed for onsite training for introductory and advanced students on the subject of electronic information on coatings.

7. Conclusions

The SSPC Board of Governors has recognized that coatings are materials that are part of the construction engineering industry and not a stand-alone product. An important goal of the SSPC's Strategic Plan is to establish a knowledge center that is strongly linked to other groups in the construction engineering community (as represented by CONMAT/CERF). SSPC does not have the resources or time to develop these ideas or practices by itself. We believe we can best serve our members by participating in forums such as these, and in building our knowledge center on the foundation of previous experiences.