

## **APPENDIX F**

### **Status of Education**

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## F.1 EDUCATION AND TRAINING RELATED TO THE CORROSION MANAGEMENT SYSTEM PYRAMID

There are several opportunities for Education and Training (E&T) for corrosion management:

- Provide translation of enhanced practices and plans from Level 2 (“Plans”) to Level 3 (“Enablers, Controls, and Measures”).
- Provide E&T for corrosion management at Level 3 (“Enablers, Controls, and Measures”), e.g. risk management tools, performance assessment tools and methods, and life-cycle cost analysis.
- Provide Awareness Training in corrosion management to higher levels of policy and decision makers, Levels 5 and 6 (“Policy” and “Strategy”).
- Provide E&T in corrosion management to corrosion professionals on how to talk/present to higher level policy and decision makers, Levels 5 and 6 (“Policy” and “Strategy”).
- Broaden corrosion E&T beyond the industries perceived to be corrosion-intensive industries.
- Develop E&T products on corrosion management practices that can be incorporated into corporate business and management E&T programs.

In the following sections, the status of E&T at each the CMS pyramid levels shown in **Error! Reference source not found.**, and relevant opportunities to expand into CMSs, are presented.

### F.1.1 Policy and Strategy (Levels 6 and 5)

Currently, there are little or no E&T materials pertaining to corrosion management at these higher management levels. Policies often have broad statements related to Health, Safety and Environment (HSE), and Strategies are developed to meet the HSE policy and also for effective and profitable operations. However, in many cases (see survey results in Section **Error! Reference source not found.**) corrosion management policies do not exist.

At these management levels, relevant strategies could include:

*The Organization provides policy statement (s) reflecting Management’s commitment to achieving its purpose, objectives and goals with respect to corrosion management.*

Learning modules should be developed for CMSs at the policy level, and the resulting potentially sound practices should then be demonstrated by means of case studies. Such corrosion management modules should be considered for incorporation in business school and management development courses, or for inclusion in other management development programs.

## F.1.2 Objectives and Enablers, Controls and Measures (Levels 4 and 3)

As with the Policy and Strategy levels, there are only limited E&T materials at these levels that pertain to corrosion management. In some industry sectors, e.g. oil and gas pipelines, there is increasing interest in and need for formal performance assessment of corrosion mitigation systems. Often this need is driven by regulatory requirements.

There is also a growing movement to consider corrosion management from a Risk Management perspective. Such risk perspective integrates well with other management systems, Asset Integrity Management, and Occupational Health Management. It also has the ability to inform an organization's management on the financial and reputational impact, including return on investment (ROI), reliability and availability, repair-replace-abandon and life extension. There are emerging Education materials and tools for corrosion risk analysis; however, there is a need further development and expansion.

At these levels, many of the strategies discussed in Section **Error! Reference source not found.** are relevant, and they make up the core of an integrated CMS. Effective practices and implementation are critical and will depend upon communication to upper and to lower levels in an organization. In order to progress on CMS implementation, CMS learning modules and courses must be created to develop, execute and report on these items. Practical experiences can be demonstrated through case studies. To be effective, corrosion management E&T course materials must be incorporated in the general management development courses and training. Finally, there is a need for E&T in methodologies to measure success of a CMS at these critical levels.

## F.1.3 Plans and Procedures/Practices (Level 2 and 1)

These two levels in the CMS pyramid form the foundation of a CMS. At these levels the corrosion and corrosion mitigation technology resides and is executed, and these levels, the majority of E&T materials addresses practices and procedures. Increased awareness and the need for more effective corrosion management give rise to remarkable growth of E&T to gain basic understanding of corrosion mechanisms, corrosion mitigation processes, monitoring and inspection, failure analysis, etc.

These levels have been the main focus of current E&T materials' development and delivery. The portfolio of E&T materials and the rate of growth on new products are vast and impressive. The needs are:

- To continue to expand the breadth of materials to more industries and a broader range of applications.
- To continue to enhance the delivery systems for E&T, e.g. on-line, remote access, simulated hands-on experience, corrosion management tools and apps.
- To train practitioners at these levels, clarifying their role in an overall CMS. A critical piece is for communication of corrosion and corrosion mitigation information to higher levels in terms that are expressed and understood at these levels.

## F.2 REPRESENTATIVE EDUCATION AND TRAINING OFFERINGS

Corrosion fundamentals, corrosion processes and corrosion mitigation are a common theme for all sources and providers of corrosion management E&T, while E&T for CMS methods in the framework of

an over management system are sparse. Filling holes and extending the coverage of the former to more industries and more applications is needed. Moreover, there is a great need is for E&T products for integration of corrosion management into the mid and upper levels of the CMS Pyramid.

The following section describes E&T offered by Technical Associations and commercial organizations.

### **F.2.1 Technical Association Education and Training Offerings**

Understandably, the Technical Associations dealing with corrosion as their main focus, e.g. NACE International, have the most extensive E&T products relevant to corrosion control. Associations dealing with specific corrosion mitigation methods, such as the Society for Protective Coatings (SSPC), are next in corrosion relevant content in their E&T products. Broad standards developing organizations, such as ASTM International, can provide significant corrosion E&T products. Metals-centric materials associations, such as ASM International, can have corrosion specific E&T products and relevant products. Specific industry focused associations, e.g. ACI (American Concrete Institute) and AWWA (American Water Works Association), have limited corrosion E&T products.

As stated above, it is recommended that corrosion management course material be developed that addresses middle to upper management in a broad range of industries and government organizations.

### **F.2.2 Education and Training Courses**

These courses are offered in a variety of formats: 3 to 5 day courses, on-line courses, webinars, etc. Often the courses offer Continuing Education Units for professional development, and they can be partial requirements for certification programs. Several entities offer On-site training.

### **F.2.3 Standards and Recommended Practices**

Standards and Recommended Practices for materials specifications, materials production, performance and testing, inspection and monitoring are an important component of a CMS. Several regulations are incorporating specific standards as part of the standard, e.g. specifying that a certified corrosion specialist is required.

### **F.2.4 Certifications**

E&T courses and practical experience are used as requirements for professional development and certification in relevant areas for the CMS. In a number of applications and industries, certified personnel are required

## **F.3 UNIVERSITY BASED EDUCATION AND TRAINING**

Corrosion is a multi-disciplinary process that derives contributions from materials science, chemistry, and electrochemistry. All deal with the corroding material, the corrosive environment and the electrochemical reactions at the corroding surface. The largest segment of University faculty teaching Corrosion resides in Materials Science and Engineering followed in numbers by Chemical Engineering, Mechanical Engineering, Chemistry, and others. There are several universities that have groups of affiliated faculty for corrosion in Centers and informal groups. In many cases, corrosion is the interest of a single professor at the university.

### **F.3.1 Graduate Degrees**

Typically, the graduate student research is conferred in the faculty advisor's department. The graduate student E&T this is primarily focused on advanced science and technology of corrosion processes and mitigation, rather than corrosion management. This pertains to the foundational levels (1 and 2) of the CMS pyramid, and there is little or none related to the mid and upper levels of the pyramid (Levels 3 to 6).

### **F.3.2 Undergraduate Degrees**

In the U.S., only The University of Akron confers a B.S. degree in Corrosion Engineering. In the Capstone courses, aspects of corrosion management are covered; however, this pertains to the foundational levels of the CMS pyramid. Corrosion E&T at most universities is from a course or two and may include an undergraduate project in corrosion. There is little or no corrosion E&T related to the mid and upper levels of CMS pyramid.

### **F.3.3 Associate Degrees and Certification**

There are a few colleges and universities that offer associate degrees in Corrosion. These are typically 2-year programs. Some include a corrosion-related certification along with the associate degree or as a stand-alone offering. As above, the corrosion pertains to the foundational levels of the CMS pyramid and does not address the mid and upper levels of the pyramid.

### **F.3.4 Student Cooperative and Internship Experience in Industry/Government**

Undergraduate students can receive corrosion E&T through formal CoOp or internships working with on company or government corrosion project. This provides valuable hands-on experience.

### **F.3.5 Short Courses**

Several universities offer corrosion E&T via short courses on the fundamentals of corrosion, corrosion processes, corrosion mitigation methods and corrosion testing. The corrosion E&T pertains to the foundational levels of the CMS pyramid and does not address the mid and upper levels of the pyramid.

