



## **Examples of Materials Engineering Consulting Support**

There are three basic types of materials engineering specialties where Carmagen Engineering, Inc. (CEI) can provide consulting support: metallic materials, refractory linings, and non-metallic materials (other than refractory linings).

### **Metallic Materials**

We have several metallurgical engineers who have extensive experience with the use of metallic materials in typical process plant applications (including both high and low-temperature regimes), typical damage mechanisms and their prevention, and development and implementation of cost-effective inspection programs. The following are examples of the types of support that CEI has provided:

- Material selection for new process plants and/or individual equipment items and for repairs and alterations that might be required for existing equipment.
- Performed corrosion audits of existing process units to identify primary areas of concern. Recommended the most appropriate and cost-effective means to either correct them or monitor their condition.
- Developed practical and cost-effective Risk Based Inspection (RBI) programs for process plants.
- Provided materials engineering support to mechanical engineers in conducting fitness-for-service and remaining life assessments of existing equipment (both pressure containing components and internals).
- Prepared and presented a course covering fitness-for-service assessments of existing equipment in accordance with API and other industry requirements.
- Conducted engineering analyses of failed equipment items to identify the type of failure, its cause and the damage mechanism involved, and the appropriate means to correct the problem. If desired by the client, CEI can also engage a local metallurgical lab to perform the necessary materials testing and failure characterization work, and then perform the engineering analysis based on their report.
- Provided materials engineering support to mechanical engineers in developing technical specifications for critical equipment items (e.g., heavy wall reactors, high temperature fluid-solids unit vessel internals, etc.).

- Investigated and recommended methods and procedures to mitigate corrosion in aboveground storage tanks. This work is often done in conjunction with the mechanical engineering evaluation and maintenance of such tanks.

### **Refractory Linings**

Internal refractory linings are used in high temperature pressure vessels and piping systems (e.g., FCCU and Fluid Coker units), fired heaters, and boilers. The following are examples of the types of support that CEI has provided:

- Wrote and/or revised general refractory engineering standards.
- Wrote refractory material selection, design, installation, and repair specifications for specific applications (e.g., internally lined piping systems and pressure vessels, cyclones and plenum chambers, internal distribution grids, etc.).
- Prepared refractory system design and repair specifications.
- Reviewed refractory designs and installations that were done by others for acceptability with respect to industry and owner company requirements.
- Provided onsite assistance before and during unit startups and turnarounds where refractory installation and/or repair was a significant issue.
- Prepared and taught a course covering the design, installation, and repair of refractory systems based on API RP 936 and other industry practices. Previous attendees have commented that the information presented in this course has saved them considerable time and money and improved overall refractory system reliability.

### **Non-Metallic Materials**

The non-metallic materials area encompasses paints and coatings, cathodic protection, insulation, internal linings (other than refractory), and fireproofing. The following are examples of the types of support that CEI has provided:

- Paint and protective coating work has involved preparation of standards, preparation or review of specifications for new plant construction or retrofit applications.
- Investigated paint, coating, and lining problems or failures at facilities.
- Performed maintenance paint surveys.
- Investigated corrosion and failure of underground thermally insulated pipe.
- Prepared engineering standards and performed design and troubleshooting work on thermal insulation systems. This has included work regarding corrosion under insulation.
- Cathodic Protection (CP) system work included preparation of guides and engineering standards, review of new CP system designs, and review of CP system surveys and performance.
- Prepared and presented courses on paints and coatings and cathodic protection systems.