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Investigating Chemistry and Materials Issues in Aircraft

Dr. Fildes often investigate incidents involving aircraft as well as industrial and chemical processes and equipment, consumer products, aviation incidents, building materials, utility operations, roadways and foundations, and sensors and controls, to name a few. Dr. Fildes' aircraft investigations involve the performance and contribution to failures of the full range of materials encountered in aircraft. His investigations cover failures of composite materials, repairs of composite materials, and corrosion of any metal.

The Role of Physical Chemistry

It is not enough to be an expert in a narrow technical domain. The incidents Dr. Fildes investigates are often characterized by being multidisciplinary in scope, complex, and involving uncertainty and missing information. Physical chemistry is central to investigating the performance and failures of chemical processes and materials. Physical chemistry provides the foundation of materials science, and of the methods to measure and model the performance of materials.

Aircraft part manufacture involve what are called thermoset resins, which are polymer precursors that form an extensive network through an irreversible exothermic (i.e. heat producing) chemical reaction. In contrast, common plastic items are made from thermoplastic resins, which contain long chains of molecules that wrap around each other to form a solid at room temperature and that unwind and allow the resin to flow at much higher temperatures, which is a reversible process. Processing common plastics involves heating to a high enough temperature and cooling. Processing thermoset plastics involves a sequence of reactions at higher temperatures that have to proceed by a tightly controlled trajectory over time so as to achieve changes in viscosity at the right points in the process, which allows gases to be expelled and the part to be compressed under pressure. Adhesives involve similar reactions. Investigations of these materials encompass understanding the thermochemistry of the resin transformations during processing, and the impact of deviations from manufacturing procedures.

Corrosion is a form of wear and an essential consideration in determining materials compatibility, and the cause of failures involving corrosion. Corrosion testing is frequently done by immersion, vapor exposure, salt spray, or similar means. These tests are easy, requiring no sophisticated equipment or experience, but they have limitations for materials and coatings with high corrosion resistance, and for fuels and lubricants with highly effective corrosion inhibitors. Electrochemical corrosion testing overcomes these limitations and provides insight into the cause and mechanism of corrosion in ways that exposure testing will never offer. Corrosion testing is intended to provide a reliable estimate of how quickly a metal will corrode in an environment. A practical approach to electrochemical testing is to perform several types of corrosion tests, which allows detection of abnormal behavior when it exists. We have the equipment, expertise, and experience to utilize the powerful, more recent ac corrosion tests as well as the conventional dc methods, so we couple measuring corrosion rates by several methods with measuring corrosion rates for a variety of exposure conditions such as temperature and fluid chemistry.

Experience and Case Studies

Dr. Fildes has investigated the failure of composite materials and corrosion in helicopters, gliders, and jets. Investigation of these types involve materials, design, chemistry, and certification and standards. Dr. Fildes' multi-disciplinary work was the basis for establishment of Northwestern University's federally funded Advanced Materials Processing Center, where Dr. Fildes did pioneering work on studying the cure of composite materials. Dr. Fildes is also experienced with advanced electrochemical corrosion techniques.

Dr. Fildes has investigated repairs of aircraft composites, which involved the thermochemistry of the cure of resins, and heat transfer in sandwich structures. Dr. Fildes has also investigated the failure of composites due to manufacturing defects, which involves assessing the viscosity of resins during processing and the impact of procedural deviations. Dr. Fildes has also investigated the failure of composite airframe components due to mechanical issues such as impact.

Dr. Fildes has a long experience with electrochemistry, which is the chemical basis of corrosion. Dr. Fildes has studied corrosion of metals and degradation of composite such as brakes in aircraft due to runway deicers, airports located near seawater, and chemicals used on aircraft. Dr. Fildes also has extensive experience with assessing the failures of protective coatings. Dr. Fildes uses sophisticated electrochemical methods to develop models that explain the corrosion mechanism and that predict its rate under various conditions.

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Dr. John Fildes

Dr. John Fildes is uniquely qualified through experience and training to provide insight on the role of science and engineering in litigation. In addition to conducting highly successful technical investigations for high-stakes litigation involving a wide spectrum of metals and materials, chemical processes, and sensors and controls, He also organized and conducted over $26 million in funded projects including research, development, and collaborations involving Government labs, large companies, and leading universities. John was instrumental in establishing and served as co-Director of Northwestern University's federally funded Advanced Materials Intelligent Processing Center, which was a was a highly successful collaboration involving University staff and professors, McDonnell Douglas (now part of Boeing), the Office of Naval Research, the Naval Air Warfare Center, and the Naval Sea Warfare Center and small companies. He is a doctoral-level scientist who has 50 published papers, reports and presentations, and has 3 patents. John's credits involve:

- *John's pioneering work was the basis for formation of Northwestern University's federally-funded Advanced Materials Intellight Processing Center. John's R&D involved advancing the state of knowledge of the sequence of thermoset cure reactions and their relation to performance and again, and the development of models and model-based processing methods that were the basis for equipment tested by McDonnell Douglas, Northwestern, and a small composites company, Production Products – St. Louis.*
- *John has investigated the failure of composite aircraft prats, the relationship of process deviations to composite performance, the relationship of resin chemistry and installation procedures to spray foam odors and fires, the expansion and contraction of wood products, and chemical issues involved in roadway resurfacing processes.*
- *John's R&D experience with statistics in experimental design and data analysis has been used in construction litigation cases where estimates of water leakage and materials failures were made from a small sample of units.*

Our approach provides:

- ✓ *The quickest and best possible outcome.*
- ✓ *A unique opportunity for early resolution based on knowing 60% to 80% of what might ultimately be uncovered.*
- ✓ *Superior technical insight for even complex and multidisciplinary issues.*
- ✓ *A reliable basis for expert testimony that meets rules for admissibility established by the Supreme Court.*
- ✓ *A strategic advantage with corporate clients since they already appreciate that this approach improves outcomes and lowers costs through use of all existing knowledge and elimination of duplication.*

Our approach uses information research and analytics early in technically related cases and *establishes the* key *MAKE OR BREAK technical issues and everything that is known about them.* This approach requires someone who has the extensive experience with both contemporary R&D methods and litigation-related expert witness investigations so as to adapt the corporate R&D technical investigation process to the unique aspects of litigation expert witness investigations. Our experience to do this is reflected in our process to bring litigators the R&D technical investigation techniques that have revolutionized industrial R&D, providing litigators with the better outcomes and lower costs that industry has achieved in overcoming similar investigation challenges.

1. Define the Technical Issues – Inspections, insight from litigation parties, and broad literature searching are conducted to gather information from prior related cases, trade association publications, patents, manufacturer's marketing materials and reports, and Internet forums to establish the key technical issues.

2. Use Analytics to Establish What is Known About the Technical Issues – The data gathered above is analyzed with data mining and modeling to adapt the data and fill the gaps that always exist in litigation investigations.

(3) Reliably Define Testing Needed – The data that has been collected and analysis that has been done ensures that existing knowledge is not recreated, the remaining work is properly focused, and all involved parties understand the challenges, methods, and progress.

(4) Coordinate, Oversee, and Effectively Communicate – This approach ensures that the overarching technical concepts are effectively framed and communicated, and eases report preparation. The results are well supported, clear, and compelling even to people not knowledgeable of science and engineering.