SECTION 1

Fundamentals of Adhesives and Sealants Technology

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Introduction

THE PERFORMANCE, and in many cases the very existence, of a wide range and variety of common products and structures in our modern society depend on adhesives and sealants. The many varieties of plywood would not exist without adhesives. Buildings utilizing curtain-wall construction would not exist without sealants. High-technology aircraft, particularly military types, could not achieve their present level of performance without adhesively bonded substructures. Multipane insulating glass windows, likewise, depend on adhesive sealants for their performance.

Between pressure-sensitive adhesive tapes, requiring only finger pressure to make them work, and the high-tech world of structural aerospace adhesives requiring a host of allied technologies for proper usage, lies a vast spectrum of adhesives of varying form and function. The same can be said of sealants, which cover the range from simple sealing tapes to the high-tech adhesive/sealant products used in multipane insulating windows.

Such a variety in materials alone is a serious problem to those who, realizing the advantages of using adhesive and sealant technology, wish to use the technology in their products. This, however, is not the only complication. Adhesives, for example, do not usually function well in a design that simply substitutes adhesive bonding for conventional mechanical fasteners. Therefore, prospective users must also be familiar with the "design rules" for using adhesives, which are, in general, different from those for conventional mechanical fastening. In addition, the initial performance and the durability of adhesively bonded structures in service are strongly dependent on how the parts to be joined are prepared and on the severity of the service environment. The structure and chemistry of the surface region of the parts to be joined and their response to service environments may well control performance. Therefore, prebonding treatments appropriate to service are a requirement for the application of the technology.

Finally, many adhesives and sealants must be cured, that is, converted from the relatively fluid, low molecular weight, non-load-bearing form in which they must be applied, to a solid, high molecular weight form able to bear sustained loads without creeping or otherwise failing. The most common way to accomplish this curing, in the case of adhesives, is by the application of heat and pressure. The required methods for applying heat and pressure are highly dependent on the geometry (and scale) of the parts to be joined and may have a large impact on manufacturability. Such issues are covered in more detail in the articles "Overview: Adhesives Technology" and "Adhesives and Adhesion."

What this means is that the application of adhesives bonding technology requires a careful integration of materials technology with (at least) design, manufacturability, serviceability, and cost considerations. Repairability may also be a factor to be considered, as noted below. In addition, if a bonded joint is a part of a larger structure, then the same considerations must be made in the context of the larger structure. That is, an overall systems approach is essential. In general, the same applies to the use of sealants.

For a variety of reasons, and despite carefully thought-out process controls, structures occasionally will fail short of their anticipated or designed service life. Because of this, the ability to do failure analysis—to determine what caused the failure and to know how to correct it—is an important added consideration.

Although it has often been said that adhesives and sealants are basically similar materials that perform many of the same functions,
it will become clear upon reading this, and later, Sections of this Volume, that this is not, in general, a correct statement. In certain limited cases the functions of the two materials do, indeed, overlap. However, the fact that they are discussed in different parts of this (and other) Sections of this Volume and that different specifications (covering different properties) and test methods (covering different tests) apply to them, should make it clear that they are, in fact, different materials performing sometimes overlapping but, in general, different functions. Such issues are addressed in the articles “Adhesives Markets and Applications,” “Sealants and Sealing Technology,” and “Sealants Markets and Applications.”

Section 1 of this Volume is an attempt to provide general background information on adhesives and sealants technology for engineering users who have limited familiarity with these materials. Its intent is to give the reader a feeling for the technologies. More detailed coverage of many of the subjects in Section 1 appears in other Sections.

A few final comments are in order. The information contained in this or, for that matter, any other handbook cannot make an instant expert of anyone who reads and digests it, except for cases of the simplest and least demanding applications of the technologies covered. It may be necessary to consider a large and complex set of interacting factors before a decision can be reached to use specific adhesives and sealants in a given assembly. The technologies are sophisticated, and technologically appropriate decisions require the input and advice of experts. In addition, all personnel responsible for the manufacture of structures using adhesive bonding should be thoroughly educated regarding its process requirements. Adhesive joints formed with state-of-the-art materials and processes will quickly become expensive junk in the hands of workers who are not well versed in the requirements of the proper practice of the technology.

The article “Guide to General Information Sources” describes the kind of information available to persons interested in the subject technologies at all levels, from fundamental research on adhesion to engineering applications of adhesives and sealants. In addition, a wealth of information on the practice of these technologies is usually available for the asking from the manufacturers of adhesives and sealants, through their technical service people or their distributors. One may expect, however, that the quality and extent of the guidance received from these and other experts will depend on the quality and extent of the information that is given them regarding a particular problem. The best policy, therefore, is to be free with information concerning all requirements.