The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual **News to Use**

November 2023

Vol. 02, No. 75

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \overline{U}_i \overline{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U}_i}{\partial x_j}-\rho\overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \overline{U}_i \overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i' h'}\right)$ *biomedical research facilities.*

Adhesives in Biomedical Construction

Adhesives have long had a prominent role in construction, but recent years have seen a rapid expansion of the types, availability, and use of adhesives throughout the industry. This article explores the state of adhesive use, specifically in the context of biomedical construction, which has far more stringent requirements and oversight than general construction. While adhesive specification is typically based on manufacturer's recommendations, often as part of a system, a general understanding of the typical adhesive types and applications is important to avoid problems which may impact performance or void warranties.

Acrylic/Methacrylic Adhesives: These polymer adhesives are common in construction applications due to their abilities to strongly bond a wide range of substrates and resist degradation from UV and moisture after they have cured. Bonding times for some substrates may be slower than for other adhesive options. These adhesives are readily available in low volatile organic compound (VOC – e.g., odors, sensitizing and/or irritating components) formulations and consistencies, ranging from liquid to paste. Cleanup typically requires the use of solvents, such as MEK or isopropanol.

Anerobic Adhesives: These uncommon adhesives utilize dimethacrylate monomers, monofunctional ester monomers, or other chemistry that cure only in the absence of oxygen. They are generally non-corrosive, exhibit low VOCs and low toxicity, and make strong bonds with non-porous substrates.

Epoxy Resin and other Curable Adhesives: Also called reactive adhesives, these require a chemical reaction to bond and cure and are generally available in one-part or two-part formulations. These adhesives can bond a very wide range of substrates and are high-strength, chemically and physically durable, and dimensionally stable. When activated, these adhesives tend to have notably short worktimes before forming high-strength, durable bonds. Many formulations are low VOC; however, some are potent VOC sources. Many adhesives of this class require specialty applicator tools.

Hot Melt Adhesives (HMA): These are thermoplastic adhesives and include carpet seaming tape adhesive and various types of stick-type media which are fed through a heating element (e.g., melt plate or hot glue gun). These adhesives are suitable for bonding a wide variety of materials and achieve their bond strength quickly. While generally low in organic compounds, HMAs can result in odors and heat damage to joint materials. In areas where VOCs are a concern, be cognizant that heating substrates may accelerate the release of VOCs from these materials. These adhesives have a long shelf life and can be disposed of without special precautions.

Phenolic Adhesives: Phenolic resins are based on reacting formaldehyde and phenol which results in a highly penetrative adhesive, particularly when used with cellulose-based building products. These bonds are strong and highly weather-resistant; however, this class of adhesive is among the most expensive on this list. Phenolic resins tend to volatilize formaldehyde, which is a sensitizing agent.

Pressure Adhesives: These adhesives are typically applied to a flexible membrane or other base surface. The bond is activated when pressure is applied, often with J-rollers or similar tools. These adhesives tend to develop bonds slowly but can become aggressively bonded over time. This class of adhesive tends to have low VOCs, but the plasticizers in the flashing tapes and other products they are attached to may have their own VOC concerns.

Polyurethane Adhesives: Another common class of construction adhesive which creates strong weather- and chemical-resistant bonds with a wide range of substrates. Available in a wide range of viscosities, pot life, and range of cured hardness, their reaction of an isocyanate and polyol produces free carbon dioxide, which can result in joint movement unless properly clamped until cured. VOC issues with polyurethane adhesives tend to be minimal.

Thermosetting Adhesives: These adhesives utilize unlinked monomers (e.g., tapes, pastes, etc.) that are exposed to a chemical hardener (two-part mix), but some formulations cure in the presence of light or heat. The curing times are generally in the range of 10-60 minutes, providing good open and workable time before the resin and hardener react and polymerize to bond the substrates, which can be non-porous to semi-porous. Thermosetting adhesives include the phenolic formaldehyde (PF) resins (listed separately); polyamide adhesives (PA), which are extremely chemical- and temperature-resistant; and polyester resins, which are used in making composite products, most notably fiberglass and carbon-fiber. VOC content is highly variable in this class of adhesive.

UV-Curing Adhesives: These adhesives utilize photoreactive free-radical polymer chemistry to achieve strong, moisture-resistant bonds in glass, plastic, etc., when exposed to natural or high-powered artificial UV light sources. While VOCs are a low concern for this class, special precautions against accidental UV exposure and injury must be taken when utilizing potent UV sources to cure bonds rapidly, or where natural UV exposure is limited. Gunnable and sprayable gypsum board adhesive is becoming established in the industry; however, there are currently no UL assemblies which allow for it, and the high churn rate of biomedical construction generally does not support its use.

Water-Based Adhesives: These adhesives are based on natural (derived from vegetable starch and destrins) or animal proteins (derived from hides, bones, or other protein sources) or synthetic polymers (derived from esters, alcohols, methylcellulose, polyvinyl, etc.). This class tends to have low VOC concerns but can have potent odors which need to be planned for and mitigated through offsite-preparation and/or high ventilation, possibly in combination with other means. This class also tends to have a short shelf life and variable pot life (associated with varying bond strength). While bond strengths of water-based adhesives tend to be high, they also tend to be resoluble when exposed to water in their service life and can support microbial growth.

Conclusion

Adhesive specification involves a complex assessment process that relies on the specifier's understanding of the performance criteria necessary for bonding similar or dissimilar materials; resisting degradation due to exposure to mechanical shock, vibration; resisting fatigue; and resisting chemical and thermal degradation. The specifier must also be familiar with bond strength requirements, ease of disassembly, and other project and instance requirements. Installers need to understand the requirements of the prep and installation of the adhesives as specified, including substrate preparation, minimum bond area, mixing and pot-life requirements, clamping, and environmental conditions. Most importantly, in biomedical applications, there must be a cooperative relationship between specifier, installer, and the contractor's safety team to ensure the health and safety of those performing the work, those nearby, and those eventually occupying the project.

References

1. The National Institutes of Health (NIH). *Design Requirements Manual,* https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx