Designation: C1564 − 20

Standard Guide for Use of Silicone Sealants for Protective Glazing Systems[1]

This standard is issued under the fixed designation C1564; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers the use of silicone sealants in protective glazing systems for building construction. Protective glazing includes systems designed for use in applications subject to natural hazards, such as hurricanes, earthquakes, windstorms, impacts from wind-borne debris; and assaults such as burglary, air blasts, forced-entry attacks and ballistic attacks.

1.2 While other glazing accessories and components are used in protective glazing, this document specifically describes the use of silicone sealants for protective glazing systems.

1.3 This guide provides information useful to design professionals, architects, manufacturers, installers, and others for the design and use of silicone sealants for protective glazing systems.

1.4 A silicone sealant is only one component of a glazing system. A glazing system that meets the testing and code requirement for protective glazing must successfully integrate the frame and its anchorage, glass, or other glazing materials, protective film or interlayer and silicone sealant into a high performance system. Compliance with code or other requirements can be determined through physical testing of the glazing system or through computer simulation.

1.5 Glazing systems using silicone sealants that have successfully met the test requirements for missile impact and airblast test requirements incorporate the use of silicone sealants specifically formulated, tested, and marketed for this application. Sealants that are commonly used today comply with Specifications C920 and C1184.

1.6 This guide does not discuss sealants intended to protect against radioactivity or provide biological containment.

1.7 The committee with jurisdiction over this standard is not aware of any comparable standards published by other organizations.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C920 Specification for Elastomeric Joint Sealants
C1087 Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems
C1135 Test Method for Determining Tensile Adhesion Properties of Structural Sealants
C1184 Specification for Structural Silicone Sealants
C1193 Guide for Use of Joint Sealants
C1394 Guide for In-Situ Structural Silicone Glazing Evaluation
C1401 Guide for Structural Sealant Glazing
C1472 Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width
C1682 Guide for Characterization of Spent Nuclear Fuel in Support of Interim Storage, Transportation and Geologic Repository Disposal
D624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
E631 Terminology of Building Constructions

[1] This guide is under the jurisdiction of ASTM Committee C24 on Building Seals and Sealants and is the direct responsibility of Subcommittee C24.10 on Specifications, Guides and Practices.

Current edition approved May 1, 2020. Published July 2020. Originally approved in 2003. Last previous edition approved in 2015 as C1564 – 15. DOI: 10.1520/C1564-20.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

E2395 Specification for Voluntary Security Performance of Window and Door Assemblies with Glazing Impact

F1233 Test Method for Security Glazing Materials And Systems

F1642 Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

F2912 Specification for Glazing and Glazing Systems Subject to Airblast Loadings

F3038 Test Method for Timed Evaluation of Forced-Entry-Resistant Systems

2.2 *GSA Standard:*

US General Services Administration (GSA) Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loading[3]

2.3 *Department of Defense:*[4]

UFC 4-010-01 Minimum Antiterrorism Standards for Buildings

3. Terminology

3.1 *Definitions*—Refer to Terminologies C717 and E631 for definitions of terms used in this guide.

4. Significance and Use

4.1 Guidelines are provided for the use of silicone sealants in protective glazing. Protective glazing incorporates various forms of glazing that are not covered in Guides C1401 and C1193. The requirements for a sealant in protective glazing are similar to the requirements for structural sealant glazing. However, for certain applications, such as missile impact and blast resistant glazing, sealant requirements may be greater. Modes of failure for blast resistant glazing can be different than the modes of failure for missile impact glazing. Of particular concern is the outbound glazing support loading from blast wave negative phase pressure or the dynamic rebound of the glazing, or both.

4.2 Many types of protective glazing systems are relatively new and the test methods and standards for protective glazing are continually evolving. Because the demands on a sealant in protective glazing systems are changing, guidelines are necessarily general in many instances.

4.3 As a component of a glazing system, the sealant can be a factor in whether a glazing system meets the requirements of a specific test method but other factors such as the frame and glazing type, may be of greater influence.

4.4 The designer of a protective glazing system should consult with the various manufacturers of the component materials. The experience and judgment of the glazing system designer working with the sealant manufacturer and other component manufacturers, can ultimately determine whether a specific glazing system will successfully meet a specific test requirement.

5. Introduction

5.1 Protective glazing systems are designed for the protection of the building occupants and the general public from various natural and man-made occurrences that could cause injury or damage. Natural hazards include hurricanes, earthquakes, and windstorms; which with their high winds and wind-driven rain, can cause failure of joint sealants. Additionally, flying debris resulting from high winds can cause damage to the glazing system. Test methods, such as E1886, simulate the effect of flying debris during a windstorm. Man-made occurrences include bomb blast, forced-entry attack, ballistic attack, burglary, and vandalism. Test Method F1642, Specification F2912, and GSA Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loading provide information related to testing and application of glazing systems subject to blast loading. Computer software programs such as WINGARD or or SBEDS-W may be used to evaluate the effects of a blast on a glazing system. Particular attention should be given to limitations of the current computer programs. For example, WINGARD is based on the assumption that the edges of the glazing are mechanically captured in a bite, which is not true for many blast load applications. Test Methods F1233 and F3038 provide procedures for evaluation of resistance due to ballistic and forced entry attack; and E2395 provides procedures for evaluation of burglary resistance.

5.2 A sealant can play a crucial role in retaining the glazing material in the opening and thus preserving the integrity of the building envelope. If the building envelope is lost due to failure of the glazing system, the building can become pressurized resulting in significant damage to the structure, its contents and its occupants. In the case of blast resistant systems, the requirement may or may not include retaining the glazing in the opening after the event. The type of framing system, glazing material(s), connections, and sealant are components of a glazing system that must meet demanding test requirements; and when considered separately, may or may not have a significant impact on system performance.

6. Sealant Considerations

6.1 Depending on the specific requirement of the protective glazing system, the properties of the sealant can be critical to the overall performance of the system. Important properties to consider when selecting a sealant for any glazing system include the following:

6.1.1 *Adhesion*—Sealant adhesion to component surfaces should be confirmed as acceptable. Components' surfaces of the glazing system may include glass, glass coatings, metal, wood, plastic, film laminate, or other material to which adhesion is required. Adhesion can be determined using Test Methods C794 or C1135. The performance requirements specified in C1184 should be considered as the minimum requirement for most missile impact and blast resistant glazing systems. Guide C1193 includes a discussion on adhesion and testing that may be helpful.

[3] U.S. General Services Administration (GSA), 1800 F Street, NW Washington, DC 20405

[4] Online, Available: https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-010-01

6.1.2 *Compatibility*—Sealant compatibility with each of the glazing components should be verified. Components include PVB, ionomer, polycarbonate or other interlayer materials used for laminated glass, insulating glass unit edge sealants, glazing and other gasket and spacer materials, metal framing materials and factory applied coatings. Compatibility with gasket or other accessory materials is determined using Test Method C1087. Guide C1193 includes a discussion on compatibility and testing that may be helpful.

6.1.3 *Strength and Modulus*—Sealant strength and modulus are very important factors in determining whether a glazing system will pass a specific protective glazing requirement. A sealant with an ultimate tensile strength that is too low may not be able to support the glazing through a specific missile impact or airblast test requirement. As a guide, the strength requirements and modulus consideration identified in Specification C1184 should be followed. For some applications, such as encountered in certain blast resistant test requirements, these strength requirements and modulus considerations may not be sufficient and a higher strength structural silicone will be required. Since certain high modulus sealants have lower movement capability, considerations should be made to ensure that relative component movement across the sealant joint does not exceed the movement capability of the sealant.

6.1.4 *Tear Characteristics and Fatigue*—Along with strength and modulus, the ability of a sealant to withstand the impact and cyclic (fatigue) loading of certain protective glazing test methods is important. Resistance to tearing and tear strength are similar concepts; and Test Methods D624 and C1682 can be useful in determining whether a sealant can withstand the impulse load of an airblast test or the cyclic loading of a missile impact test. The ability of a sealant to withstand the fatigue associated with cyclic loading is an important consideration that may deem a sealant appropriate for missile impact applications. It is recommended that information regarding fatigue and cyclic performance for the product(s) under consideration be obtained from the sealant manufacturer(s).

6.1.5 *Durability*—Sealant durability is important in protective glazing. A sealant used in protective glazing is subject to a broad range of environmental factors including: temperature cycling, solar radiation exposure, moisture from the environment or condensation, ozone, and airborne pollutants. These factors can cause premature failure of certain sealant types. Guide C1193 includes a discussion on sealant durability and testing.

6.1.6 *Movement Capability*—The movement capability of a sealant is important if the sealant also serves as a weatherseal in a protective glazing system. Consideration of a sealant's movement capability is important for a glazing system to remain watertight and function as intended. Environmental thermal cycling and other framing system movements may impact the ability of a sealant to perform as a weatherseal. Sealant joint design is important in determining whether a sealant can perform as for a weatherseal. Test Method C719 should be used to determine movement capability of a sealant. Guides C1193 and C1472 should be used to determine proper sealant joint design.

7. Design Considerations

7.1 Currently there are no industry-accepted standards for the design of sealant joints in protective glazing systems. The considerations discussed below are based on findings from actual tests of protective glazing systems according to Test Methods E1886, F1642, and GSA Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings. Unlike structural glazing where joint dimensions can be calculated and precisely determined, this capability does not exist for the design of joints in protective glazing systems. Variables such as glass type and dimension, laminate type, framing system, anchoring, applied loads, and other factors will all have an impact on the performance of the sealant joint in a protective glazing system. In most cases, the glazing should be designed to remain in the opening after the load event. While that is the recommended result, an exception includes glass fragments entering the room as classified by the GSA Standard Test Method for Glazing and Glazing Systems Subject to Dynamic Overpressure Loading or by Test Method F1642 and Specification F2912. Another exception is the possible allowance for the glazing panel to be ejected from the frame to the outside of the building as allowed by UFC 4-010-01 for lower levels of protection. The allowance for the glazing to leave the frame introduces various post-event safety and security concerns. Accordingly, there should be clear definition as to whether ejection of the glazing panel is acceptable or if the blast design should include resistance to ejection of the glazing panels.

7.2 *Applied Loads*—Protective glazing that is designed to resist blast loading must also be designed to resist other lateral loads such as those required by the local building code, which usually include lateral wind loads and seismic events. For example, the design requirements for protective glazing to resist airblast loading can sometimes differ from those for an applied lateral load from the local wind environment. Glass or a glass composite product with the necessary strength and deflection characteristics for a protective glazing system, when designed for blast resistance, may not have the necessary strength and deflection characteristics to resist a building code or laboratory test determined wind load. The designer of a protective glazing system must consider both airblast and wind load requirements. Doing so may change the design requirements for the glazing product, glazing sealant joint, glazed opening metal framing, and framing anchorage requirements from those solely required for resisting an airblast load.

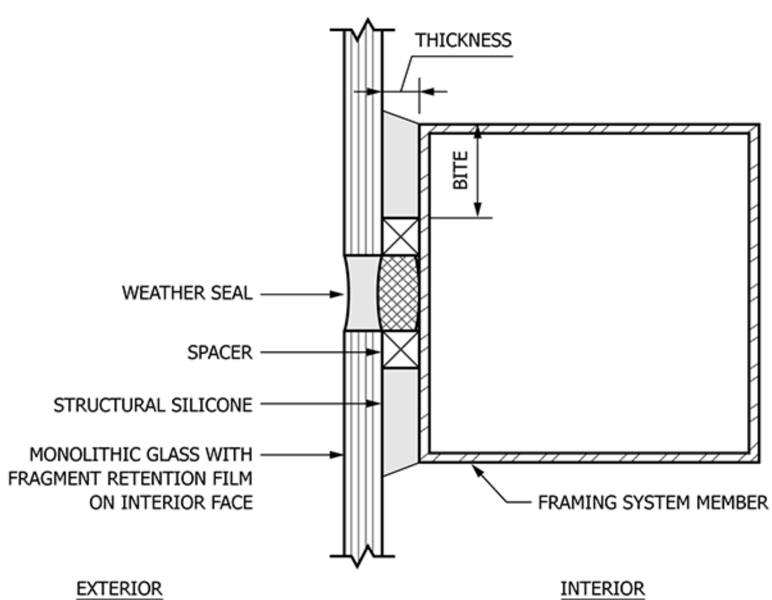
7.3 *Joint Movement*—Joint movement is a primary consideration for classical conventional design conditions including wind and seismic loading. In blast design applications the glazing mid-panel deflections are most often much larger than those for conventional load conditions. The associated glazing edge movements can result in joint movements on the order of 5 – 10 times joint movements in conventional load applications. Accordingly, if there is an assumed dependence on the capacity of sealant to retain the glazing unit in the frame, the sealant must be evaluated with consideration for inbound (positive phase) panel deflection plus outbound deflection from rebound or negative phase, or both. Note that the sealant can be damaged due to inbound movement and thus have a compromised resistance to outbound movement.

7.4 *Joint Sizing and Dimensions*—As important as the selection of a sealant is, the geometry of the sealant joint in the glazing system is of critical importance. In a protective glazing system, the sealant joint may be either structural or non-structural. For a structural joint, the applicable guidance outlined in C1401 should be considered. For a non-structural application, the sealant does not act to structurally support the glazing under the influence of a wind-load but would be expected to retain the glazing in the framing system during the testing or during an actual event. In this respect, the sealant does act in a manner similar to a structural sealant and the properties of the sealant and design of the sealant joint are important. Bite and thickness are two terms used to describe the dimensions of a structural joint (see Guide C1401). These terms also apply when describing a non-structural glazing system. The joint design must be sufficient to allow the joint surfaces to be properly cleaned and allow adequate sealant application into the joint opening. See 8.1.2 for a discussion of sealant curing considerations.

7.4.1 *Structural Sealant Glazed Joint – Missile Impact*—A silicone sealant may be used in a structural sealant glazed system that is also expected to meet certain protective glazing requirements. At least the bite and thickness minimum guidelines stated in Guide C1401 should be met. Glazing systems which have passed either small or large missile impact tests have bite dimensions of at least 12 mm (½ in.) and in some cases bite dimensions greater than 25 mm (1 in.) have been required. Other key factors affecting glazing system performance include glazing selection, bite configuration, frame strength, and other factors. Currently, actual full-scale performance is used to establish appropriate bite or thickness dimension necessary to successfully pass a missile impact test. Typical structurally glazed systems designed to pass missile impact test requirements are shown in Figs. 1-3. Fig. 1 illustrates a typical system with monolithic glass having a fragment retention film on the interior facing surface of the glazing. Fig. 2 illustrates a conventional laminated glass. Fig. 3 illustrates a laminated insulating glass unit.

7.4.2 *Non-Structural Sealant Glazed Joint – Missile Impact*—A sealant may also be used in a glazing system where it is not intended to support the glass structurally under wind load. In protective glazing, the sealant serves the dual purpose as a weatherseal in the glazing system and as an anchor for the glazing in missile impact. The sealant performs non-structurally prior to missile impact; and serves to anchor the glazing in the opening after it is fractured. For this reason, a higher performing structural sealant should be considered. In this design, sealant may be installed on the inside, the outside, or both, surfaces of the glass. Conventional laminated glass typically requires sealant on both the inside and outside surface to successfully meet impact test requirements. As in a structurally glazed joint, there are no clear guidelines as to the appropriate bite and thickness requirements necessary to pass a missile impact test. Systems that have successfully passed missile impact tests typically use sealant bite dimensions of between 12 to 25 mm (½ to 1 in.) with a thickness of 6 to 12 mm (¼ to ½ in.). Typical non-structurally glazed systems that have passed missile impact requirements are illustrated in Figs. 4-6. Fig. 4 illustrates a generic use of a monolithic glass lite with a fracture retention applied to the interior facing surface of the glass. Fig. 5 illustrates a generic use of a conventional laminated glass. Fig. 6 illustrates a generic use of a laminated insulating glass unit. See 8.1.2 for a discussion of sealant curing considerations.

7.4.3 *Classical Blast Window Sealant Glazed Joint*—Classical design of blast windows includes the assumption of edge restraint similar to Fig. 7 where a mechanical attachment is included at the outer surface of the glazing panel. The



NOTE: FIGURE DETAILS SIMPLIFIED FOR CLARITY.

FIG. 1 Generic Missile Impact Detail with Monolithic Glass with Fragment Retention Film

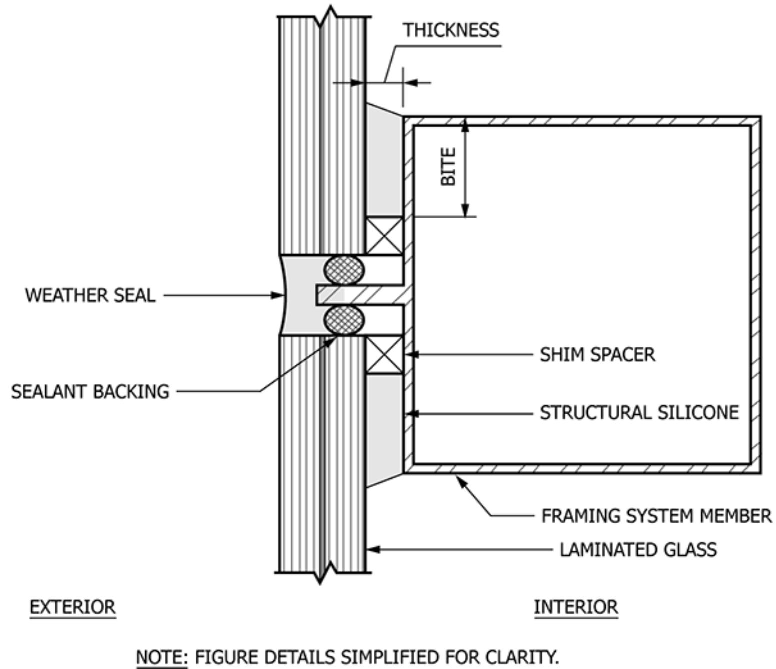


FIG. 2 Generic Missile Impact Detail with Laminated Glass

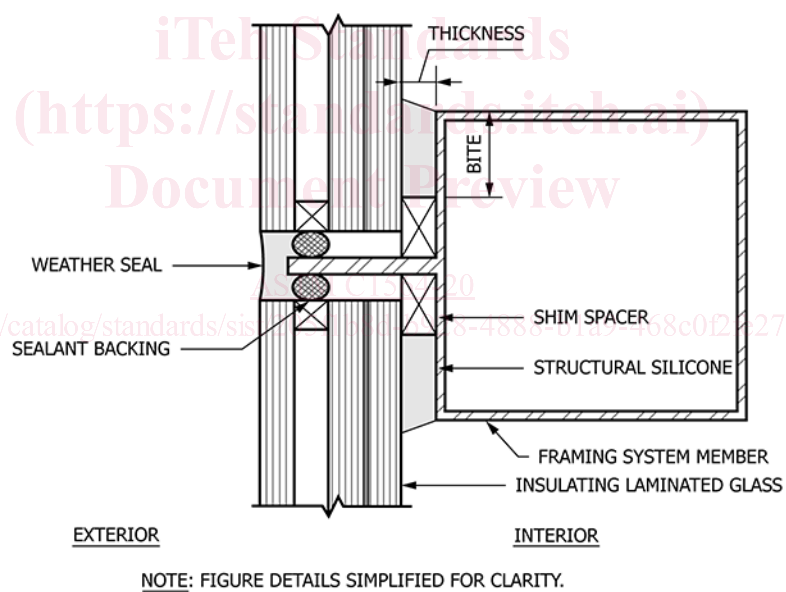


FIG. 3 Generic Missile Impact Detail with Insulating Laminated Glass

mechanical attachment structurally captures the edge of the glazing; and thus, resists outbound movement of the glazing. This edge condition is integral to the assumptions in classical blast window evaluation tools like WINGARD. Given a wet glazed system as shown in the figure, there is allowance within WINGARD, as an example, for the structural silicone to help resist the in-glass-plane pullout of the glazing edge. However, the outbound edge shear reactions perpendicular to the plane of the glazing from rebound or negative phase, or both, must still be resisted through the mechanical connection (referred to as a captured bite).

7.4.4 *Uncaptured Bite Blast Resistant Window – Sealant Glazed Joint*—While captured bite designs may provide added assurance that the glazing panels will remain attached to the frame after a blast event, many contemporary window and glass curtain wall designs depend strictly on the structural sealant to retain glazing panel attachment after the event. A representative example of that type of connection is shown Fig. 8. In this case, the sealant must be capable of absorbing joint movements from inbound loading and have enough residual capacity to resist outbound loading and movement. The associated sealant joint evaluation is well outside of the scope of