

Science and Technology of

Building Seals, Sealants, Glazing and Waterproofing

FIFTH VOLUME



Michael A. Lacasse, editor
STP 1271

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Building Seals, Sealants,
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Fifth Volume***

Michael A. Lacasse, Editor

ASTM Publication Code Number (PCN):
04-012710-10



ASTM
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
Printed in the U.S.A.

ISBN: 0-8031-2049-4
PCN: 04-012710-10
ISSN: 1062-967X

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Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

To make technical information available as quickly as possible, the peer-reviewed papers in this publication were prepared "camera-ready" as submitted by the authors.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

Foreword

This publication, *Science and Technology of Building Seals, Sealants, Glazing, and Waterproofing: Fifth Volume*, contains papers presented at the Charles J. Parise Fifth Symposium on Science and Technology of Building Seals and Sealants held in Phoenix, Arizona on 25–26 Jan. 1995. The symposium was sponsored by ASTM Committee C-24 on Building Seals and Sealants. Michael A. Lacasse of the Institute for Research in Construction, National Research Council Canada in Ottawa, presided as symposium chairman and is the editor of this publication.

Related ASTM Publications

Building Seals and Sealants, ASTM STP 606, 1976.

Science and Technology of Glazing Systems, ASTM STP 1054, 1989.

Building Sealants: Materials, Properties, and Performance, ASTM STP 1069, 1990.

Science and Technology of Building Seals, Sealants, Glazing, and Waterproofing: Second Volume, ASTM STP 1200, 1992.

Science and Technology of Building Seals, Sealants, Glazing, and Waterproofing: Third Volume, ASTM STP 1254, 1994.

Science and Technology of Building Seals, Sealants, Glazing, and Waterproofing: Fourth Volume, ASTM STP 1243, 1995.

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Overview

Introduction

ASTM Committee C24 on Building Seals and Sealants is faced with having to maintain, refurbish, and develop new standards for the sealant, glazing, and gasket industry. The significant efforts made by many within this group over nearly the past four decades have resulted in these standards being used not only within the North American context but also throughout the world. Indeed, these standards very often have formed the basis for the development of national standards in countries of emerging economic importance. Hence, if these standards are to remain relevant in the global marketplace, the committee must keep abreast of new developments and emerging technologies in their domain. This represents a considerable challenge since it is well known that marketplace globalization is creating an overwhelming need to reevaluate the usefulness of existing standards and to bring these to a level that will maintain an industry's competitive edge. The challenges that confront Committee C24 can be met only if this group has the necessary scientific and technological information to assist them in their efforts.

These symposia help fill the need for useful scientific and technological reference and hence are a vital support to the needs of the various task groups within Committee C24. The papers published in this volume were presented during the fifth symposium on the Science and Technology of Seals, Sealants, Glazing, and Waterproofing held 25–26 Jan. 1995 in Phoenix, Arizona. The current series of symposia have been held yearly since 1989, although other proceedings of related symposia have been published prior to this date. A list of related ASTM publications is provided in the front of the book. It is noteworthy to mention that proceedings of the 6th symposium, edited by symposium chairman James C. Myers, will soon be published, and Committee C24 has planned 7th and 8th symposia to be held in the coming years.

The current proceedings provide reviews of technological advances and the most recent developments in the domain of significant importance to both researchers and practitioners in the sealant industry. This would include, for instance, those involved in test method and product development research and practitioners having expertise in the areas of building joint seal and waterproofing design, specification, application, failure diagnosis, maintenance and repair, and other related domains.

This volume contains eighteen contributions covering a wide spectrum of areas related to the science and technology of sealants and waterproofing and cognate systems. The papers have been organized into six categories: joint design and sealant selection; joint sealant failures; design, evaluation, and application of structural silicone glazing sealants; aesthetic performance; recent advances in adhesion testing; and studies related to the long-term performance and aging of sealants and gaskets. Provided below is an overview of the various papers as outlined in the sections above. Concluding remarks will be provided following suggestions for future developments in the domain.

Joint Design and Sealant Selection

Sealant products in themselves are, typically, reasonably resistant to weathering; they are significantly less durable if inadequately considered in design, improperly specified, or in-

appropriately installed. Furthermore, the nefarious effects emanating from their premature failure may, in certain instances, bring about the need for very costly repairs to the building envelope or interior spaces, not to mention the very significant cost of removing and re-installing sealant product in cladding joints. Consequently, the importance of adequate design and proper selection of seal products cannot be overemphasized.

Of the three papers in this section, the first truly represents the state-of-the-art in building joint sealant design. "Recent Developments in the Design of Sealant Joints for Movement and Other Effects" is the most comprehensive design guide and specifiers aid yet to be published and will undoubtedly become the key reference in such matters. It includes information not available in a previous paper by the same author (ASTM STP 1069) and updates information from it. It is a highly recommended paper for all those wanting a thorough review of factors to consider in joint design, and it also provides complete worked examples of a number of joint designs typically found in the field. The following paper, "A Comparison of Different Sealant Butt Joint Shapes," compares the relative performance of three types of sealant butt joints, i.e., square, rectangular, and "hourglass." It is very useful for obtaining detail in regard to the performance of different joint configurations, and the work is supported from the use of finite element analytical techniques and results of mechanical testing of sealant products. "Building Sealants in Russia" gives information on the technical requirements and physical properties of various sealants produced in Russia. It is of interest from the point of view of comparing the level at which the Russian sealant industry operates or has operated in the recent past in relation to that in Europe or North America.

Joint Sealant Failures: Case Studies and Methods of Evaluation

As noted above, premature failure of joint sealants can bring about very costly decisions for the building maintenance manager, and recourse is often made to obtain the services of a knowledgeable building sealant practitioner competent in joint inspection and seal failure diagnosis. Kenney and Piper are evidently two such practitioners, and their paper, "Case Study on Sealant Reversion," is particularly significant in that it is the first to document sealant reversion in the field. Of importance as well are the techniques used in determining the possible cause of premature failure. Kenny et al. use a Fourier transform infrared (IR) spectroscopic analysis of the material to determine its peak intensity at a given wavenumber. This provides the necessary technical basis to understand this somewhat obscure phenomena that has, therefore, not been adequately explained.

"History of Building Joint Sealants" is not a history of the technological developments in the sealant industry per se. Rather, it is aimed at investigators trying to identify the types of sealants used in either older buildings or when a building was last refurbished. A review of methods useful in investigating premature sealant failures is given and an understanding is provided of the significance of when different products came onto the market with regard to failure investigations.

Structural Silicone Glazing: Design, Evaluations, and Applications

The rapidly expanding use of structural sealant glazing (SSG) systems in the past decade and a half has necessitated the development of standards for their use that take into consideration not only their mechanical properties but also their time-dependent performance attributes. The paper by Gutowski et al., "Structural Silicone in Curtain Walls," represents a significant contribution to this area and offers an understanding of proper design based on extensive laboratory studies related to the durability of these materials.

That SSG materials have so far met with appreciable success is not in question; that they can withstand continued aging over several decades in harsh environments has yet to be proven conclusively. The treatment offered in “Physical-Chemical Changes in Silicone Elastomers Used for Building Sealants” sheds some light on the potential changes that can occur in these materials under specific environmental conditions.

It is also apparent that these materials can be used for a number of different types of glazing systems. The paper “Structural Behavior of Silicone Bonded Glass Block Panels” provides an example of a research project aimed at demonstrating the viability of novel uses of structural silicone sealant.

Aesthetic Performance of Sealants

In this section, three papers are provided on the aesthetic performance of sealants. It should be noted that this topic was the focus of abundant discussion during the symposium presentations; hence, the subject cannot be considered trivial. In fact, many building owners, and property managers as well, are especially keen on maintaining the aesthetic appeal of their building facades. Hence, products must be chosen that can maintain an adequate level of performance with the minimum of maintenance over extended periods of time.

Such issues have been thoroughly dealt with by O’Neil and Wolf in a previous offering by the same authors (published in ASTM STP 1243), and the current paper builds on this aforementioned effort in significant detail. “Effects of Weatherproofing Sealants on Building Aesthetics—Part II,” together with Part I, can collectively be taken as exceptionally useful reference documents on this topic. Practitioners wishing to avail themselves of information on the types of tests and useful standards in this area should refer to these manuscripts.

“Staining Potential of Sealants in/on Exterior Wall Substrates” is a contribution reporting on the results of a number of field investigations of exterior walls of high-rise buildings and the subsequent laboratory work on various commercially available sealants. It provides insights into why certain sealants have a propensity to stain particular substrates, and it is useful to designers who wish to make appropriate choices of materials in cases where staining may potentially be a problem.

Following this theme is a laboratory study by Farmer and Cechner entitled: “Laboratory Testing of Sealants with a Marble Substrate.” This work was undertaken on three polyurethane sealants, and an evaluation is given of the effects on porous substrates of plasticizer migration and the adhesion of these products.

Advances in Adhesion Testing and Adhesion Promoters

Substantial efforts have been made in recent years to enhance adhesion testing since it has been shown, as suggested by Cerra and Gutowski, that existing adhesion tests for sealants lack the discriminatory ability necessary to determine the relative adhesion performance of different products to a given substrate. In this area, “Performance-Based Adhesion Testing of Structural Sealants” makes important advances in the domain. This paper reports on the evaluation of a test method designed to degrade the adhesive interface at stress levels below that of the cohesive strength of the product. Using this method, adhesive failure is induced that can result in a true measure of adhesive performance of the product.

Another fundamentally sound research effort is provided in “An Analysis of the 180° Peel Test for Measuring Sealant Adhesion” by Shephard and Wightman. This work demonstrates that no single adhesion-in-peel measurement adequately describes the integrity of the sealant joint because this type of test is specific to the test, specimen geometry, and rate of peel. Alternative methods are suggested that yield useful sealant/substrate adhesion properties.

Hubin-Eschger describes a development project of a novel sealant curing system in "Improvement of Initial Adhesion on Aluminum to Insulating Glass Polyurethane Sealants Using A Tertiary Amine Based Curing System." This curing system, developed for a polyurethane-based sealant used for insulated glass units, provides the product with the necessary mechanical and permeance properties to achieve an adequate seal. It is evaluated for enhanced performance in initial adhesion to aluminum in comparison to an existing but potentially environmentally harmful product.

Studies Related to the Long-Term Performance and Aging of Sealants and Gaskets

The final section is comprised of four papers treating in general the long-term performance of sealant products. The first two, in particular, are concerned with the use of automated cyclic testing devices for inducing fatigue failure in sealants. The paper "The Effect of Artificial Weathering and Movement Accommodation Testing on Building Sealants" by Beasley and Jenkins reports on the evaluation of seven types of sealant subjected to a cyclic test regime after aging in artificial weathering conditions. Commentary is offered on the effect of the aging procedure and its impact on the survival of specimens to cyclic testing. The work by Lacasse et al., "Evaluation of Cyclic Fatigue as a Means of Assessing the Performance of Construction Joint Sealants, Polyurethane Sealants," elaborates on the aging of polyurethane sealant products using cyclic fatigue testing and adds to their previous work (ASTM STP 1243) evaluating silicone sealants using the same methods.

There is continued interest in reviewing performance tests of products subjected to standard test methods; this has been adequately dealt with by Fiorillo in "Evaluation of Various Generic Types of Building Sealants Against ASTM C920—Standard Specification for Elastomeric Joint Sealants," in which results are presented on the testing of ten high-performance sealant products.

"A Review of Recent Developments and Improvements in Accelerated Outdoor and Indoor Xenon Weathering Devices and Methodologies" by Putman et al. provides some insight into accelerated outdoor weathering and artificial indoor weathering techniques with emphasis on recent improvements in the technology that have permitted developing new test methods in this area. This is by no means an exhaustive review of the subject as these have been more thoroughly dealt with elsewhere (see, e.g., Brown, R. P., *Polymer Testing*, Vol. 12, 1993, pp. 459–466; Kockott, D., *Polymer Degradation and Stability*, Vol. 25, 1989, pp. 181–208). However, it does provide the industrialists' viewpoint offered by a group knowledgeable in the field.

Future Work

There are a number of standards and guides the committee may develop in the future, and the broad areas of development, outlined below, are provided principally for the benefit of those not as well versed in the domain as members of ASTM Committee C24. To members, these items are generally well known, and those who are knowledgeable in this area would, doubtless, be able to provide more depth and detail to that which is suggested in the outline. Nonetheless, the listing of these future endeavours has merit from the point of view of fostering useful discussion. They have been classified in two distinct areas: materials and methods.

Materials

- Increased use of environmentally friendly (“green”) products implying a move from:
 - ⇒ solvent-based products to water-borne products;
 - ⇒ solids-based and metal-catalyzed products to other systems;
 - ⇒ increased use of thermoplastic elastomers and other recyclable products.
- Increased use of gasket technology for sealing building envelopes.
- Development of completely designed jointing systems integral to the building envelope system.

Methods

- *Design and Installation:* use of information technologies for accessing information and optimizing the process of design, selection, specification, and application techniques specific to the type of cladding being designed.
- *Maintenance:* increased implementation of maintenance planning, methods and techniques of inspection, inspection strategies, and improved failure diagnostic techniques.
- *Testing and Evaluation:* increased use of analytical techniques to assess the performance of sealant products, of small sample testing, and the development of probabilistic methods for predicting long-term performance of products in the laboratory and the field.

The above represent but a short list of future developments in the domain without offering pertinent details, as this would be a report in itself. It is hoped, however, that in making these brief contributions, they will find use to those active in sealant standards technical committee work of ASTM Committee C24 and elsewhere, thereby stimulating discussion on these topics.

In closing, I would like to gratefully acknowledge the many generous contributions submitted by the authors, as well as the dedicated efforts of reviewers and ASTM personnel who helped make this publication possible. Thanks are also extended to the COP representative for these proceedings, George Beestman, whose guidance and thoughtful advice were particularly useful in the review and preparation of this text.

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ISBN 0-8031-2049-4