Field Correlation of the Performance of Insulating Glass Units in Buildings— A Twenty-Five Year Study

A. William Lingnell, PE
Member ASHRAE

James L. Spetz, PE

ABSTRACT

The correlation of insulating glass units (IGUs) relating to the actual field performance as compared to laboratory testing was a project undertaken by SIGMA (Sealed Insulating Glass Manufacturers Association) that started in 1980. The study was undertaken to establish the correlation between the various levels of testing as outlined in the ASTM E 774 standard for weathering and high humidity/high temperature testing classifications C, CB, and CBA. The study was intended to obtain data on IGUs having visual obstructions in the airspace or seal failures as determined by frost points or visual inspections for 140 buildings in various climates in the United States and compare the results with the classifications of the ASTM standard. The buildings selected had distribution of the units over the three classifications for the standard. The field inspections were conducted at various intervals of five year periods to obtain the data. This paper will present an overview of the study and show the results of the twenty five year field correlation study completed in 2006. The information in the paper will also include data on various conditions that were observed in glazing systems, sealant types in the study, location of the projects evaluated, and data to demonstrate field failure rates for the classifications of laboratory testing. The paper will also highlight a second study that was conducted on over 14,000 insulating glass units with the CBA classification that was started in 1990 and completed in 2005. In addition, information will be presented that is important to the continued use of IGUs for energy savings and long term durability for the future considerations in North America.

The study was originally sponsored by SIGMA and the Department of Housing and Urban Development (HUD) and was continued to completion by the support of the Insulating Glass Manufacturers Alliance (IGMA).

INTRODUCTION

The Sealed Insulating Glass Manufacturers (SIGMA) now the Insulating Glass Manufacturers Alliance (IGMA) along with the U S Department of Housing and Urban Development (HUD) initiated a research project to field evaluate certified insulating glass units (IGU). SIGMA and HUD began this research study in 1980 with joint sponsorship. HUD along with SIGMA was charged with encouraging and promoting the acceptance of advanced construction methods and materials. One of the efforts in this regard was a field performance evaluation of certified of IGUs relating to the ASTM Standard E 774 "Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units". The units certified to Class C, Class CB, and Class CBA of the Standard. This report is intended to provide a brief overview of the results of the study over the 25-year period (1980-2005). The report will be comprised of many major topics, the first being a description of the ASTM E 773 Test Method and E 774 Specification, a section describing the seal systems, areas and climates in the study, followed by a summary of the 10-year study, a glazing system study, a second study of CBA units only, the 15-year data, the 25-year data, summary of the 1980 and 1990 study, comments and lessons learned from the study, future studies recommended, and conclusions from the research and evaluation. Acknowledgements are presented at the end of the report.

A. William Lingnell *is with Lingnell Consulting Services, Rockwall, TX.* ***James L. Spetz*** *is with Jim Spetz Consulting, Wickliffe, OH.*

DESCRIPTION OF E 773 AND E 774 STANDARDS AND INSPECTION METHOD

The purpose of the study relating to the IGMA Field Correlation project was to determine the correlation of actual in-service insulating glass unit failures to the ASTM E 773 Test Method and ASTM E 774 Specification for classification C, CB, and CBA. The ASTM Standard E 773 describes the test method for accelerated weathering of sealed insulated glass units. The units are subjected to a high humidity condition of 60 ± 3°C (140 ± 5°F) and 95 ± 5% relative humidity. The same units are subjected to an accelerated weathering cycle test apparatus which incorporates a six-hour cycling that lowers the temperature during the first hour from room temperature to –30 ± 3°C (-20 ± 5°F). This temperature is maintained for one-hour ± five minutes. The temperature is then allowed to rise from the low temperature to room temperature over a period of one hour ± five minutes and then over a time period of one hour ± five minutes a water spray and ultraviolet lamps are incorporated, and the temperature rises from room temperature to 57 ± 3°C (135 ± 5°F). During this time, the water spray is turned off after 30 minutes to allow the temperature to continue to rise to the high temperature level. The temperature is maintained at the high temperature with continued ultraviolet exposure for a period of one-hour ± five minutes. The two test methods are alternated, as shown in Table 1, for the various high humidity and accelerated weather cycles.

The study began in 1980 and in the first seven years frost points (a method using dry ice and alcohol in a special container to determine the temperature at which frost occurs inside the sealed space of an insulating glass unit) were taken on almost all of the units. The original study was composed of approximately 2,400 units representing over 140 buildings in 14 cities. The study continued with visual inspection for obstruction of vision or seal failures in the remaining years of each study. This was completed eight times in the first 10-years and again at the 15-year point. Almost all of the 2,400 units studied faced south or southwest. The principal investigator throughout the 25-year project was Mr. James L. Spetz, P. E. presently of Jim Spetz Consulting Company in Wickliffe, Ohio.

It should be noted that in the final inspection for the overall study, a number of buildings were not accessible, certain buildings were replaced, security issues prevented inspection, and building occupants were not accessible to achieve an inspection during the 25-year inspection conducted in year 2005. Approximately 75% of the original population was captured in the final inspection.

Table 1. Summary of High Humidity and Accelerated Weathering Test Specification

Class	High Humidity (days)	Accel. Weather (cycles)	Frost Pt.
C	14	140	–34°C (–30°F)
B	14	56	–29°C (–20°F)
A	14	56	–29°C (–20°F)

SEAL SYSTEMS IN THE ORIGINAL STUDY

The majority of the sealant systems available in 1980 were studied with the insulating glass units that were offered for the study by various manufacturers. The sealant technologies available consisted of single seal and dual seal units and are summarized as follows:

Single Seal	Dual Seal
Polysulfide	Polyisobutylene/polysulfide
Permapol	Polyisobutylene/silicone
	Polyisobutylene/hot melt butyl
Hot Melt Butyl	
	Hot Melt Butyl/silicone

AREAS AND CLIMATES DURING THE FIELD CORRELATION STUDY

The intent of the Field Correlation Study was to evaluate IG use in various parts of the United States. The study included various climate conditions throughout the United States with climate zones including cold climates in Minnesota and Wisconsin, more moderate climates in Ohio and Massachusetts, warm areas in Atlanta and Dallas, very warm and humid in Florida, and hot and dry in Arizona, which represents a wide range of climates in the United States. The following is a list of the 1980 original study locations of the 2,400 units that were included with 140 buildings:

Boston	Atlanta	Tampa
Cleveland	Minneapolis	Dallas
Montana	Denver	Phoenix
Sacramento	Lake Tahoe	Seattle
Portland	San Francisco	

Approximately 40 manufacturing plants were represented in the initial study that was conducted with insulating glass units provided for the various projects by those manufacturers participating, and supplying insulating glass that met classifications of C, CB, and CBA.

FIELD STUDY AT TEN YEARS—1980 TO 1990

The first major tally of results from the insulating glass units from the original 1980 study were accumulated with 2100 units that were accessible for evaluation. Table 2 represents the results of the study with the total fogged units and percent fogged listed as shown.

This Summary included all jobs. Two jobs that were found to have inadequate weep systems accounted for approx-

Table 2. Results of the Study at Ten Years

	Class C	Class CB	Class CBA
Total Fogged	69 of 809	8 of 242	26 of 1049
% Fogged	8.5%	3.3%	2.5%
Total Failure Rate: 103 of 2100 = 4.9%			

Table 3. Types of Systems

Residential	Commercial Glazing
Aluminum—marine gasket	Aluminum/lock strip gasket
Aluminum—dry interior and wet interior	Aluminum—dry exterior and wet interior
Aluminum—both wet seals	Aluminum tape exterior and dry interior
Wood—marine gasket	Wood—both wet seals
Wood both wet seals	

Notes:
1. Wet seal exterior had 10% of the number of failures as dry seal on the exterior 1990 survey.
2. Aluminum with marine gaskets and on-site glazed units with lock strip gaskets resulted in much higher failure rates due to trapping water against the edge seal unit at the sill.

imately one-half of the failures. Without those two jobs the CBA rate is 1.2%.

GLAZING SYSTEM TYPES IN STUDY

The original 1980's study consisted of approximately 40% of the study being residential units with remaining 60% of the units being commercial glazed units. Table 3 summarizes the types of systems that were incorporated in each of the basic types:

1990 STUDY CONTAINING CBA UNITS ONLY

In 1990, an additional study was undertaken to study the CBA units only. This included some of the newer seal and edge technologies that were added since the original study and were incorporated in the new study. The new study which included only CBA units was reviewed using a visual inspection method for fogged units and performed every two or three years with major inspections conducted in 1995 and again in 2005. The 15-year failure rate of 10,944 units was one-percent. Units were inspected in 102 buildings in Ohio, Arizona, Georgia, the Carolinas, Florida, Wisconsin, and Minneapolis. Over 50 SIGMA manufacturing plants certifying to be Class CBA of ASTM E 774 had units in this 1990 study. Many of the plants had units in two or more areas. Several companies with multiple plants were represented in supplying units for this study. There were six dual seal systems and six single seal systems in the 1990 study. Several plants, at this time, had installed semi-automatic production lines increasing production capabilities and quality to the manufactured units.

Table 4. Results of the Study at 15 Years

	Class C	Class CB	Class CBA
Total Fogged	77 of 730	35 of 246	42 of 976
% Fogged	10.5%	14.4%	4.3%
Total Failure Rate: 154 of 1952 = 7.9%			

Table 5. Results of the Study at 25 Years

	Class C	Class CB	Class CBA
Total Fogged	85 of 791	43 of 126	29 of 797
% Fogged	10.7%	34.1%	3.6%
Total Failure Rate: 157 of 1714 = 9.2%			

FIELD STUDY AT 15 YEARS—1980 TO 1995

During this survey there were 1952 units accessible for evaluation. Table 4 represents the results of the study at the 15-year period.

The summary included all jobs. Eliminating the two projects with known problem-glazing systems brought the CBA failure rate to 2.9%.

FIELD STUDY AT 25 YEARS—1980 TO 2005

During this survey there were 1714 units accessible of the original 2400 or over 71%. Table 5 shows the results at 25 years.

This summary did not include the two previous jobs with known glazing system problems, thus, the 3.6% for CBA is accurate for the purpose of this study.

SUMMARY COMMENTS AND LESSONS LEARNED FROM STUDY

The Field Correlation Study offered many insights into areas that provided basic information for improving the glazing systems utilized, manufacturing techniques, and overall performance criteria of insulating glass. It was found that systems with marine gaskets and lock strip gaskets demonstrated high failure rates due to poor or lacking weep systems.

The 1990 study examined over 10,000 CBA units in 102 buildings from units made in over 50 manufacturing plants with a failure rate of approximately one-percent at 15 years. These were units that were in buildings throughout the United States and in the various climate zones previously referenced, and offer a representation of insulating glass units provided by over 50 manufacturers in the U S.

Based on the information obtained from the 25-year data, it is estimated that the failure rate of C and CB units is in excess of 20% due to the number of buildings re-glazed and known systems that were not properly performing because they failed to keep water away from the insulating glass edge.

The number of C and CB units demonstrating failure in the 25-year study (14%) had approximately three to four times the number of failures as compared to the CBA units (3.6%).

This would clearly demonstrate that those units that achieved the CBA level of certification outperformed the units that had only achieved the C or CB level of certification that were observed from the Field Correlation Study of 1980.

CONSIDERATIONS FOR FUTURE STUDY

The future work for Field Correlation Studies of insulating glass units should also include new sealant technologies developed since 1990 or those not previously included in the actual study. Future evaluations should also include gas-filled units and units that are installed in the United States and Canada to incorporate a broader-based North American study.

Consideration should be given to reviewing the climate zones presently incorporated in the Energy Star program sponsored by the Department of Energy for those zones in both the United States and Canada.

Because of the vast geographical region that could be incorporated in this study, it would be advantageous to use regional agencies for the study in order to minimize the travel, expense, and efforts of those collecting the data and information required for a study.

The units considered for the study would be units certified to the ASTM E 2190 and also some recent ASTM E 774 and CGSB 12.8 for comparison with the main emphasis being on the E 2190 units as this Standard Specification is being accepted throughout North America.

It would be advantageous to use volunteer insulating glass manufacturers with certified units and fund by assessing member companies and suppliers to assist in obtaining the data for the correlation study.

CONCLUSIONS FROM RESEARCH AND EVALUATION

It has been demonstrated that certification to class CBA of ASTM E 774 resulted in a much higher level of field performance than Class C and CB. This is represented in the table that illustrates the SIGMA 15 –year and 25-year correlation studies summary as indicated below:

Units that were certified to Class CBA had failure rates of 1 to 2.9% at 15-years for systems that were properly weeped for both 1980 and 1990 studies respectively.

Table 6. Summary Survey Failure Rates

	1980 Units				1990 Units
	25-year		15-year		15-year
	C+CB	CBA	C+CB	CBA	CBA
Failure Rate	14.0%	3.6%	5.9%	2.9%	1.0%
Units	917	797	786	760	10944

The 1990 study resulted in a one-percent failure rate for Class CBA units with those sealant technologies of 1990. This represented areas and glazing systems encompassing all of the normal and severe weather conditions of the United States.

Certification to Class CBA in comparison to C and CB was in part, justification for the one level of testing as developed for the ASTM E 2190 Standard. The E 2190 Standard is currently being adopted by all testing agencies in the United States and Canada for the certification of insulating glass units.

Those manufacturing insulating glass for both residential and commercial applications are encouraged to follow the published glazing guidelines provided in the publication "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use" and the minimum sealant dimensions for insulating glass assembly as referenced in the IGMA Technical Bulletin TB-1201 as well as incorporating a quality assurance program that will ensure long-term durability of insulating glass performance.

Insulating glass units should be certified to ASTM E 2190 (replacing ASTM E 774 and CGSB 12.8) for assurances of long term durability against fogging (seal failure) and be glazed in accordance to IGMA Standards.

ACKNOWLEDGMENTS

Special acknowledgment and appreciation is to be given to the Department of Housing and Urban Development, SIGMA (currently IGMA), the Board of Directors of IGMA for continuing the study into the 25th year, Margaret Webb, Executive Director of IGMA for support in advancing the study, and Mr. James L. Spetz, P. E. for his 25 years of service and devotion to the Field Correlation Study.