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Maintenance and Repair of Historic Aluminum Windows

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Introduction

In historic preservation, aluminum windows are generally thought of as replacement windows, common since the 1970s. Many people are surprised to learn that aluminum windows in buildings have been around since the 1930s and that numerous landmark buildings in the 1930s and 1940s prominently featured them in their design. After World War II, aluminum windows gained more widespread use in the construction industry and soon surpassed steel window sales. By the 1970s, they rivaled the dominant wood window industry, particularly in commercial and institutional construction. The historic significance of early aluminum windows is now being recognized and efforts are being taken to preserve and rehabilitate them.

Aluminum windows actually appeared as early as 1912 for use in railroad cars, streetcars, and buses. The Union Pacific Railroad touted them in their modern streamlined trains for their "high efficiency as to weather tightness, great ease of operation, low up-keep costs, great strength and beauty."

It was the modern look and appeal of aluminum that helped generate a market in the 1930s for aluminum windows in buildings, particularly in signature buildings and high-end projects. By 1932, the Aluminum Company of America (ALCOA) was running separate full-page advertisements in *Architectural Record* proudly featuring buildings such as the Cities Services Building in New York City with its 2,652 double-hung aluminum windows and the Medical Center Building at Louisiana State University School of Medicine in New Orleans with its 570 windows (see Figure 1).

Leaving no opportunity to chance, manufacturers began offering aluminum windows that mimicked Colonial-style wood windows with true divided lights, and also casement, projecting, and accordion windows to compete against a thriving steel window industry. A 1932 advertisement for residential aluminum windows that appeared in the *Architectural Record* read: "It isn't a fad — it's just plain thrift to use building materials of Alcoa Aluminum. . .Take casements for instance. Because windowframes, sashes and sills made by Alcoa Aluminum are non-rusting, they won't drip stain and leave unsightly streaks on adjoining surfaces. . ." (see illustration above). Over time, aluminum windows even took on their own design, in contrast to the appearance of wood and steel windows.

Historic aluminum windows should be maintained and repaired. In the event replacement is necessary, a new window should match the historic one being replaced in design, size, configuration, and detail.

Figure 1. In 1932, Architectural Record *magazine ran an advertisement for ALCOA Aluminum featuring the 2,652 fixed, double-hung and casement aluminum windows in the newly constructed Cities Services Building in New York City. The ad touted the wide adaptability of aluminum in building products.*

Whether a distinctive part of a major architect-designed building or representative of an early use on a vernacular building type, aluminum windows from the 1930s to the 1950s have earned their place in the history of building construction in the United States. Today, they merit consideration for preservation and repair when dealing with historic buildings.

Early Fabrication

Most early aluminum windows were designed either to look like wood or steel windows. Their fabrication borrowed heavily from both manufacturing processes. In fact, a number of the early steel and wood window manufacturers began offering aluminum windows as an additional product line.

Early aluminum windows can be generally characterized as either residential grade or commercial grade, with the latter designed particularly for larger window openings and non-residential applications. Early aluminum windows employed much heavier gauge aluminum than is used today, particularly with commercial and better quality residential windows. Some of the commercial grade aluminum windows also utilized steel for the sub-frame or for the connection to the wall opening, because of its greater strength. The steel sub-frame usually had welded corner joints to provide a continuous frame. Windows with steel sub-frames also commonly featured steel sills and/or mullions.

Manufacturers either prescribed panning over all or part of the exposed steel components with aluminum or simply painting the steel and leaving it exposed. Although some residential grade windows came with similar steel components, most utilized an all aluminum sub-frame, sill, and mullion, often made with a thicker gauge of aluminum than the sash.

Extruded aluminum was used to fabricate the frame and the sash. In cross-section, the aluminum frame for a hung window would usually consist of two or more extruded pieces, interlocked and secured with screws. Window sashes designed to look like wood double-hung or casement windows were often described as tubular or of hollow-metal construction by their early manufacturers. This distinction characterized the sash as a rectangular hollow construction, different from most steel window construction. Typically, the mitered corners of both the sash and aluminum frames were welded. Muntins were integral to the sash frame and duplicated the appearance of either wood muntins or steel glazing bars, depending upon the look of the window.

Aluminum window sash tended to operate much in the same way as traditional wood or steel windows. For example, hung windows were set into either extruded channels similar to those used in some of today's aluminum windows or they were installed in guide strips similar to the stops and parting beads used in wood windows.

Like steel windows of the time, many manufacturers of aluminum windows relied on the manner of construction and fit of operable units to minimize air

Figure 2. Aluminum windows gained early attention in part due to their use in signature buildings and to their appeal to Art Deco designers. Still one of New York's finest Art Deco skyscrapers, the original Cities Services Building projected a strong corporate image and utilized aluminum in many features, including the windows. (Photo: Shannon Koy.)

infiltration and did not rely on weatherstripping. However, a number of early aluminum window companies did place considerable attention on well-designed weatherstripping features. Stainless steel or zinc weatherstripping was used along with wool felt, pile woven fabric, and other materials. Measures were also taken to reduce friction between the sash and frame, including the use of "bumpers" to cushion against jarring metal when operating the sash. Wool felt and rubber were used for ease of operation, along with newer synthetic materials such as Duprene, a rubber-like material manufactured by Dupont. Continuous fins or receptors for the weatherstripping and bumpers were often included as part of the extruded sections of the sash and frame.

Hardware for aluminum windows drew heavily on that which was available for wood and steel windows. Spring balances and metal tape balances were popular for hung windows and placed in the frame, either at the head or jamb. For a sleek modern appearance, sash locks and lifts were available in white metal and chromed bronze to compliment the color of natural aluminum.

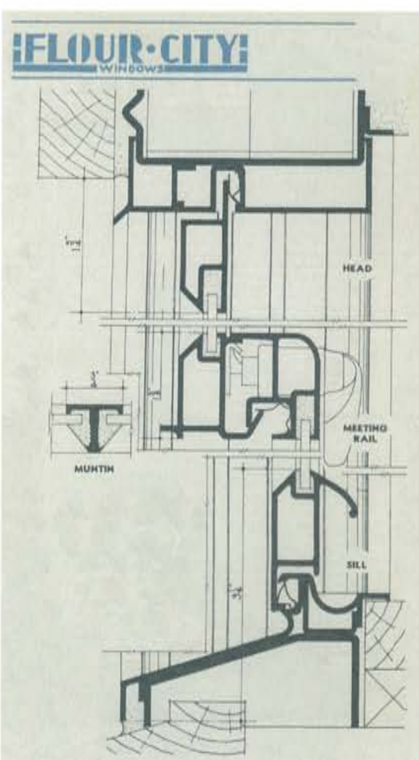

Figure 3. In 1938, the Flour City Ornamental Iron Company of Minneapolis was making aluminum double-hung windows. Instead of glazing compound along the glass edge of the sash frame, they extruded an aluminum bevel, a feature copied in many historic replications today.

Glazing depended on the type of window. Traditional outside putty glazing was common. Integral muntins were standard for divided lights. As with steel windows, some aluminum windows featured inside putty glazing, which was particularly desirable in factories. Some commercial grade windows with inside glazing included the option of using glazing beads for a more finished appearance.

Various manufacturers also offered exterior insect screens with full-length tracks integral to the window frame. Others had full or half screens as separate attachments as well as full-length, removable, exterior aluminum storms.

Early Finishes

Aluminum windows came in a variety of surface treatments, including nonfinished, anodized, chemical conversion coatings, and painted (or lacquered). The most common finish used between 1920 and 1950 was a "nonfinish," also called a "mill finish." These terms are used for a bare aluminum surface with only its natural oxide patina, which forms upon exposure to air. This natural film was thin, transparent, tough, and to a considerable extent, protective. Nonfinish aluminum varied in appearance, depending on the fabrication technique. The surface could be smooth, highly polished, or brushed. It could have a patterned texture as well, created by casting, extruding, or machining. With time, the unfinished surface darkened and discolored, eventually turning a darker color, typically gray.

An anodized finish consisted of an extra thick coating of oxide film (from 0.05 to over 1.5 mils) produced in an acid bath by passing an electric current through the aluminum. The thickness of the coating was determined by the strength of the current and the duration of the treatment. The coating could be clear or integrally colored by adding pigments or dyes before it was sealed. Anodizing increased the resistance of the metal to corrosion and wear, and

Figure 4. Early aluminum windows often mimicked wood windows in appearance and operations, even utilizing such details as parting beads, sash chains, and weights and pulleys. Photo of Folger Shakespeare Library in Washington, DC built in 1935.

prepared the surface for other processes and coatings including paint. Although exceptionally resilient, anodized aluminum could still be damaged by harsh chemicals, abrasion, and abuse. Such conditions usually affected only the surface finish and did not reduce the service life of the aluminum. In the 1930s and 1940s, this finish was used most extensively on naval aircraft, in particular on seaplanes, and was not readily available on architectural elements until the 1950s.

A third type of finish was a chemical conversion coating which consisted of a thin oxide, phosphate, or chromate film formed by chemical reaction on the bare surfaces of aluminum and aluminum alloys. The coating could be dipped, sprayed, or brushed on, its thickness varying by the dwell time. This finish was thinner and less abrasion resistant than anodic coatings and was often used as shop preparation before painting. When a conversion coating was the final finish (without paint), it was typically clear or colored gold, gray, golden brown, green, or blue-green.

Figure 5. During WWII, the federal government entered the aluminum business producing large quantities for military applications including airplanes, gasoline tanks, artillery shells, and canteens. This greatly diminished the availability of aluminum to the civilian building industry and also fostered greater use of thinner gauge aluminum. By the 1950s, most aluminum windows, as in this 1951 apartment building in Washington, DC, were made lighter weight than their predecessors of the 1930s, utilizing thinner gauge aluminum extrusions.

Whether clear (lacquer) or pigmented (paint), various types of organic coatings could be applied in the factory over a chemical conversion finish. In the field, a clear organic coating (lacquer) or a paint could be applied over a weathered or clean, grease-free surface, after the face had been mechanically or chemically roughened, or treated with a suitable wash primer.

Causes of Deterioration and Common Problems

Early aluminum windows were well constructed and, if properly maintained, were designed to last the life of the building. Some did incorporate features that proved deficient. As with the window industry as a whole, there were companies that provided low cost products with shorter service life or units not properly engineered for the size of the window opening.

In assessing the condition of early aluminum windows, it is easiest to identify those problems that also are common with older steel and wood windows. At the same time, it is important to recognize areas of deterioration that are more specific to older aluminum windows.

Unless the windows have been regularly maintained, excessive air leakage may be a problem. It can be accompanied by water leakage as well. Leakage is commonly caused by cracked perimeter caulking, missing or cracked glazing putty, cracked or broken glass, and worn, ill-fitting, or missing hardware. Such conditions are typical of long-term use and deferred maintenance. If the windows originally incorporated weatherstripping, most of this material would have exceeded its life expectancy and would now be worn, cracked, deformed, or even missing altogether.

Misaligned or deformed window sections can also cause air and water leakage. In investigating water infiltration around window openings, it is important to ascertain the actual source. Problems with the exterior wall rather than the window may manifest itself as moisture on the interior walls around window openings. Where windows have become misaligned over the years, it is common to find stopgap measures being used to reduce air and water infiltration, such as retrofitted weatherstripping or caulk. Such measures often only aggravate the problem and lead to further misalignment.

Moisture problems with the exterior wall also may affect the window subframe. Both steel and aluminum subframes may prematurely corrode where in contact with damp, porous brickwork and stonework. It is thus important to insure that the connections of the subframe to the wall and to the window frame are secure.

As with wood or steel windows, the most serious problems with the aluminum window frame and sash tend to occur where the units were originally undersized for the opening, have been subjected to intensive use and abuse or were of poor quality construction. Under such conditions, the windows may be racked or bowed and sections may even be bent or otherwise damaged.

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Figure 6. Deferred maintenance can result in a series of problems, such as broken hardware, cracked or missing glazing putty, and missing perimeter caulk (all shown above). All of these problems can be corrected. Note the uneven nature of the surface deposits of pollutants and grime on the mullion and sill of this window due to weathering and lack of cyclical cleaning.

The U.S. Department of Justice Building, Washington, DC

Located within the 70-acre Federal Triangle complex in Washington, DC, the U.S. Department of Justice Building is a monumental structure spanning an entire city block. Constructed of limestone, the seven-story building includes five separate courtyards of varying sizes. The large windows along the outside perimeter and in these courtyards provide natural light and ventilation to the offices as well as help define the architectural character of the building.

Figure a. In the primary courtyard within the U.S. Department of Justice Building, the aluminum windows emulate the appearance of steel windows with true divided lights. Depending on the floor level and location, the windows differ in size and consist of a varying combination of fixed lights, casements, and a hopper-style unit.

Designed by the Philadelphia architectural firm Zantzinger, Borie and Medary, and completed in 1935, this classical revival style building reflected the architecture of existing buildings in the Federal Triangle complex. In a distinct departure, however, the extensive use of aluminum throughout the building, as both a utilitarian and a decorative metal, provided a showcase for federal architecture in the variable new uses of aluminum. Besides the 20-foot decorative entrance doors, aluminum was used for the interior stair railing, grills, doors, light fixtures, elevator cabs, and decorative artwork. In contrast to the steel windows commonly used in the federal complex, the 1,908 windows in the Justice Building were fabricated from aluminum. While it was $100,000 more expensive to use aluminum for features throughout the building, the architect justified the extra expense in terms of projected maintenance savings.

Nearly 65 years after construction, the Justice Building underwent major renovation work, starting in 1999, to update systems original to the building. During the renovation, offices were relocated within the building to accommodate the work. The project included the restoration of the original 1930s aluminum windows, which was undertaken in three phases and spanned a period of six years.

The predominant window type consists of a pair of outward swinging casements centered above a hopper that opens inward. A single row of fixed lights flank the operable hopper and paired casement windows. Depending on the floor level and location, the individual windows had either a single or double row of fixed lights above the casement or none at all (Figure a). Windows with a single row of fixed lights at the top measured approximately 10'-2" by 5'-5". Overall, the aluminum windows emulate the appearance of traditional steel windows and include true divided lights. The aluminum sash and frame have a mill finish that has weathered on the outside to a gray color.

Window Survey

A window survey was first undertaken to record the condition of each window and to inventory the hardware, fasteners, and missing frame pieces. Although the windows retained a high degree of historic integrity, some changes had been made over the years. To allow for the installation of ventilation louvers or window-mounted air conditioning units, over 400 of the hoppers below the casements had either been removed or had been rendered inoperable and the wide vertical muntin removed. Although the historic windows were not designed for weatherstripping, some of the windows had been retrofitted with weatherstripping to reduce air infiltration as a result of worn hardware or deflections in the operable units. At various times, caulk had been applied to set in replacement glass or to fill in unwanted gaps. Areas of surface deterioration were also evident including discoloration and varying degrees of corrosion and pitting.

Figure b. The panes of glass were secured into the frame with aluminum glazing stops, each individually cut, drilled, and fixed in place from the inside. Here the vertical stop is in place while the horizontal is missing.

The renovation plan called for cleaning the aluminum window parts, replacing the existing glass and any missing or damaged parts, and making the historic windows fully operable again. Mock-ups of all phases of the work were required early on to establish the work standard to which the finished job would be held. It was anticipated that most of the work could be done in place, with work on the interior and exterior portions of each window done simultaneously.

Abatement

Early testing of the original glazing compound showed varying levels of asbestos. As a result, an abatement team was brought in to remove the metal glazing stops which secured the glass in place, dislodge and dispose of the glazing compound and existing glass, temporarily reinstall the glazing stops, and provide temporary protection over the unglazed window openings. Since each of the original metal glazing stops had been individually cut, drilled, and fixed in place when the glass was installed and were not interchangeable, it was important that each stop be returned to its original location. Thus, as each pane was abated, it was specified that the glass stops were to be put back in the same location and secured with mechanical fasteners (see Figure b). For the duration of the removal, 6-8 crews worked at once. Each crew was to complete one window bay each day.

Cleaning

After the glass was removed, the aluminum frames and muntins were thoroughly cleaned on the inside with an aluminum jelly cleaner, pumice, and scouring pads, when needed. The aluminum was then rinsed to remove the cleaner residue (Figure c). For the exterior surfaces of windows that were more heavily corroded, the aluminum restoration company proposed a more aggressive chemical cleaner be used. This necessitated that the surrounding limestone surfaces around each window be well protected. During a mockup cleaning exercise, this chemical cleaner proved too acidic, difficult to control, and damaging to the adjacent stone. After testing some alternate products, the team found that a diamond abrasive pad used in combination with the Duro Aluminum Cleaner in jell form, worked the best. Special care was still necessary to protect the surrounding limestone.

Some of the windows had areas of surface delamination. In such cases, the deteriorated surfaces were first ground down to remove the delamination and then cleaned as described earlier.

Figure c. In cleaning historic aluminum windows, the gentlest means possible should be used. More aggressive cleaners should be used only where necessary. The interior surface of this window was cleaned ten years ago with an aluminum jelly cleaner, rinsed and then dried thoroughly. The original mill finish still retains its luster.

Hardware

The hardware used on the aluminum windows was similar or the same as used on comparable steel windows of the time. The hardware consisted of nickel bronze, brass, steel, or a combination thereof. Each of the individual casements was attached to the mullion with three hinges along the side. Fastened to each casement along the bottom rail and at the frame, casement adjusters permitted each unit to be fixed in various open positions. To secure the casements closed, a cremorne bolt extended vertically at the intersection of the two casements.

To permit the hopper to be opened inward for ventilation, it had a handle attached to the center of the top rail with a corresponding keeper at the frame, matching hinge arms that secured the side of each rail, and pivot hinges along either side at the bottom.

Each piece of hardware was inspected for wear or damage. A number of the casement hinges were cracked or broken, which contributed to the malfunctioning of the operable sash. Deficient ones were replaced with new, matching hinges.

Handles, adjusters, and cremorne bolts were cleaned, repaired, and lubricated as needed. Worn or redundant screw holes were filled in. Where hardware was missing or damaged beyond repair, original parts were salvaged from less significant areas, such as the basement and attic, for use on windows in more significant areas.

It was also necessary to reproduce some of the missing hardware for use on the primary floor levels. For secondary locations, it was possible to purchase currently available new pieces that were similar but not exact matches. Some of the original hardware finishes were difficult to match but satin sanding and tumbling often brought the reproduction hardware closer to the historic appearance.

It was decided early on that the mechanical fasteners, which included primarily aluminum but also some brass screws, would largely be replaced because of their age and condition. Some were unique in size and shape, and had to be specially made.

Extrusions

Sections of the window frames had been removed or cut away to allow for various alterations over time, including the installation of window air conditioner units and ventilation louvers. Some original pieces were found in the attic of the building and were subsequently reused.

An aluminum company reproduced the vertical muntin that historically existed in the hopper unit but was missing from numerous units. After the muntins were cut to size, each was slotted at the end and fitted into the hopper frame, and then welded at the tip. The same company also made custom extrusions for the rails and stiles of the hopper units for use in fabricating entire hoppers where missing (Figure d).

Additional Repairs

Most of the repair work was done on site. Units that needed to be completely reconstructed (less than 5%) were moved to a welders shop. Where areas of severe corrosion on the exterior of the windows were encountered, Lab-Metal, a high temperature repair epoxy, was used to fill voids and to build-up surfaces to their original outside dimensions. Because the windows were generally in good condition, the use of epoxy fillers was not widespread.

In very limited areas on the exterior where severe delamination had occurred, the flaking aluminum was removed, epoxy applied to even the surface, and then an aluminum flat bar was attached with stainless steel screws to re-establish the original profile.

Replacement Glass

After the windows had been cleaned and repaired, new glass was installed from the inside. Unlike the original glass, 6.4 mm laminated glass was used as a replacement, providing the additional qualities of shatter resistance and enhanced energy performance. The laminated glass consisted of an outer layer of clear, heat-strengthened glass

Figure d. Numerous hopper units have been removed over time to accommodate air conditioning units. Replacement hopper units were manufactured, as needed, to match the original hoppers elsewhere in the building.

with a Low-E coating and an inner layer of fully tempered glass. A contemporary glazing tape was used instead of glazing compound to seal the glass and the aluminum glazing beads were affixed to the inside with screws to secure the glass. It was necessary to purchase additional aluminum glazing bead to augment historic beads that could not be reused.

PROJECT DATA

Owner:
General Services Administration

Project Manager:
Gilbane Building Company, Washington, DC

Window Contractor:
Clyde McHenry, Inc., Hyattsville, MD

Aluminum Cleaning and Finishing:
Atlantic Refinishing & Restoration, Inc., Waldorf, MD

Hardware Supplier:
Blaine Hardware Inc., Hagerstown, MD

Glass Supplier:
Northwestern Industries, Inc., Seattle, WA

Project Date:
1999-2005

Factory windows and residential windows of very lightweight construction were most prone to such problems. On many buildings, however, such conditions are uncommon or are limited to only some windows.

More common are instances where sash have been damaged as a result of previous retrofits of either mechanical vents or window air conditioning units. Such installations may also have resulted in the removal of one or more muntins to accommodate these units.

While interlocking seams were found on some early aluminum windows, units were normally assembled using mechanical fasteners and welded joints. Operable units that were primarily welded together tend to have been higher quality windows and are generally found in better condition than windows that were mostly fastened together with screws, bolts, or rivets. Machine screws may have a tendency to loosen over time, which can contribute to various problems that require remedial work.

In assessing the condition of the sash and frame, any flanges and receptors for weatherstripping that were extruded as part of the sash or frame should be examined, as some sections may have been damaged over time. Aluminum glides or stops for operable sash also need to be checked to determine whether they are bent, gouged, corroded, or painted. These conditions could impede the ease of operation of the sash.

Other problems that can affect the operability of the window include broken balances, corroded and broken hardware, misaligned or loose hardware, and windows that have been later sealed or painted shut.

While aluminum is resistant to most types of corrosion, it is affected by certain agents such as alkalis, hydrochloric acid, and lead-based paints.

While considered a durable building material, aluminum does deteriorate. It is subject to corrosion when wet and in contact with certain alkalines, such

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The Raymond M. Hilliard Center
Chicago, Illinois

Figure a. One of two identical 16-story senior citizen apartment buildings within the Raymond M. Hilliard Center, each with 182 apartment units. The window openings are elliptical in shape and center on each reeded bay. (Photo: Holsten Real Estate Development Corp.)

Built in 1966 by the Chicago Housing Authority, the Raymond M. Hilliard Center was originally a public housing complex of five buildings with 710 apartments located south of Chicago's downtown loop. Designed by Bertrand Goldberg, it is acclaimed for both its mixture of elderly and family housing and its modern "new-expressionist" architecture. Of special note are the 2,300 window openings of a modified ellipse shape with the bottom and top curved segments compressed into straight parallel edges, set into the concrete walls of the tower buildings. These openings have been described as "television sets," "beehives," and "airplane windows" (Figure b). The windows are a combination of two rectangular aluminum horizontal slider sash with flanking radial fixed panes. Each flanker is set back at an approximate 22.5-degree angle to the outer face of the center units, conforming to the curved outer wall (Figure a).

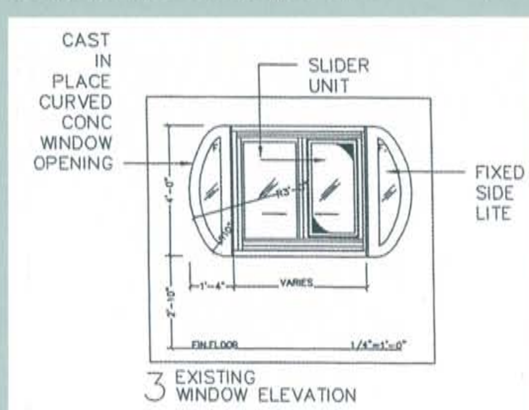


Figure b

Problem

Early on, the private developer, Holsten Real Estate Development Corporation, committed to rehabilitating the Hilliard Center for continued use as mixed-income housing. They recognized the importance of the original aluminum windows and sought to preserve as many as possible. Distinctive in their configuration and form, the windows, however, were light residential units manufactured with affordability in mind. They had thin aluminum members, lacked drip edge or weeps to direct water away from the openings, and, typical of the time, were only single glazed. There were provisions for insect screens but not for storm windows.

Nearly all of the original windows had survived 40 years of Chicago's harsh winters and numerous abuses from high-density occupation. The architect completed a condition survey of 120 typical windows and found that 61% of the windows lacked the original glazing (replaced with Plexiglas or similar material), 31% had damaged operating sash, 29% were boarded up with damage to the frame, 25% were missing their original operating glazing sash, and 71% were missing screens. Only 15% of the windows had no visible defects.

Solution

The decision was made to save the historic windows for the first four floors of the towers, since they would be most visible from the ground. Units on the first four floors in bad condition were to be replaced by windows in better condition relocated from above floors. Matching aluminum replacement windows were to be installed on the upper floors.

The window survey provided an overall view of the necessary repair work to the historic units. There were standard components within each of the different window types and the aluminum had proved durable where not abused. Thus it would not be necessary to replace large numbers of the entire window assembly within each bay on the lower floors. The windows could be repaired, utilizing parts easily salvaged from other units within a building to replace worn-out or missing ones. In the total project, 336 original windows were to be repaired and 2,016 to be replaced.

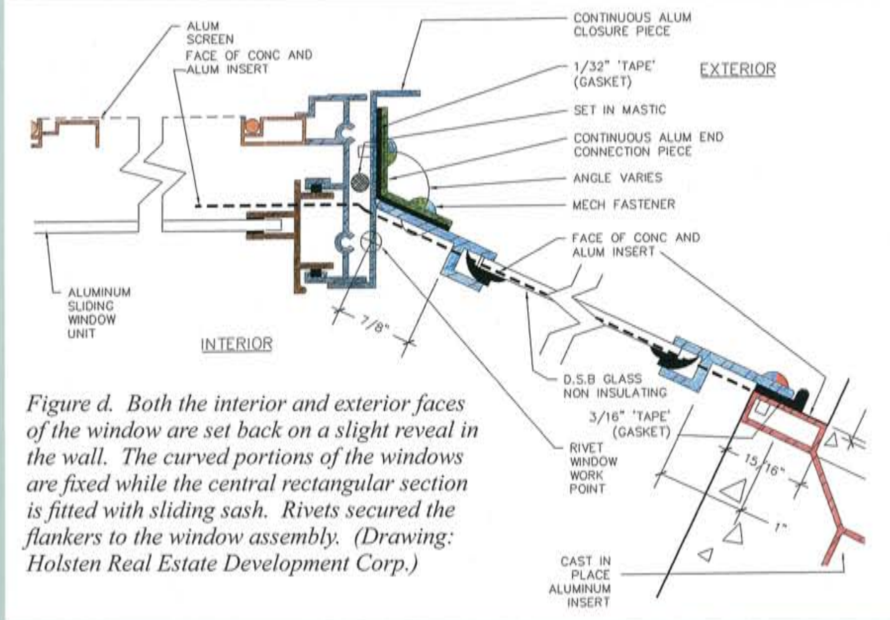


Figure d. Both the interior and exterior faces of the window are set back on a slight reveal in the wall. The curved portions of the windows are fixed while the central rectangular section is fitted with sliding sash. Rivets secured the flankers to the window assembly. (Drawing: Holsten Real Estate Development Corp.)

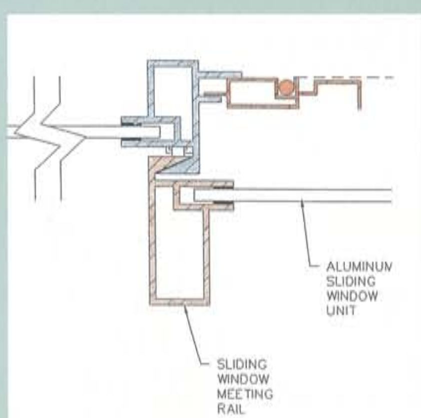


Figure c. Detail showing the sliding aluminum meeting rails in a closed position. (Drawing: Holsten Real Estate Development Corp.)

Disassembly and Salvage

Windows on the upper floors that were in good condition were marked for salvage and then taken to the repair shop in the basement. There they were sorted and stacked by size and by their original inside or outside position in the window track.

For the window repair work on the lower four stories, a portable shop area was created on each floor. Here the crew assembled a gang box of their tools to be used: 6″ metal bender, reciprocating saw, chisels, screw drivers, scrapers, wire brushes, drills, acetylene torches, caulk, and caulking guns.

Most of the frames could be repaired in place. In areas where the frames were to be removed and replaced, a reciprocating saw was used to cut the rivets holding them in place. A 1/8″ space adjacent to the frame was needed to accommodate the blade to cut the rivets. When the frame was too tight against the concrete, a 6″ bender was used. This work was done from the inside of the window both for convenience and also not to damage the exterior finish of the unit. The mastic that held the window frame to the continuous aluminum closure piece was also cut away. Once loose, the frames could be grabbed on both ends and lifted out of the opening.

One of the more time consuming aspects of the project involved the radial flankers. Many of these historic window units were broken and had been caulked together in a repair effort. Due to age and stiffness, it was necessary to first heat the sealing gasket for the glass with a small acetylene torch. The gasket could then be removed from around the frame, thus freeing the broken glass for disposal. Typically this involved the handling of a number of broken pieces of glass and subsequently took a great deal of time to clean it down to the raw opening.

If the frame for the flanker unit was to be removed, rivets securing the unit were cut at both ends and the unit lifted out (Figure d). At this point, the only remaining window piece in the opening was the aluminum subframe to which the window frame was attached. Set within the concrete walls, the subframe was left undisturbed.

Salvaging parts from upper level windows saved considerable money. This was particularly the case where entire operable units were taken intact and reused from upper floor units. As a result of salvaging parts, no new parts were needed other than items such as rivets and weatherstripping. Even latch mechanisms and locks were salvaged by first removing the old rivets and then cleaning and reattaching them as needed.

Cleaning Procedure

Over the years many attempts had been made to make the windows

Figure e. Both interior and exterior aluminum surfaces had become dull, soiled, and oxidized as a result of traffic exhaust and air pollution. Cleaning the aluminum stabilized any further deterioration and brought back the luster of the original mill finish. (Photo: Holsten Real Estate Development Corp.)

operate better. As units became worn, loose, or deflected, pieces of weather-stripping were added between the sash and sash tracks to better seal out the cold. Metal plates were added to the bottom of the operable sash to enable it to better slide in the channel and caulk was applied to close up unwanted openings between the glass and the frame, as well as to repair broken pieces of glass. Residual dirt, putty, grease, and paint coated many of the window units.

The aluminum surfaces needed to be cleaned and taken back closer to their original appearance. Because of the effect of weathering and use, it was considered acceptable in this project to use certain cleaning techniques not normally recommended for more ornamental architectural aluminum. A common chemical cleaner and/or denatured alcohol were used to remove the general residue on the aluminum. Wearing rubber gloves, the crew wiped on the cleaner with a damp cloth, allowed it to stand for 3-5 minutes, and then wiped it off with a clean damp cloth. Scouring pads and scrapers were sometimes used on more encrusted areas, as needed. The removable sash units were cleaned in the basement shop, while any frames that remained in situ were cleaned in place (Figure e).

Repair and Reinstallation

Some window units were in such good condition that they only needed to be cleaned, with any minor repairs being made at the same time. Others required more substantial work and were sent to a separate workstation after cleaning. Repairs varied from replacing or resecuring any loose screws holding the sash frame together, to realigning pieces by bending or reforming. All the sash hardware was cleaned, lubricated, and then reattached.

Figure f. Repair and replacement work was done from the inside to lessen the risk of damage to the outside finish. (Photo: Holsten Real Estate Development Corp.)

There were a sufficient number of operable sash with existing glazing and frames in serviceable condition that they could be used for the entire lower four floors. Such was not the case with the flankers where 50 pieces of glass costing a total of $1,300 had to be ordered to augment what existed. Before the new glass for the flankers could be installed, a template in the shape of the radial opening was made and then taken around to various openings where glass was to be replaced. Adjustments to the shape were made as needed in an effort to get the best-standardized shape. The new glass was custom ordered and delivered to the on-site shop for installation.

When reinstalling window units, care was taken to ensure correct alignment. This was particularly important with the operable units to guarantee a good weather tight seal when closed (Figure f). New screen windows were installed as part of the final completion work.

PROJECT DATA

Owner:
Holsten Real Estate Development Corporation, Chicago, IL

Project Date:
2001-2004

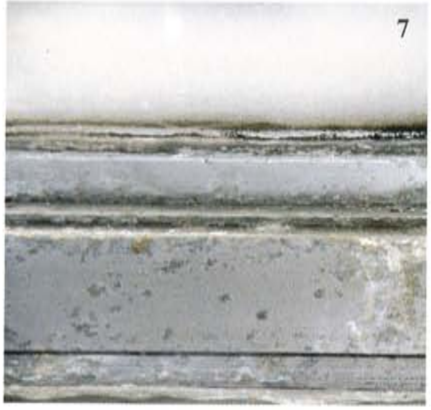
Architect:
Lisec & Biederman, Ltd., Architects and Planners, Chicago, IL

General Contractor:
Linn-Mathes Inc., Chicago, IL

Glass Contractor:
Tortensen Glass, Chicago, IL

Window Screen Supplier:
Commons Manufacturing, Chicago, IL

Project cost:
The cost for window repair, including both labor and materials, totaled $1,486 per window. The cost for a new aluminum unit ran $1,700 per window.



Figures 7 and 8. Aluminum corrosion can appear as a white discoloration and forms on the surface as the protective oxide film breaks down, as seen in these 60 year old windows in the PSFS Building, Philadelphia, before they were replaced. The small dark bumps are where surface dirt, grime, and pollution particles collect. Over time, pits form beneath these dark areas as the surface continues to corrode. This corrosive action is further encouraged by foreign particles, such as dirt and chlorides, which hold moisture next to the surface. (Photo: Powers & Company Inc.)
Figure 9. Some aluminum alloys are less corrosion resistant than others. Delamination, as seen on this aluminum railing in front of a window at the Folger Shakespeare Library, can occur when an aluminum-copper alloy is introduced and used in an outdoor setting. The original specifications called for aluminum and chromium, but were not followed.

as concrete, mortar, and plaster. Some forms of wood, wallboard, lead-based paints, and insulation materials may also attack aluminum. Particularly important, acid-based chemicals used to clean masonry surfaces can also corrode aluminum.

Aluminum is also subject to damage by galvanic action when in contact with certain dissimilar metals such as copper and steel. Nonconductive materials like paint or mastics are needed to electrolytically insulate the metal. This was a common procedure where steel was used as the subframe for aluminum windows.

Aluminum and any protective oxide films and finishes are also subject to deterioration caused by air-borne abrasives. Certain air pollutants, dirt, sand, and high humidity work to break down the protective finishes. When combined with a low priority maintenance program, they will shorten the life span of an aluminum window.

Understanding the variety of aluminum alloys, tempers, finishes, and treatments used historically is important to uncovering the specific causes of deterioration and to developing sound conservation approaches. Visual examination can help determine or confirm production finishes. Simple tests using a steel needle or a rubber eraser in a small area can preliminarily identify finishes. Laboratory analysis can also be used to confirm alloys, tempers, and coatings but often require the removal of window sections and destructive testing.

Cleaning

Aluminum windows can benefit from periodic cleanings. Even a simple water wash can cut down on the accumulation of surface dirt and pollutants. A mild soap and water may be safely applied to any aluminum finish.

The effect of different chemical cleaners on aluminum depend on many factors, including chemical concentration, dwell time, and temperature, as well as the aluminum alloy type, production method, surface finish, and coating. The *Care of Aluminum*, a technical guide published by The Aluminum Association, provides useful information on the maintenance of aluminum, including the cleaning of surfaces and

Figure 10. The shine and luster of an aluminum window with an original mill finish was a perfect compliment to the stainless steel exteriors found on 1940s/1950s diners. The Hollywood Diner is an authentic Mountain View Diner built in 1954. It first operated in Westbury, New York and was later moved to Baltimore, Maryland. In the 1980s it was the location site for several Barry Levinson's films including "Diner." Most of the original windows remain in this building.

Figure 11. Aluminum windows were described as a perfect choice for Lustron Homes because of their modern appearance and ease of maintenance. Along with the procelain-enameled-steel exterior wall panels, the manufacturer claimed that the only cleaning and maintenace materials required for a Lustron Home were "soap, water, and a damp cloth." Today, cleaning is recommended for any historic aluminum window as part of a cyclical maintenance program.

application of watertight protective coatings.

The Association's technical guide lists five categories of aluminum cleaners: 1) mild soaps and detergents, and non-etching cleaners, 2) solvent and emulsion cleaners, 3) abrasive cleaners, 4) etching cleaners, and 5) special heavy-duty cleaners. In dealing with historic materials, the gentlest means possible should be used to clean aluminum windows. More aggressive cleaners should be used only where necessary. The goal of cleaning is not to return the aluminum to an "as good as new" look, but rather to remove harmful deposits and, where appropriate, improve the existing appearance where corrosion or deposits have significantly altered the historic appearance.

In many cases of deferred maintenance, abrasive cleaning methods appropriate for aluminum will be needed to remove surface oxidation and heavy encrustation. These cleaners come in different forms, such as polishes, metal brighteners, and powders. Only certain mild abrasives should be considered for anodized, painted, or chemical conversion coatings to avoid damage to the finish. With nonfinish aluminum, abrasive cleaners may be used in combination with fine stainless steel wool or abrasive nylon pads, depending upon the need and the results of cleaning tests. Alternatively, etching cleaning may be used instead on nonfinish aluminum, again depending upon test results. When other means are unsuccessful on nonfinish aluminum, medium abrasive cleaners or mechanically driven pads of fine steel wool or abrasive nylon can be considered in limited cases. Special care must be taken to protect the glass. These more aggressive cleaners and methods should not be used simply for expediency when more gentle abrasive cleaners are also effective.

Figure 12. Cleaning tests may include a variety of products and methods such as mild soaps and detergents, etching cleaners, and abrasives. The gentlest means possible should be used, understanding that the goal is not to create a like-new appearance but rather to remove excessive grime and surface pollutants. Use of heavy etching cleaners or heavy-duty abrasives should be avoided on certain historic finishes. In this photographs a mild etching cleaner in jell form is being tested on a storm window with a mill finish.

Spot tests should always be performed beforehand to determine the suitability of any application to an existing finish. Regardless of the type and strength of any required cleaner or its form of application, it is important that all cleaned surfaces be thoroughly rinsed and wiped dry.

A cyclical program of cleaning using a gentle method will help maintain a newly cleaned finish. Clear lacquers or waxes can be applied to nonfinish, anodized, and conversion-coated aluminum to help protect the newly cleaned finish as well. A clear lacquer application (sprayed or wiped on) will preserve the appearance of cleaned aluminum for an appreciable time. Wax offers a shorter protective life and will require frequent reapplication. In cases where the anodized finishes have failed and cannot be restored through cleaning techniques, painting may be a suitable option.

Common Repairs

Early residential and commercial grade aluminum windows share various common maintenance approaches and repair techniques. However, repair approaches must be tailored to the specific project. For example, when working with early heavy-gauge aluminum windows that emulated steel

will need to be tightened and deficient ones replaced with screws appropriate for use with aluminum. Welded joints that have failed should be re-welded and any cracks in the frame repaired.

Missing or Damaged Sections

Techniques for repairing missing or damaged sections of aluminum windows vary according to the type and quality of the historic units. One approach is to cannibalize units that will be replaced. Damaged pieces of the frame, sash, or sill can be detached by removing fasteners or cut out. Salvaged pieces can then be reattached with traditional fasteners, welded in place, or secured with contemporary bonding material. Filler material, especially made for aluminum, can be used to fill holes and, depending upon the makeup of the window, to fill depressions caused by abuse or delamination.

For larger projects involving common missing sections, such as muntins that have been cut out for window air conditioning units, a custom extrusion can be made to match the shape and profile of the missing pieces. These pieces can then be cut and welded in place. Entire units can be replicated where sufficient quantities merit the expense of such custom work. For small projects, it may be possible to have a machine shop mill the missing pieces from standard aluminum stock.

Figure 14. Hardware for early aluminum windows came in a variety of materials including steel, bronze, and nickle. Specialty hardware manufacturers can easily replicate suitable replacements today, matching the originals in both material and finish. The manufacturer's stamp, visible through the glass on the exterior sill of this window at the Folger Shakespeare Library in Washington DC, identifies Wm. H. Jackson Company of New York as the maker and dates the window patent to 1926.

Hardware

A wide variety of hardware is found on older aluminum windows, including locking handles, lifts, balances, sash chains, hinges, fasteners, and casement operators. Most existing hardware will need to be cleaned and lubricated. In many cases, this requires removing the hardware to do the work and reattaching each piece in its original location, after the work has been done. When present, worn sash chains can be replaced with new ones that match the original ones.

For severely worn, broken, or missing hardware, several options exist. Specialty hardware companies may stock matching replacement or reproduction pieces. Original hardware can be duplicated or suitable replacements may be available from salvage companies. Similar hardware can be used where functional rather than visual match suffices. Alternatively, original window hardware can be taken from secondary locations within a building for use in more prominent areas, and stock new hardware used as a substitute in the secondary locations.

When retrofitting existing aluminium frames with insulating glass, special care should be taken to insure that older hardware can handle the added weight.

This Preservation Tech Note was prepared by the National Park Service. Charles E. Fisher, Technical Preservation Services, is the Technical Editor of the Preservation Tech Notes series. Information about the U.S. Justice Building was generously provided by Clyde McHenry of Clyde McHenry, Inc., and Cathy McIntyre and Mike Ragan of the U.S. Department of Justice. Information on the Raymond M. Hilliard Center was generously supplied by Peter Holsten and Andy Hestness of the Holsten Real Estate Development Corporation. Thanks are also extended to Charles Fisher and Rebecca Shiffer of the National Park Service for their review and assistance. Thanks also go to The Aluminum Association; Edward Bartlett, Custom Window Company; Sam Wharton, Fenestra, Inc.; and Alex Paolucci, Atlantic Refinishing & Restoration Inc., for their assistance. Unless otherwise noted, photographs are by the author.

Preservation Tech Notes are designed to provide practical information on traditional and innovative techniques for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures and standards. This Tech Note was prepared pursuant to the National Historic Preservation Act, which directs the Secretary of the Interior to develop and make available to government agencies and individuals information concerning professional methods and techniques for the preservation of historic properties.

Comments on the usefulness of this information are welcomed and should be addressed to Preservation Tech Notes, Technical Preservation Services, National Park Service, 1849 C Street NW, Washington, DC 20240.