UNDOING A MIRACLE CURE-ALL
REMOVING AN ACRYLIC COATING FROM FEDERAL HALL NATIONAL MEMORIAL

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Overzealous attempts to protect historic properties have often led to inappropriate applications of cure-all products to traditional building materials. Sometimes such products create more problems than they solve, as was illustrated at Federal Hall National Memorial, located in the heart of New York City's financial district (Fig. 1).

Federal Hall, completed in 1842 as the U.S. Custom House, is one of the finest examples of Greek Revival architecture in the United States. Its enduring beauty is revealed in its cohesive spaces, its construction--almost entirely of marble--and the exquisite stone detailing found throughout the interior and exterior. To preserve and restore some of these qualities, Federal Hall was cleaned in 1971. When, in the words of the project completion report, "the cleaning process did not cause any miracles," the entire building, except for a test area, was spray coated with a poly(hydroxymethyl methacrylate) surface coating marketed under the trade name Hydron 300. Hydron did seem to promise miracles; it was chosen, according to the same report, for its ability "to seal and protect against pollution, the elements, and graffiti."[1]

The Hydron was applied in mid-summer. Within a few months something unexpected began to happen: Federal Hall's golden white marble facades began to turn a dull, ashen grey. Worse, the darkening tended to be more pronounced where the coating was thicker, so that every drip mark and overlap from the spraying was highlighted. It had become obvious, the project completion report continued, "that the treated area was attracting dirt more rapidly than the untreated area."[2] Believing that the coating had been faultily applied, the project supervisors ordered the accumulated surface dirt washed off, and the building was sprayed, at no additional cost, with a second coat of Hydron. But Federal Hall began again to turn grey, growing progressively darker over the next fifteen years until, in 1986, the coating was removed.

Identifying the Problem

Although it was not recognized in 1971, the coating itself, not the way it was applied, was the source of the problem. Hydron 300, manufactured by Hydron International, Inc., is marketed principally as an antigraffiti coating. Its hydrophilicity, or ability to attract and hold moisture, and its cross-linked chemical construction, which creates a polymer of superior strength, stability, and durability, make it especially effective for this purpose: a surface that holds moisture is slippery and therefore difficult to write on, and a cross-linked polymer resists degradation by many of the solvents present in paints and markers. Its manufacturers also claimed that Hydron 300 was an effective sealant and waterproofing agent. The coating was therefore seen as an all-in-one solution to the problem of protecting and preserving Federal Hall's exterior, and was applied even to out-of-reach areas that had never seen graffiti. Where graffiti resistance was not necessary, it was evidently

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thought, the coating's waterproofing characteristics would be useful. Unfortunately what was not foreseen was that the very properties that make Hydron graffiti-resistant make it unsuitable as an all-over coating on a building in a densely populated urban area: a surface that attracts moisture will also attract moisture-borne pollutants and dirt. The unsettling results of the 1971 application of Hydron to Federal Hall were exhibited again on a weathering test panel installed on the building's roof in 1986, demonstrating how remarkably fast this effect can happen (Fig. 2).

In 1986, the National Park Service concluded that the only way to reverse the darkening effect of the Hydron and to restore Federal Hall's marble facades to their natural golden white color was to remove the coating. To do so required first analyzing the coating to gain a thorough understanding of its properties and intended use and then testing a range of methods to select an appropriate removal technique. That the entire building had been spray coated with Hydron, not once but twice, increased the challenge.

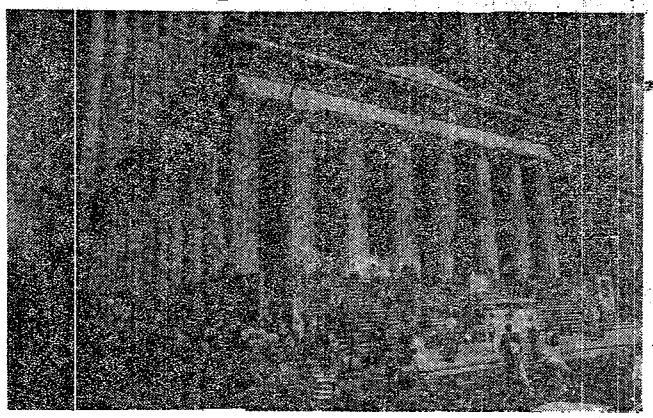

Figure 1. Federal Hall National Memorial, prior to coating removal, June 1986.

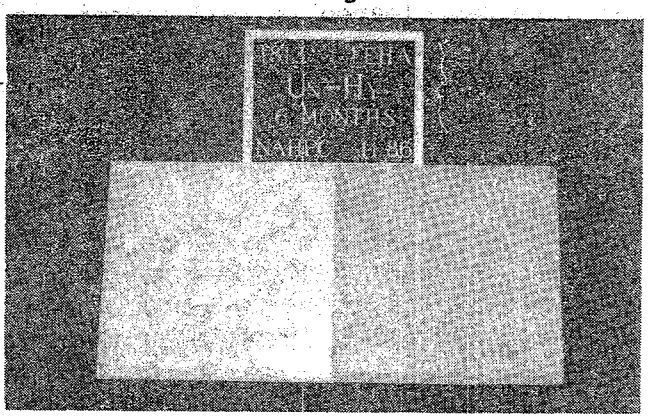

Figure 2. Weathering test panel on the roof of Federal Hall, November 1986. The right half of panel was coated with Hydron in May 1986, the left was left uncoated.

Designing a Testing Program Tailored to Project Goals

The goals of the project could be simply stated: to completely remove the coating without harming in any way Federal Hall's finely tooled exterior surfaces. With these criteria in mind, a testing program was designed to evaluate potential techniques consistently and objectively in order to determine the most effective and at the same time the most gentle method of removal.

A 1976 report documenting testing of solvents to remove the coating from Federal Hall noted its resistance to dissolving, and this was again confirmed by the Hydron International chemists when we consulted them in 1986.[3] Poly(hydroxymethyl methacrylate) is technically not a reversible coating. The chemists at Hydron International therefore suggested that mechanical cleaning using water held the most promise as a removal technique and that presoaking the coating or washing it with methyl alcohol or detergent, which tend to cause Hydron to "fatten up," or swell, might make it easier to remove. This information enabled us to narrow initially the selection ot techniques to be tested.

Two series of tests were performed: the first to evaluate each technique's ability to remove the coating, the second to determine surface loss. The first sequence of tests was done on individual marble panels, each measuring 12 x 24 x 1 1/4 (30.5 x 61.0 x 3.12 cm) inches and each masked into three equal parts, two to be tested and one a protected control surface. The

Morrisania and Tuckahoe marbles from Westchester County, New York, of which Federal Hall was constructed are no longer available,[4] but one sample of weathered mid-nineteenth-century Tuckahoe marble salvaged from Brooklyn Borough Hall was tested (Fig. 3).[5] The rest of the panels were fabricated of marble from Lee, Massachusetts. Both Lee and Westchester marbles are dolomitic (formed principally of magnesium carbonate) and, except that the Lee marble has a finer grain, they are similar in structure and chemical composition. The test panels were coated with Hydron and cured for seven days.

Tests for surface loss were made on Federal Hall itself. The testing was done in areas deemed most susceptible to abrasion or similar abuse: joint edges, sharp corners, and places where there were delicate tool marks or evidence of previous damage, such as spalling. Latex molds were taken from the locations before and after the tests to allow precise evaluation of changes in the surfaces (Fig. 4). Plaster casts made from the molds would facilitate objective comparison of the tested and untested surfaces.

Figure 3. Tuckahoe marble salvaged from Brooklyn Borough Hall. Thin section magnified 30x under polarized light; note grain and weathered edge, left.

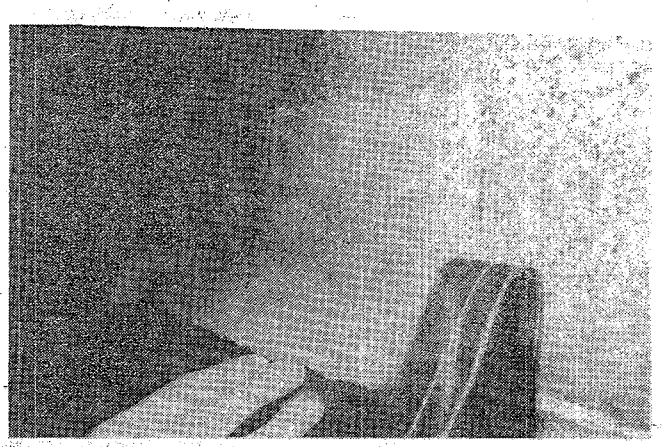

Figure 4. One of the latex molds used to evaluate precisely any damage to finely tooled surfaces on Federal Hall, April 1986.

Pressure Washing

Pressure washing was the first technique to be tested. If the aim of the testing was to find the gentlest effective method, one might wonder why the first system scheduled was chosen at all, as the forces it can generate are anything but gentle. We had several reasons for wanting to evaluate it. Although the system was being actively marketed for use on historic sites, its specific effect on historic masonry had not yet been determined. Its use in 1985 and 1986 at two sites in New York--Grant's Tomb and the Statue of Liberty--had provided empirical evidence of both its strengths and its limitations as a method for cleaning and removing paint from granite surfaces. The testing for the Federal Hall project would yield quantifiable results. Our intent was also to underscore the need for such testing and to further evaluate the efficacy of using numbers alone to predict the absolute effects of pressure washing techniques, a subject that has recently been much debated.[6]

The first pressure washing system we tested requires a truckload of machinery capable of developing pressures from 5,000 to 25,000 pounds per square inch (34.47 to 172.37 MPa). Water is fed at approximately 1.3 gallons per minute (4.8 L/m) to a hand-held gun with a rotary head containing several nozzles (in this case twelve). The head, which spins at 2,000 revolutions per minute, is sometimes inaccurately referred to as a "water scrub brush." The

profile of the water jet leaving the nozzles is such that the head must be held 3 to 4 inches (7.6 to 10.2 cm) from the surface; beyond that distance pressures decrease at a dramatic rate, so that at 18 inches the jet is effectively reduced to a fog (Fig. 5). The equipment was tested at its highest and lowest effective pressures.

As was expected, the test results confirmed that applying water pressure of 5,000 psi or higher to marble causes unacceptable damage. Even more significant, they showed that lower pressure did not necessarily mean less damage. In fact, far more damage occurred at 5,000 than at 25,000 psi. At any pressure, this technique removed the Hydron only where the coating was hit directly by the water jet, and once the surface was wet it became impossible to tell where the coating had or had not been removed. We noted that at the lower pressure the operator compensated by blasting some areas repeatedly, and at the close working distance dictated by the water jet's profile this became not only a laborious process but an injurious one. Even on the small sample areas the damage from the uneven washing was great in some places, and where the operator had lingered as long as 30 to 45 seconds it was explosive. The panel in Figure 6 shows the effect at 5,000 psi; the panel to the right of it shows the relatively lower (though still significant) levels of damage caused by pressures five times as severe applied for only 5 to 10 seconds. The duration of application was as significant a factor in causing damage as was the amount of pressure.

Testing of a second pressure washing system was aided by the insights gained from the above results. This equipment produced pressures of from 1,200 to 2,500 psi (8.27 to 17.24 MPa). It too featured a hand-held gun with a rotating head (with two nozzles) and required a close working range (2 to 3 inches).[7] Although pressures of 2,500 psi are still unconventionally high, the system was capable of removing the coating without damaging the marble, with judicious application of the water jet. As with the first system, however, this proved to be impossible. Again, the coating was removed only where it was hit directly by the streams of water from the spinning nozzles. Unable to accurately monitor the progress of the removal this operator, too, found it necessary to go over the same surfaces several times, so that even the marginally safer range of 1,200 psi became potentially hazardous.

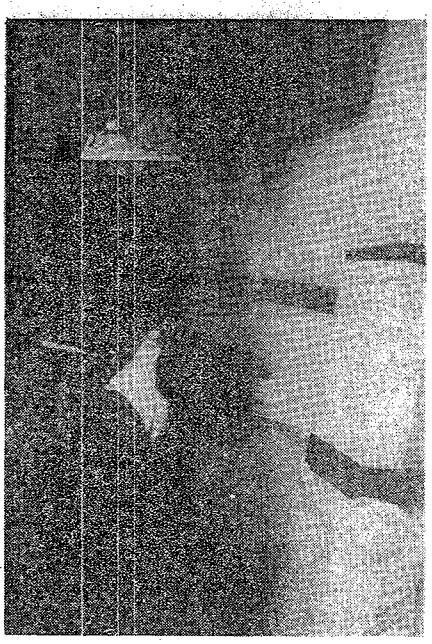

Figure 5. Pressure washing test at 5,000 psi (34.47 MPa), April 1986; note the shape of the water jet and the close working range required.

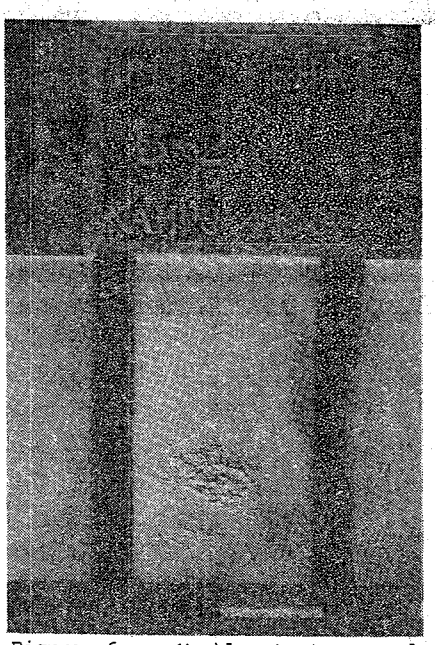

Figure 6. Marble test panel damaged after pressure washing for 30 to 45 seconds at 5,000 psi, April 1986. Panel at right, washed at 25,000 psi for 5-10 seconds, shows far less damage.

Pressure washing with pressures under 1,200 psi did not remove the coating. Presoaking the panels under a water mist for forty-eight hours before

washing them had no noticeable effect, nor did supplemental hand scrubbing with nonionic detergents, using nylon and natural bristle brushes.

Chemical Treatments

Water-only treatments, though simple and safe to apply, therefore could meet neither of the project's two criteria: they could not guarantee complete removal of the Hydron, and they were capable of causing irreparable damage to the historic fabric of Federal Hall. The introduction of chemical additives to the process began to look more attractive, even though using chemicals introduced new concerns, chiefly about the logistics of safe and simple application in a densely populated city location.

A handful of solvents known to have some effect on the acrylic polymer Hydron were identified and graded as to toxicity and volatility: toluene, acetone, dimethylformamide, methylene chloride, butyl cellosolve and ethylene glycol. Ethylene glycol surfaced as both relatively safe to use and relatively slow to evaporate and was selected to be tested. To increase its potential effectiveness, the ethylene glycol was mixed with a surfactant in the ratio of 50:1. It was then applied to the coating with a natural bristle brush. After a dwell time of about 15 to 20 minutes, the solution did begin to break down the coating in small patches. But even ethylene glycol's slower rate of evaporation was too great. The solution dried so quickly that it had to be applied and agitated repeatedly to be effective. In the field this would have been impractical and would have raised costs dramatically.

Next, a propriety mixture of solvents including methylene chloride and ethylene glycol, in a thixotropic base, was tried. Because the mixture was less volatile, it performed extremely well when given a dwell time of 25 minutes, followed by a water wash at 400 to 600 psi (2.76 to 4.14 MPa). It seemed we had found the answer. As a final precaution before we enthusiastically recommended this treatment, we scheduled a test to be done on the building itself. To our consternation, the process failed to remove the coating from the building. Even experimenting with dwell time, finally doubling it, had almost no effect. The lackluster response was attributed to several factors, the most significant of which were the age and increased toughness of the building's coating, the rougher surface of the marble of the facades, and the inhibiting effect on the solvents of accumulated dirt. The test was a pointed reminder of a fundamental but easily overlooked maxim: Always verify test results on the actual surfaces to be treated.

We resumed testing, trying next a treatment somewhat harsher than we had anticipated would be necessary. A highly alkaline proprietary solution containing primarily potassium hydroxide worked well when followed by a water wash at 400 to 600 psi. This solution worked not only on the test panels but on the more stubborn coating on the building's surfaces. It too had its drawbacks, however. There was the potential danger of overcleaning if left on the surfaces too long, or of reacting with iron compounds in the marble and leaving brown ferrous hydroxide stains, thus affecting the subtle golden hues of the marble along with the Hydron. To minimize the danger, we experimented with dwell times and determined that 15 minutes was optimal and that leaving the solution on the marble for up to 45 minutes still posed no serious threat. The possible effect of the acid wash required to neutralize the alkali solution was another concern. The dolomitic marbles on Federal Hall are naturally resistant to relatively weak acid solutions, and the dilute acetic acid specified for the wash caused no harm. Nevertheless, it was further decided that all building surfaces and the final rinse water should be

continuously pH-monitored throughout the cleaning process. Having assured ourselves as to its effectiveness and safety, we chose the potassium chloride solution as the optimal treatment.

The acrylic coating has been removed from two sides of Federal Hall, and the work is to continue in 1987 (Figs. 7,8). The newly cleaned facades, which still retain the beauty of the stone's natural patina of age, attest to the success of the project.

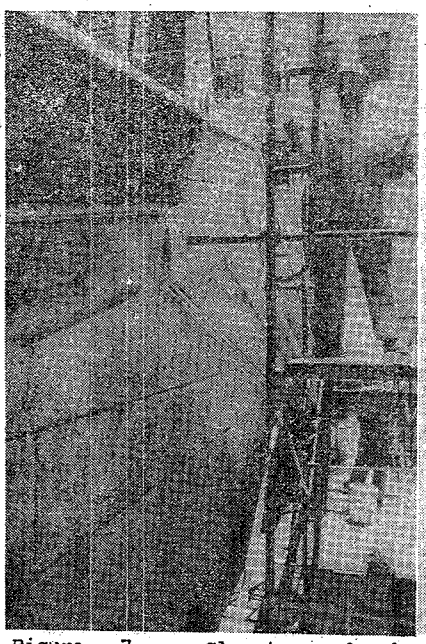

Figure 7. Cleaning Federal Hall's cornice with alkaline solution, June 1986.

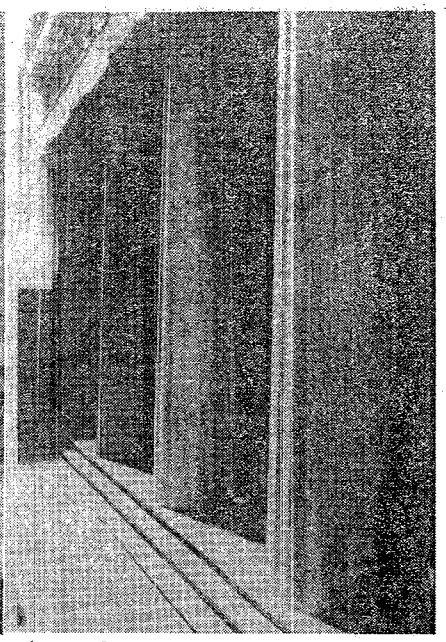

Figure 8. Two cleaned columns on north portico, June 1986.

Conclusion

The results of the Federal Hall tests have direct application to coating removal and cleaning projects of similar scope, and they offer useful observations about the real effects of pressure washing techniques on building materials. The experience has wider implications as well. It points up the dangers inherent in expecting, or wanting, a product to remedy several problematic conditions at the same time and emphasizes the need for making choices of products or techniques based on appropriate pretesting and evaluation.

Footnotes:

1. "Completion of Rehabilitation: Federal Hall National Memorial," Work Order no. 5951 200-16 Rev.4, (National Park Service: Harpers Ferry, W.Va., 1973). This paper reports one instance of the improper use of Hydron 300 and is not meant as a criticism of the product's effectiveness in other instances and under other conditions.
2. Ibid.
3. Letter from Norman R. Weiss, Consulting Scientist, to the North Atlantic Regional Office, National Park Service, Boston, August 4, 1976.
4. By 1930, all Morrisania and Tuckahoe quarries had closed; see Gordon R. Urquhart, "The Architectural History of the Westchester Marble Industry," Master's thesis, Columbia University, 1987.
5. I am grateful to A. Ottavino Corporation, Ozone Park, New York, for donating this stone.
6. Alfred M. Staehli, "Appropriate Water Pressures for Masonry Cleaning," APT Bulletin 18:4 (1986) pp. 10-17.
7. In both systems tested, the rotary head appeared to be a novelty only; it had no noticeable effect on the equipment's performance in these tests, except to modify the field of application.

All photos by author, except Figure 3 by Leonard Cannone.

UNDOING A MIRACLE CURE-ALL
REMOVING AN ACRYLIC COATING FROM FEDERAL HALL NATIONAL MEMORIAL

Summary

The application of an acrylic coating to the marble facades of Federal Hall National Memorial in New York City created more problems than it was intended to solve. Most notably, shortly after application the treated surfaces began attracting dirt, turning suddenly from golden white to ashen grey. They darkened progressively for fifteen years until, in 1986, the coating was removed. The process of analyzing and selecting an appropriate removal technique has direct application to other projects of similar scope. It also examines some critical effects of pressure washing for coating removal.

The applied coating, Hydron 300, has certain properties that make it effective as a graffiti-resistant coating. Those same properties in a dense urban context, however, proved detrimental to Federal Hall's marble facades. They also made removal extremely difficult; the coating is technically not reversible. Complete removal of the coating was the only way to guarantee the building would be effectively cleaned. It was also important that the removal not damage the historic marble surfaces. A comprehensive testing program was developed to evaluate a wide variety of potential removal techniques against these two criteria: complete coating removal and no surface loss. Coating removal tests were conducted off the building on marble test panels treated with Hydron and cured. Surface loss tests were made on Federal Hall itself, using latex molds to evaluate precisely the effect on the building's finely tooled surfaces. The goal was to identify the gentlest effective technique.

Results were illuminating. The first system tested was one intended to establish the upper limits of pressure washing effect. It was capable of developing pressures of 5,000 to 25,000 psi (34.47 to 172.37 MPa), with water exiting a multi-nozzled rotating head. As expected, test results showed that such high pressures will create unacceptable damage. But it was interesting to note that lower pressures did not mean less damage; operator control was a larger contributing factor and accounted for far more damage at the lowest pressure than at the highest. The next system tested developed a more conventional pressure of 1,200 psi (8.27 MPa) and also employed a rotary head. Although it effectively removed the coating without damage to the stone, it did so only where the water jet directly hit the coating. The inability to monitor what had or had not been cleaned once surfaces became wet would not allow sufficient control by the operator to guarantee no surface damage would occur. The rotary head, on both techniques, had no effect; neither did presoaking panels nor supplemental hand scrubbing. A handful of solvents known to have some effect on the acrylic polymer were tried, but their volatility reduced any effectiveness. A proprietary mixture of the same solvents in a thixotropic base was tested and worked well when followed by a 400-600 psi (2.76-4.14 MPa) pressure wash. In subsequent testing on the building's coating, though, it was disconcertingly ineffective. This was thought to be due in part to the earlier coating's age (and increased toughness), the relative roughness of the building surfaces vs. the panels, and the inhibiting effect of accumulated dirt. Finally, an alkaline solution was tested, found effective, and selected for use. Although its required neutralizing acid wash was a concern, Federal Hall's dolomitic marble was resistant to the mild acid solution applied, and surfaces were pH monitored throughout the cleaning process to ensure safety.

The newly cleaned surfaces enlivened the historic facades while still retaining the beauty of the marble's natural patina of age.

COMMENT REVENIR SUR UN TRAITEMENT-MIRACLE?
SUPPRESION D'UN ENDUIT ACRYLIQUE --FEDERAL HALL NATIONAL MEMORIAL

Résumé

La protection acrylique appliquée aux façades de marbre du Federal Hall National Memorial à New York a finalement créé plus de problèmes qu'elle n'en a résolu. En effet, peu après son application, les surfaces traitées ont commencé à se couvrir de poussière et à virer soudain du blanc-doré au gris-cendré . Puis, durant quinze ans, elles ont peu à peu foncé, jusqu'à ce que finalement la décision soit prise en I986 de supprimer l'enduit acrylique. L'analyse et la sélection d'un procédé technique approprié pour cette opération délicate pouvant avoir des applications directes pour des projets similaires, il est utile de les examiner et, par la même occasion, d'étudier les problèmes critiques du lavage sous pression pour la suppression des films protecteurs.

Le film protecteur en question, Hydron 300, a des propriétés particulières qui le rendent résistant aux graffittis et autres rayures. Mais ce sont précisément ces propriétés qui, dans le contexte urbain particulièrement dense de New York, ont endommagé le marbre des façades du Federal Hall, et rendu le ravalement très difficile, le processus de protection étant pratiquement irréversible. Or, la disparition complète de la couche protectrice était la condition sine qua non d'un nettoyage complet et efficace du bâtiment. Il était d'autre part essentiel que l'opération n'abime pas le marbre ancien des façades. Un programme de tests a donc été mis au point de manière à évaluer toute une gamme de techniques de nettoyage, avec deux objectifs en vue: suppression complète du film protecteur et préservation intégrale des surfaces concernées. Les tests de suppression d'enduit ont été effectués hors bâtiment, sur panneaux de marbre traités au Hydron 300, et après durcissement. Pour tester la conservation des surfaces de marbre, on a travaillé sur le bâtiment lui-même, à l'aide de moules en latex, pour évaluer de manière précise l'effet de chaque technique sur ses façades finement taillées. Il s'agissait de déterminer la technique la plus efficace et la plus douce à la fois.

Les résultats sont probants. Le premier système testé devait établir les tolérances limites au lavage sous pression.Il permettait d'atteindre des pressions comprises entre 344,7 et 1723,7 millibars (5000 à 25000 psi), à l'aide d'un multi-jet rotatif .Bien entendu, les tests ont confirmé que de telles pressions étaient inacceptables. Mais des pressions plus basses ne signifiaient pas nécessairement moins de dommages: en effet, la parfaite maîtrise de la manipulation est un facteur-clé de réussite, plus encore à basse pression. Le second système mis à l'épreuve était beaucoup plus conventionnel: 82,7 millibars (1200 psi) de pression et jet rotatif. Totalement efficace pour enlever la couche protectrice sans abimer la pierre, il a le désavantage de ne fonctionner qu'au point de contact exact de la pierre et du jet. D'autre part, l'impossibilité de détecter sur les surfaces mouillées celles qui sont déjà nettoyées de celles qui ne le sont pas encore, empêche tout contrôle sur les dommages superficiels. La tête rotative, dans les deux cas, n'a aucun effet, ni le frottage à la main postérieur. Quelques solvants connus pour leur efficacité sur les polymères acryliques sont totalement inefficaces dans notre cas à cause de leur volatilité. Par contre, l'application d'un mélange des mêmes solvants et d'une base épaississante a donné de bons résultats, à condition d'être suivie d'un lavage sous-pression à 27,6-41,4 millibars (400-600psi). Contre tote attente, appliquéee au bâtiment, cette solution n'a pas marché. Ceci est dû sans doute à l'âge de la protection (à sa plus grande dureté), à la rugosité du bâtiment comparéee à celle des panneaux-tests, et à l'accumulation de poussière. Finalement, c'est une solution alcaline qui donne les meilleurs résultats, malgré les problèmes dûs au fixage à l'acide.Et meme si le marbre dolomitique du Federal Hall a bien résisté à la solution légèrement acide, il a fallu contrôler sans arrêt le Ph de la pierre pour éviter d'éventuelles lésions.

Aujourd'hui, le ravalement fait revivre les façades, tout en gardant au marbre la beauté de la patine de l'âge .