GRAEF
ANHALT
SCHLOEMER
and Associates Inc.

Engineers & Scientists
345 North 95th Street, Milwaukee, Wisconsin 53226 • 414-259-1500 • FAX 414-259-0037

February 7, 1994

Mr. Ivars Zusevics, Managing Architect
Department of Public Works and Development
Milwaukee County
Courthouse Annex, Room 303
907 North 10th Street
Milwaukee, Wisconsin 53233

RE: Mitchell Park Horticultural Conservatory
Structural Condition Study

Dear Mr. Zusevics:

We are submitting herewith our Structural Condition Study of the Mitchell Park Domes.

The purpose of this report is to quantify the nature and extent of deterioration, determine feasible methods for performing repair work, and provide data necessary to develop a reasonable plan/schedule for doing the repair work. This report includes the summary of available information and observations of interested parties regarding the Domes. It also contains the results of various inspections, research into repair approaches, and preparation of preliminary cost estimates.

This report is the first step in the process of updating the structural condition of the Mitchell Park Domes.

We have enjoyed working with Milwaukee County and appreciate the assistance and cooperation we have received from you and your colleagues during the project.

Sincerely,

GRAEF, ANHALT, SCHLOEMER & ASSOCIATES INC.

Kenneth E. Grebe, P.E.
Project Manager

Cynthia R. Minshall, P.E.
Project Engineer

CRM:KEG:fls
enclosure
cc: John Goetter, GAS

Milwaukee, Wisconsin
Green Bay, Wisconsin
Madison, Wisconsin
Chicago, Illinois
Colorado Springs, Colorado

TABLE OF CONTENTS

MITCHELL PARK DOMES

INTRODUCTION

The Mitchell Park Horticultural Conservatory consists in part, of three conoid structures, referred to as "domes," a central lobby, and a transition greenhouse.

Each of the three domes contains a different climate. The individual domes are referred to by their specific climate and include the Arid, the Tropical, and the Show Domes. The Mitchell Park Conservatory has a unique variety of plants not found in other Conservatories. The Domes attract approximately 250,000 visitors annually.

Construction of the Domes began with the demolition of the previous Conservatory in 1955 and proceeded in phases until final completion in 1965 at a total cost of $4,168,000.

The individual domes are comprised of a precast concrete frame, supporting an aluminum framed wire glass cladding, and a steel framed apex. Each dome is 85 feet high and has a 140-foot base diameter. The precast concrete frame is a series of hexagons, diamonds, and triangles which make up the conoid shape. The individual concrete sections were formed on-site and erected over a temporary steel frame. The aluminum framing containing the glazing system is supported by stub posts attached to the concrete frame. The aluminum frame has an internal drainage system to channel condensation. There is a total of 9,438 lites of 1/4-inch thick wire glass. The apex is 37 feet in diameter and houses mechanical equipment for the air handling system.

The domes were designed using concepts which advanced the state-of-the-art of conservatories and construction. Ideas developed from construction of the domes have been studied and utilized on other projects throughout the country. It is a unique structure that must be maintained if future generations are to enjoy it.

According to the Milwaukee County records, the domes have required very little annual maintenance. The domes have performed satisfactorily for 30 years, but are now showing signs of age. A variety of deficiencies that affect functionality and operating costs have been identified. These deficiencies will only increase if maintenance is delayed.

In October 1993, Graef, Anhalt, Schloemer & Associates Inc. (GAS) was retained by Milwaukee County to perform a structural condition study of the Mitchell Park Domes.

The purpose of this study was to quantify the nature and extent of the deterioration, determine feasible methods for performing repair work and provide data necessary to develop a reasonable plan/schedule for doing the repair work. This report is the first step in the process of developing a plan for updating the structural condition of the Mitchell Park Domes.

The scope of the study included gathering available information, obtaining the observations and concerns of interested parties, visual inspection and testing of the domes to quantify the nature and extent of deterioration, research of different repair approaches and preparation of preliminary cost estimates for the repair approaches. The study was limited to the three domes above the level of the concrete foundation wall.

STUDY

The structural condition study began with a visual inspection of the three domes and included limited concrete and drainage system testing. Deterioration, such as cracking of concrete and glass, leaks and stains, unwanted plant growth, peeling paint, and concrete spalling was noted.

Precast Concrete Frame

A pattern of concrete cracks appear in each of the domes. These cracks appear typically where two separate precast pieces were connected during construction (Appendix A, Photo No. 1). There is also visible cracking between the concrete base and the precast frame members (Appendix A, Photo No. 2). The cracks, although unsightly, appear to be only superficial in nature. The cracks, however, give access points for moisture to come in contact with the steel reinforcing and connections. This may lead to deterioration of the concrete frame. To eliminate the cracks, the areas should be routed and caulked. The caulk should be troweled flat and must be compatible with the concrete and the paint.

There are an average of 12 small spalls per dome. A spall is a form of concrete deterioration, most often caused by corrosion of embedded steel. As the steel corrodes, the corrosion products take up more volume than the original steel, causing outward pressure against the concrete. This cracks the concrete between the steel and the surface, causing a spall. The spalls typically occur at the embedded plate for the attachment of the hub assembly to the concrete frame and are visible from the catwalk around the base of the domes (Appendix A, Photo Nos. 3 and 4).

The exposed rusting steel at the spall locations should be, in general, cleaned to the base metal with a needle gun and then a power wire brush. The bare steel should then be touched up with two coats of corrosion resistant paint. The spalls are not typically visible to visitors, they need only be painted to match the surrounding concrete frame. Patching with grout is not necessary as the grout may shrink and crack or fall off causing further problems.

The embedded plate at the precast frame to hub connection has pulled out of the precast at one location on the west side of the show dome. There is a visible gap between the back of the plate and the face of the concrete. This must be repaired. This may exist at other locations and should be watched for when painting or replacing glazing. We have estimated this situation has occurred at six locations.

Half cell testing was performed to determine if there is active corrosion occurring in the reinforcing steel. The testing was performed at five hexagons in the Tropical Dome and at three hexagons in the Show Dome. No testing was done in the Arid Dome. This testing indicates that there is a greater than 90 percent chance that no active corrosion is occurring at these locations at this time. See Appendix B for the field report containing the results of the testing.

In conjunction with the half cell testing, a continuity check was performed in the limited area tested. There generally is good electrical continuity between the reinforcing steel and the embedded plates in the hexagonal members. Cathodic protection for the reduction of corrosion activity may be an option in the future, since there appears to be good continuity in the reinforcing steel.

Currently, the concrete appears to be in good condition based on the testing performed, but without adequate protection the concrete can deteriorate causing significant structural problems in the future.

Paint

The concrete frame was originally painted with a minimum of two coats of epoxy paint. This paint was specified to have a life expectancy of 10 to 15 years (see Appendix D for the original paint specification). The paint has been in service for approximately 30 years and is chalking and peeling. The majority of the peeling is seen in the lower areas of the Tropical Dome which has the highest humidity (Appendix A, Photo No. 5). The paint is no longer resistant to fungi and mold growth as originally specified, as there is plant growth on the surface of the paint in all of the domes. The paint protects the concrete and should be repaired to maintain the integrity of the structural frame.

There is visible dirt streaking on the paint in each of the domes (Appendix A, Photo No. 6). Dust propagation from the walkways was believed to be partially responsible for the amount of streaking. The walkways in the Arid and Tropical Domes have been paved to reduce the amount of dust. There currently is no easy way to wash the interior of the structure.

Two options for painting have been evaluated. The first option is to repaint the entire concrete frame and steel apex. The second option is to paint only the lower section of the concrete frame to a height of approximately 30 feet.

To reach the upper sections of the domes, either a lift or lightweight rigging will be required. Available lifts may have a wider wheel base then the designated walkways. Some of the existing plants may need to be removed during the refurbishing. The weight of a lift may cause damage to the paved walkways, requiring asphalt repairs. The use of lightweight rigging will require a structural review of the dome's load-carrying capability to insure that the rigging can be adequately supported by the concrete frame. Since work will be done overhead in either case, a portion, or all of a dome, may need to be closed during the repainting.

It is estimated to take between 5 and 8 weeks per dome to remove and/or clean the existing paint and repaint the entire concrete frame and apex. To repaint the lower section, it is estimated to take 3 to 5 weeks per dome. More than one shift may be utilized to decrease the estimated time of repainting.

The concrete frame should be painted after all leakage problems from the drainage system are fixed and all the leaking glass has been replaced so that paint work is not immediately stained.

Additional air handling equipment may be required to improve air circulation and the air quality during painting. Drop cloths will be required to keep paint chips from contaminating the soil as the existing paint is removed and to protect the plants during repainting.

The painting contractor could be responsible for cleaning the inside of the glass since they would already have the equipment on-site to reach all areas of the domes.

Glazing

Each dome has approximately 3,150 pieces of 1/4-inch thick wire glass. The breakage count in each dome was approximately 100 broken pieces in the upper one-third of the dome and approximately 100 broken pieces in the lower two-thirds. The 200 broken pieces per dome account for about 7 percent of the total glass in a dome.

The majority of glass breakage in the upper one-third of each dome is thought to be caused by the brittle nature of the 1/4-inch wire glass (Appendix A, Photo No. 7). Most of this type of breakage is believed to have occurred during the first few years of the Domes' existence. The breakage in the lower two-thirds is a combination of the brittle nature of the glass and vandalism. Some breakage may have been caused by the shifting of the aluminum frame. Some breakage may have been caused when a cart was used as a platform for the window washers to clean the exterior of the glass.

Vandals have used stones, hammers, and guns to break the glass. In some cases, entire lites have been broken to gain access to the structure. This type of damage is typically seen on the east side of the domes which is not visible from the street and occurred when the domes were closed to the public. Some of the vandalism has resulted in large holes in the glass which could not be repaired (Appendix A, Photo No. 8). The holes, as well as some of the cracks, allow moisture to enter the domes. Conservatory Management feels that vandalism is a major security issue. There is concern for the safety of individuals and property in the Domes.

In the Arid Dome, there are two pieces of cracked glass over the apex (Appendix A, Photo No. 9). The glass has been caulked to stop leakage onto the mechanical equipment. It is estimated that the Tropical and Show Domes each have similar quantities of broken glass in this area.

There have been a small number of lites of glass replaced or repaired. Two lites in the Tropical Dome and one lite in the Arid Dome were replaced with a polycarbonate material. There have also been lites replaced with 1/4-inch wire glass, but these are not visibly detectable. Repair work has included caulking small holes in the glass and using boards to close off larger holes (Appendix A, Photo No. 10).

Aluminum Frame - Drainage

The aluminum frame has an internal drainage system to channel moisture. The drainage system was designed to allow moisture to flow down either the neoprene gasket and gutter or the rafter gutter to the hub. (Appendix F, Diagrams 1 and 2.) From the hub, the moisture was channeled through the interior of the aluminum rafter members and hubs until the moisture reached the bottom of the lowest hub which is left open. The water is allowed to run down a cap flashing to the lowest point on the bottom hexagon where there is an embedded pipe in the concrete wall which directs the water into the basement of the dome (Appendix F, Diagram 3).

Above the doorways, no drainage pipe appears to have been placed to direct the water. Water is channeled inside the dome and collects at the low point on the ledge above the doorways. Above the east service door in the Arid Dome, there was approximately 2-1/2 inches of standing water with a high water line of 6 inches visible on the face of the hub (Appendix A, Photo No. 11). When the water reaches a certain level, it flows to the canopy above the door. The canopy is sloped inward to the center and water ultimately drips onto the floor. The worst area is the east service door in the Tropical Dome which almost continually drips water. The canopy above this service door always has standing water which holds debris and attracts bugs.

On the exterior of the Tropical Dome, above the service door, water from the inside has found its way through the base flashing. The water runs down the exterior face of the dome onto the roof above the door. There is deterioration of the exterior concrete wall (Appendix A, Photo No. 12). This flashing should be replaced and the concrete wall repaired. The water at the low points needs to be redirected to eliminate dripping at the doorways.

There is water leakage beneath the base flashing in at least two locations on the northwest face of the Tropical Dome (Appendix A, Photo No. 13). The base flashing should be removed and replaced to eliminate the water leakage. Approximately 10 percent of the base flashing should be replaced during reglazing. The remaining 90 percent of the flashing should be cleaned of plant growth and dirt.

A total of 13 out of the 5,500 hub caps were removed to determine the cause of water dripping on the inside of the building from the hubs. There were 8 hub caps removed in the Tropical Domes at locations known to drip water. Three hub caps in the Show Dome and two in the Arid Dome were also removed. Typically, water does not drip from the hubs in the Arid or Show Domes unless it rains, however, there is almost always water dripping from the hubs in the Tropical Dome. The inspection of the hub interiors showed that there was debris in all hubs. The debris included dirt and in some cases dead plant matter. In the Tropical Dome, the majority of locations had so much debris that the vertical drain pipe was clogged. The water in the inspected hubs reached such a point that it ran over the exterior opening and dripped from a low point on the hub interior. See Appendix B for field reports containing testing information. All hub interiors should be cleaned of debris and the excess water removed during the reglazing process.

There are at least five missing hub cap assemblies (Appendix A, Photo No. 14). Most missing hub cap assemblies are low on the structure and easily accessible. There are also at least three missing hub center caps. Where the center cap is missing, the hole has typically been filled with caulk. The missing hub cap assemblies detract from the aesthetics of the domes. The opening allows moisture and bugs to enter the drainage system, while heat escapes the building in the winter. It was noted during an inspection that ice had formed in an open hub. The ice blocks the channeling of moisture in the drainage system. The missing hub cap assemblies should be replaced during reglazing.

There are numerous locations where the perimeter of the hub cap assembly was caulked to prevent moisture from entering the internal drainage system (Appendix A, Photo No. 15). These seals may not be fully effective and are unsightly. The affected hub caps should be removed and resealed during reglazing.

Due to the difficulty of access to the upper portions of the domes, only visual observations were made of these areas. There may be deterioration present that requires repair which has not been noted to date. As actual repair work progresses and equipment is available to access all areas of the domes, a close-up inspection of all members and surfaces can be performed.

Related Maintenance Needs

As the glazing is replaced, the gasket material and seals could be replaced with new silicone based gasket material and silicone sealant. The missing hub cap assemblies should also be replaced during reglazing.

While the hub cap assemblies are removed for reglazing, the interior of the hub should be cleaned of all debris and standing water. The cleaning of the hub interiors should facilitate water flow through the internal drainage system and eliminate some of the water leakage problems. If only limited reglazing is done, then hubs which are dripping or suspected of dripping should be cleaned of debris. The connection between the lower vertical pipe and the hub could be tightened at some locations during reglazing. This will act to compress the neoprene seals which may have taken a compression set over the years.

There are at least three lightning rods that are not properly attached to the hub assembly as visible from the ground. The connection between the hub and the lightning rod has been broken, and the rods no longer stand perpendicular to the hub cap. The lightning rod may not be functioning properly and the appearance is unsightly (Appendix A, Photo No. 16). The lightning rods should be repaired at the same time reglazing is done, while equipment and manpower are available on-site.

Plant growth is occurring between the glass and the gasket material and is most noticeable in the northwest section of the Show Dome. There is also growth on the inside face of the glass, which is most visible as a dark stain on the glass in the Tropical Dome. On the surface of the base flashing, there are various locations in all domes where there is considerable plant growth. This problem would most likely be alleviated if the drainage problem is corrected. All unwanted plant growth should be eliminated by cleaning or removing affected area.

The steel in the apex appears to be in good condition, based on a limited visual inspection of the Arid Dome's apex, both from the interior catwalk and the exterior platform around the dome. There is some peeling paint in the Arid Dome, exposing the primer. The interior surfaces of the apexes should be painted to protect the steel frame. This painting should be done during the repainting of the concrete frames. This cost is included in the concrete frame painting estimate. There is plant growth on the exterior of the apex around the intersection of the vertical walls and the dome, which needs to be cleaned.

There are approximately 45 screens in the three domes in need of repair or cleaning; 25 are ripped, and 20 have debris trapped between the screen and louver. This debris includes old leaves and plant growth (Appendix A, Photo No. 17). The ripped screens allow bugs and animals access to the domes. The debris prevents the louvers from drawing in the required air intake which causes the air handling system to run inefficiently. The ripped screens should be removed and repaired. The debris between the screen and louver should be removed and the screens replaced.

Stainless steel screws were originally used to attach the screens and caps to the structure. Over time, an estimated 1,000 screws were replaced. At these locations, stainless steel screws were not used and the replacement screws have corroded (Appendix A, Photo No. 18). The replacement fasteners have had a galvanic reaction with the aluminum which causes discoloration and loss of material. The corroded fasteners should be replaced with stainless steel fasteners and any deterioration of the screen frame should be cleaned. Some of the corroded screws are on screens that need to be removed and repaired or cleaned. This cost is included in the screen replacement cost.

Repair Options - Glazing

There were five levels of glazing replacement evaluated.

1. Minimal replacement - only lites that leak or have holes. Estimated to be half of the breakage count or 300 lites for the three domes.

2. Replacement of all cracked or broken lites. All 600 broken lites.

3. Replacement of all lites in the upper one-third of all three domes (approximately 3,000 lites) along with all broken or cracked lites in the lower two-thirds.

4. Replacement of all cracked or broken lites along with selected lites around the base where vandalism is a major concern. All 600 broken lites plus an estimated 280 lites at the base of the domes. The 280 lites represent a band around the entire Arid Dome and the east face of the Tropical and Show Domes.

5. Total reglazing of all three domes. This would include replacing all 9,438 lites over a number of years, one dome at a time.

There are three types of glazing materials suitable for glazing replacement which have been researched. The first type of glazing is a clear laminated product consisting of two pieces of 3/16-inch clear heat-strengthened glass, laminated with a 0.030-inch Monsanto Saflex interlayer. The second type is a similar clear laminate as listed above, with a Low-E coating on the interior surface and a 0.060-inch interlayer. Finally, for areas where vandalism is a major concern, a 3/8-inch polycarbonate material was evaluated. The relative performance data of these products is included in Appendix F, and is shown with respect to the existing 1/4-inch clear wire glass.

The replacement glazing evaluated uses a 3/8-inch thick material even though the existing glazing is only 1/4-inch thick. The glazing system can accommodate the small difference in glazing material thickness.

Insulated glass is significantly thicker and heavier than the existing glass. Its use would require modifications to the glazing system. Insulated glass is a more expensive glazing product.

Other glazing materials may also be acceptable. The glazing material cost will be different for each material, but the cost of materials is only a small fraction of the total glazing cost. Therefore, the selection of glazing material may be based on factors other than material cost.

Laminated glass is generally capable of withstanding damage from hail and other weather conditions. A glass supplier will typically warrant laminated glazing against delamination for 10 years but will not give a warranty against breakage once a lite is installed in an approved manner. Milwaukee County can obtain insurance against breakage.

A polycarbonate product was evaluated for use in areas where vandalism is a concern because it offers an impact resistance approximately 250 times greater than that of glass and approximately 30 times greater than an acrylic product. There should be no significant yellowing of the material detected within 5 years. The material may have significant yellowing over its life which will result in light transmission loss. A polycarbonate product is not anticipated for reglazing except in areas deemed to have a vandal/security problem. A mar-resistant and ultra-violet filtering coating is available at an additional cost.

The 1/4-inch clear wire glass was not evaluated as an option, although still available, because it is not the state-of-the-art in glazing material. It is also a brittle glazing material and its production is limited. Appearance differences between clear glazing and the existing wire glass were deemed by Conservatory Management to be insignificant.

A more energy-efficient glazing system should result in reduced annual gas costs. It is our understanding that gas service currently has an annual cost of approximately $125,000. Wisconsin Gas Company does offer rebates for more energy-efficient designs. Reglazing could qualify the domes for participation in Wisconsin Gas Company's energy rebate program. The Domes are eligible for a maximum rebate of $4,500 based on current rebate programs.

Repair Priorities

The repair program should be prioritized to ensure the structural integrity of the Domes. Currently, there is broken glass and a malfunctioning internal drainage system which, in addition to paint peeling off of the concrete frame, is significantly increasing the chance of deterioration of the concrete frame. Should the concrete frame deteriorate, major structural repairs will be required in the future.

Conservatory Management feels that, with all else being equal, repair work should be performed in the Show Dome first, as this dome generates revenues from being rented out. The Arid Dome should be the next priority, as it contains the most valuable exhibit. Finally, the Tropical Dome should be repaired. However, based on the amount of deterioration currently present, the repair of the Tropical Dome should be considered a priority.

Repair Cost Estimates

The domes are unique structures. Only limited repair work has been performed so there is a lack of reliable historical cost information available to assist in estimating. The full extent of repairs required will only be known when actual repairs are being performed and equipment is available to access all areas. The estimates given, therefore, contain a relatively high level of uncertainty.

Repair work to be done requires a high degree of craftsmanship, as the products should be expected to perform for at least another 30 years. Access and protection of the plants will present a major challenge to even experienced contractors. Care should be taken to choose the most qualified restoration contractors that have the knowledge, experience and manpower to perform this work. Similarly, materials will need to be carefully specified and supported by warranties to assure long life and low maintenance. Some of the repair work will require at least a portion of a dome to be closed, so scheduling of work and materials will be a challenge. These factors will undoubtedly contribute to the cost of any work performed.

The painting costs listed are based on estimates obtained from three paint contractors. They also supplied information on the different methods of access.

Super Sky Products Inc. was retained by Graef, Anhalt, Schloemer & Associates Inc. as a glazing consultant. Super Sky Products Inc. was the original aluminum frame designer, supplier, and installer. The glazing prices are based in part on their knowledge of this structure and extensive experience in restoration work.

Repair Item	Quantity/Dome	Cost/Dome	Total for 3 Domes
Repair Hub Attachment	2	$ 3,000	$ 9,000
Repair Spalls	12	2,000	6,000
Fix Cracks	750 ft.	13,000	39,000
Paint Full Frame & Apex	24,000 sq.ft.	150,000	450,000
Paint Lower 30 Feet	11,500 sq.ft.	60,000	180,000
Drain Water Above Doors	3	3,000	9,000
Replace Flashing & Clean	490 ft.	5,000	15,000
Replace Screens and Clean Screens of Debris	15	3,000	9,000
Replace Fasteners	--	1,000	3,000

Glazing

The costs given are totals for all three domes. These costs include lightning rod repair, cleaning of hub interiors, replacement of gasket material, and replacement of missing hub assemblies.

	3/8-inch Heat-Strengthened Laminated	3/8-inch Laminated with Low-E
Minimal Replacement 300 lites	$ 900,000	$ 920,000
All Broken Replaced 600 lites	1,750,000	1,790,000
All Upper 1/3 + All Broken 3,300 lites	4,650,000	4,850,000
All Broken + Vandal 600 + 280 lites	2,220,000	2,260,000
Total Reglaze 9,438 lites	10,000,000	10,500,000

All cost estimates include overhead and profits and are based on current pricing. Appropriate factors must be applied to cost estimates to account for inflation, market changes, engineering, and contingencies. The cost of any disturbances to the Domes has not been included in the costs of repair. For example, the cost of moving plants has not been included.

SUMMARY

The nature and extent of the deterioration, as it affects the structural components of the Domes, was determined by visual inspections, and limited concrete and drainage system testing.

Based on these observations and tests, we have found the structure has broken and leaking glass, missing hub caps, broken lightning rods, and a poorly functioning drainage system. The concrete frame appears to be in good condition, however, the paint is peeling and isolated areas of deterioration are present. Without the protection of the paint, and with the poorly functioning drainage system, the frame will continue to deteriorate, resulting in major future repairs. There are also other maintenance items such as ripped and dirty screens, and corroded fasteners.

This report has listed the information available on the existing construction, the concerns of persons interested in the future of the Domes, various repair approaches, and preliminary cost estimates extrapolated from tests and observations.

The following summary of repair items is recommended as the minimum repair program necessary to protect the structural integrity of the Domes. These repairs should be accomplished within the next two to three years to avoid major repairs of much greater cost in the future.

Recommended Minimum Maintenance Repair Program

Protect Structural Integrity	Estimated Cost
Repair Item - For 3 Domes Unless Noted	
Repair Hub Attachment	$ 9,000
Repair Spalls	6,000
Fix Cracks	39,000
Replace Leaking Glass (300 Lites)	900,000
Paint Tropical Dome (only) Frame and Apex	150,000
Drain Water Above Doors	9,000
Replace Flashing and Clean	15,000
Correct Functional Deficiencies	
Replace and Clean Screens of Debris	$ 9,000
Replace Fasteners	3,000
TOTAL	**$1,140,000**

This study is the first step in establishing a detailed plan/schedule for updating the structural condition of the Mitchell Park Domes. Any repair work performed should be of the highest quality in materials and workmanship because of the inaccessability of the structure. This structure is unique and must be maintained if future visitors are to enjoy it.

APPENDIX A

PHOTOGRAPHS

Photo No. 1
Arid Dome - East Face

Cracks and staining on concrete frame

Photo No. 2
Tropical Dome - Above East Service Door

Cracking between concrete members.
Visible plant growth on paint.

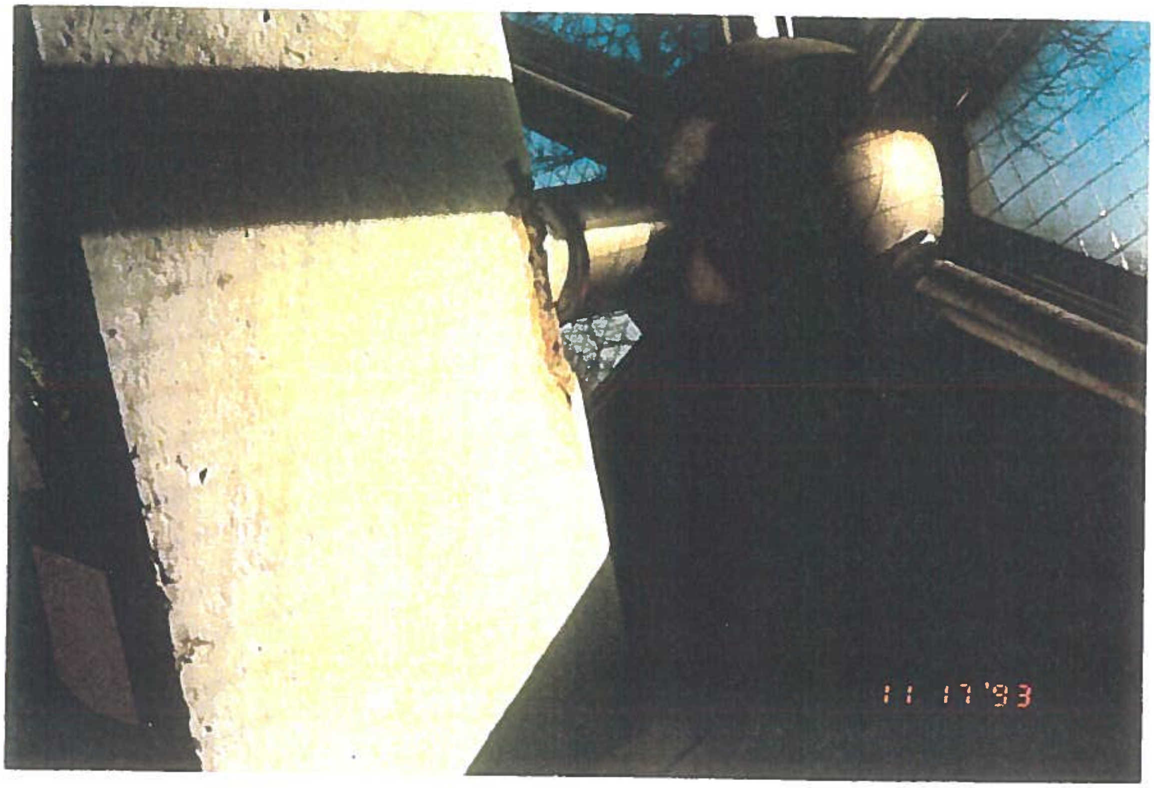


Photo No. 3
Arid Dome - East Face

Concrete spall which has exposed embedded steel plate.
Steel plate is rusting.

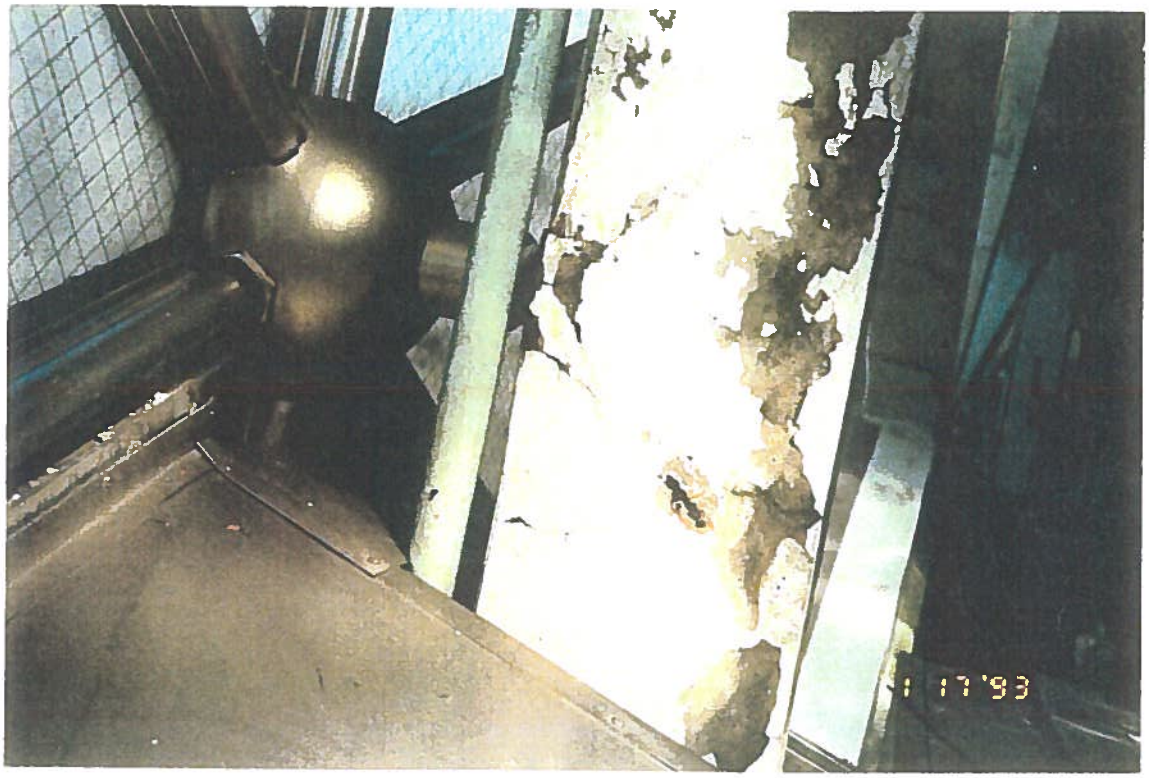


Photo No. 4
Tropical Dome - West Face

Peeling paint and exposed, corroding reinforcing steel

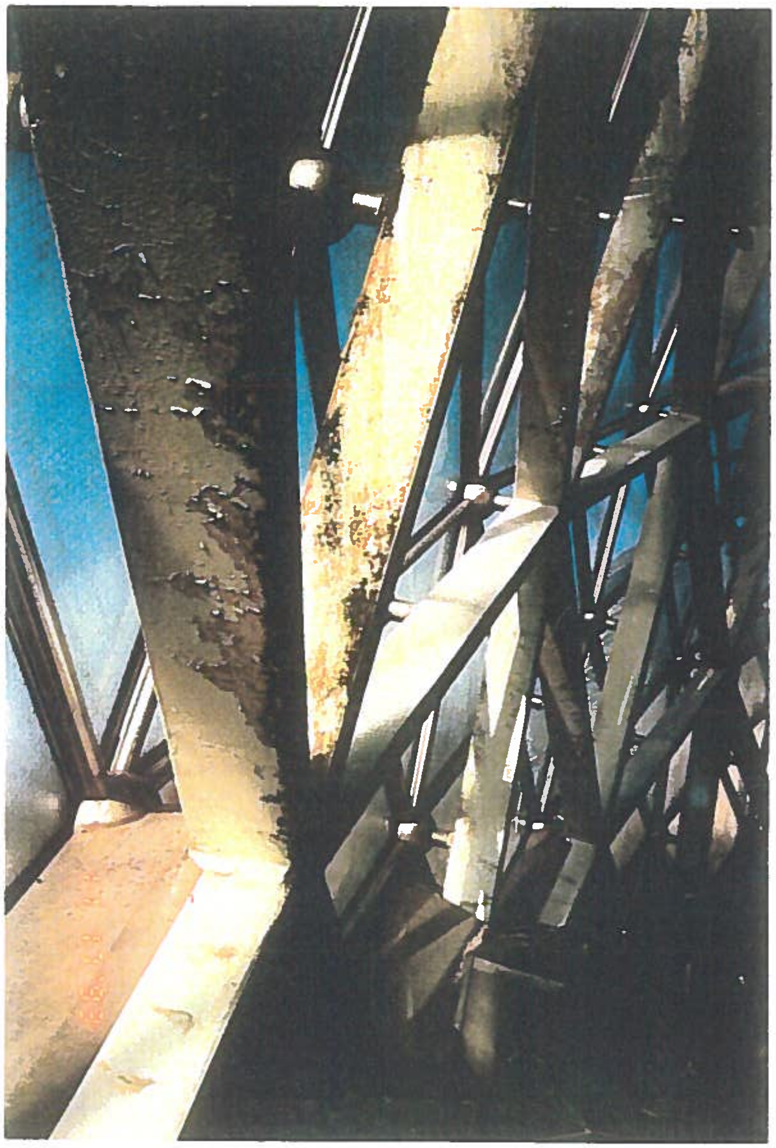


Photo No. 5
Tropical Dome - West Face

Peeling Paint and Plant Growth

Photo No. 6
Arid Dome

Typical dirt/dust streaking on concrete frame.

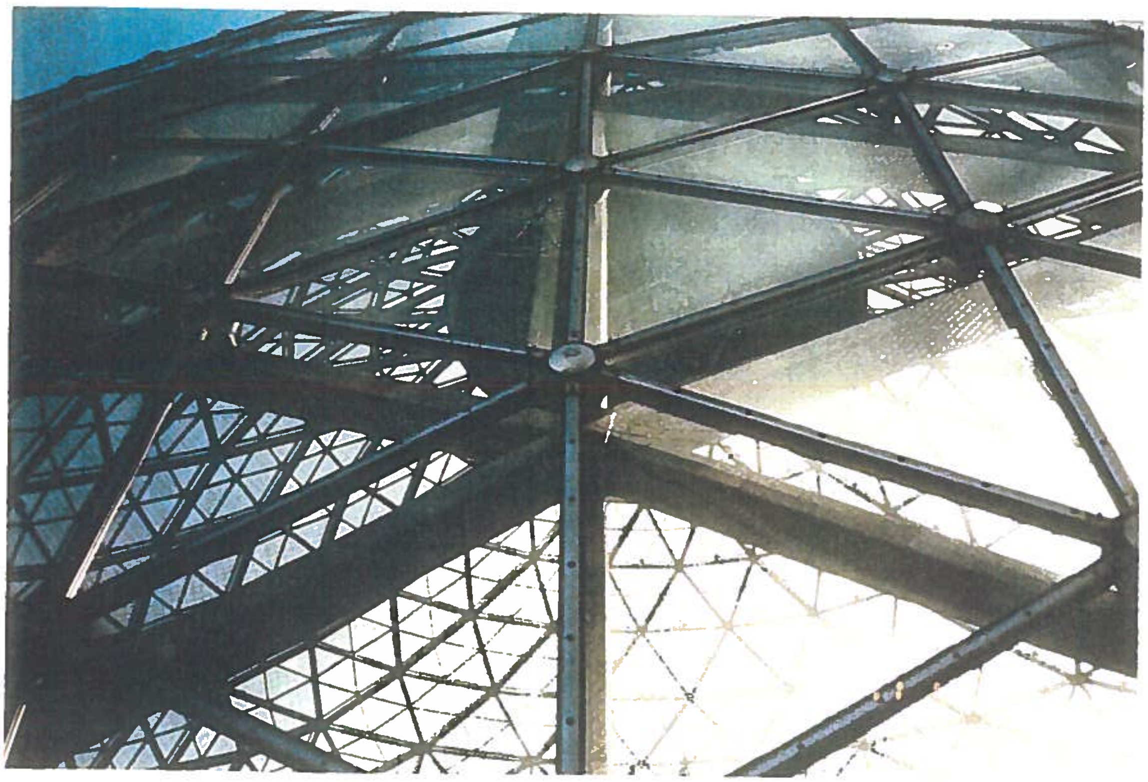


Photo No. 7
Arid Dome - North Face

Typical Broken Glass

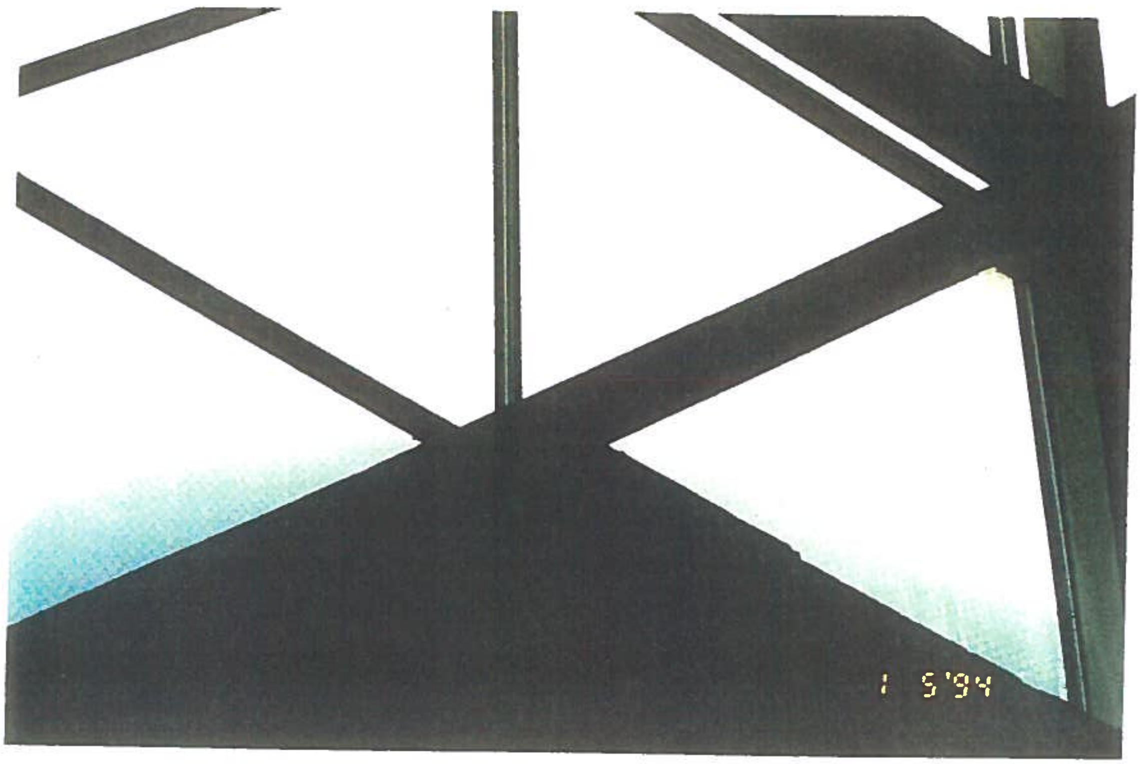


Photo No. 8
Arid Dome

Typical glass breakage caused by vandalism

Photo No. 9
Arid Dome - South Face

Broken Glass At Apex

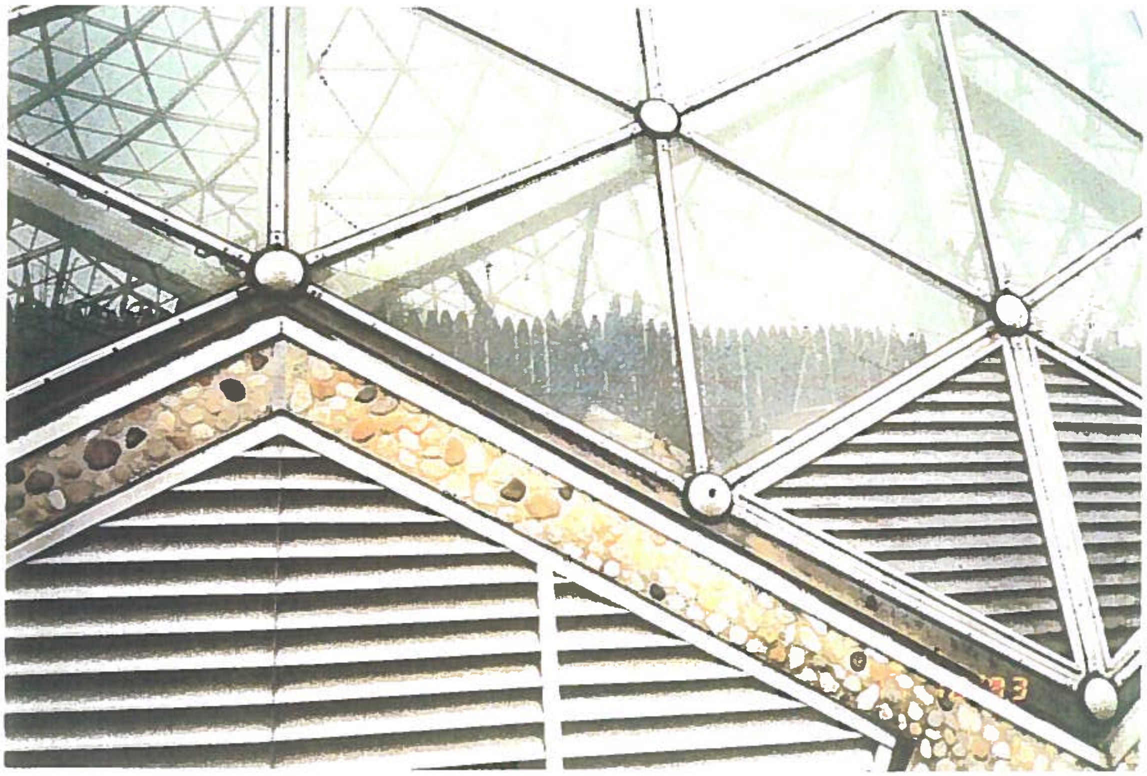


Photo No. 10
Arid Dome - East Face

Board used to close off large hole.
Also, missing hub center cap.

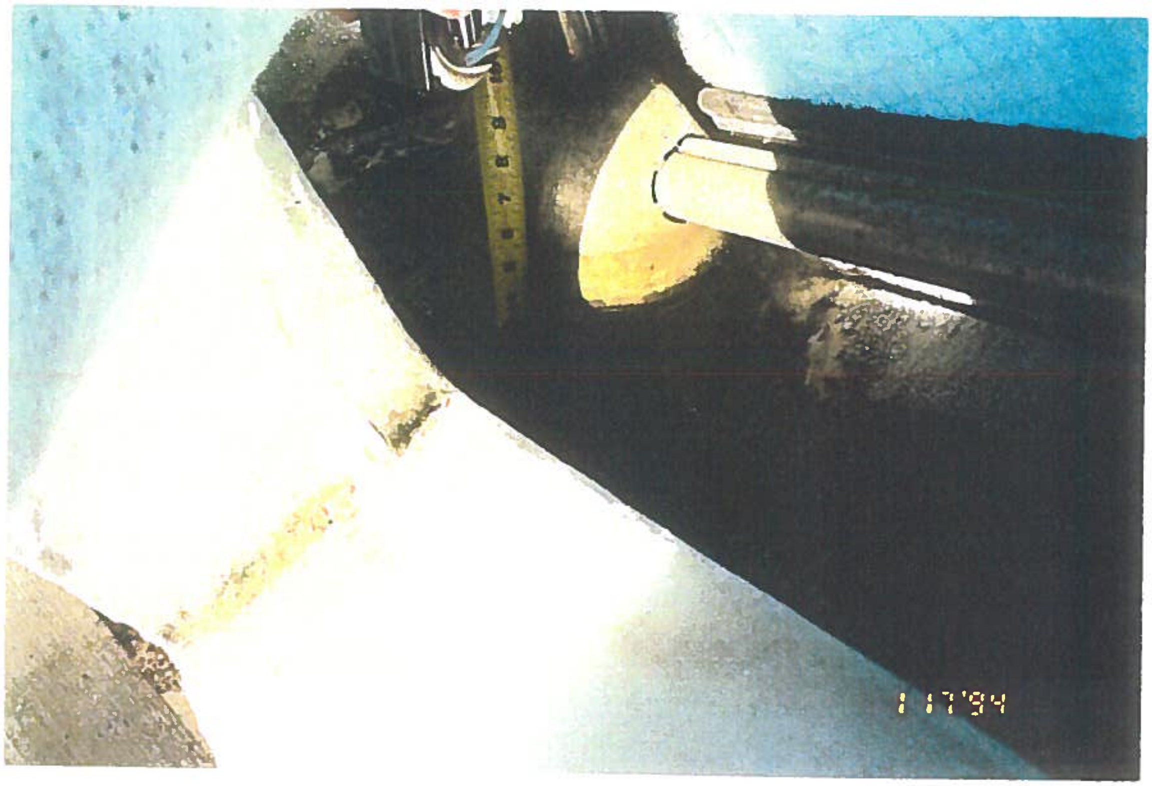


Photo No. 11
Arid Dome - Above Service Door

Standing water in low point above service door

Photo No. 12
Tropical Dome - East Face

The hub above the service door, which has
caused water to leak onto the concrete wall.
Paint has peeled, plant growth is evident, and ice has formed.

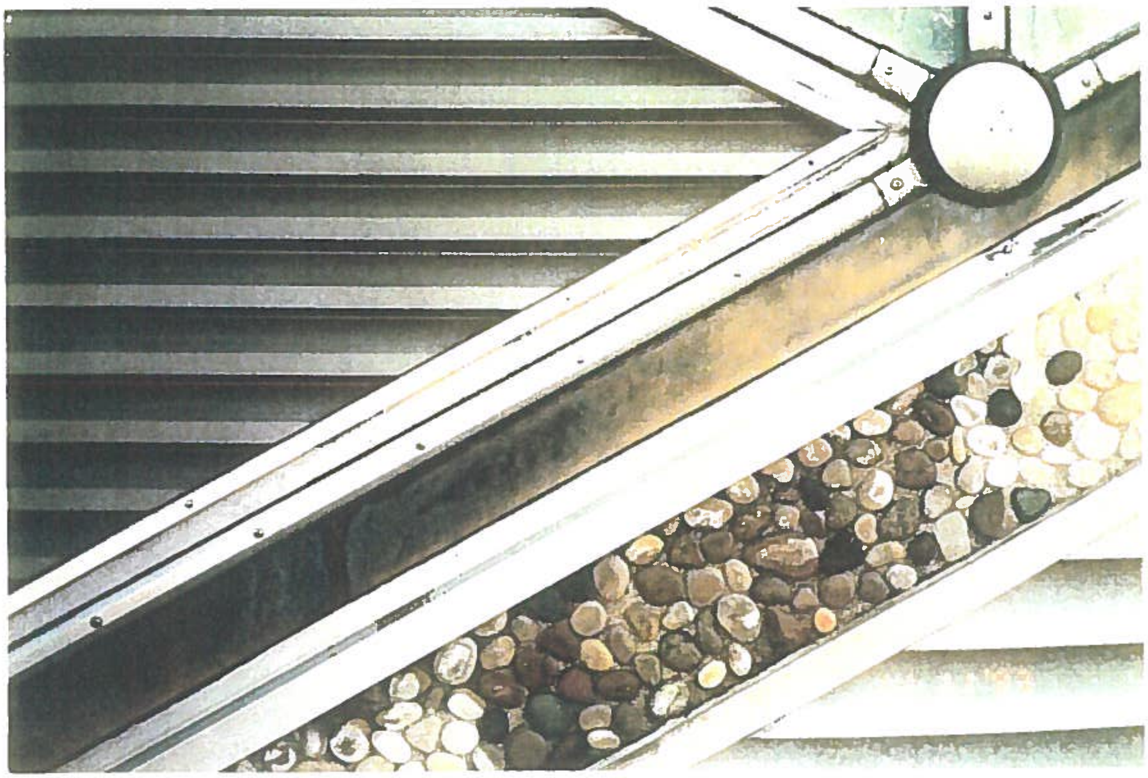


Photo No. 13
Tropical Dome - West Face

Water leakage through glazing system frame

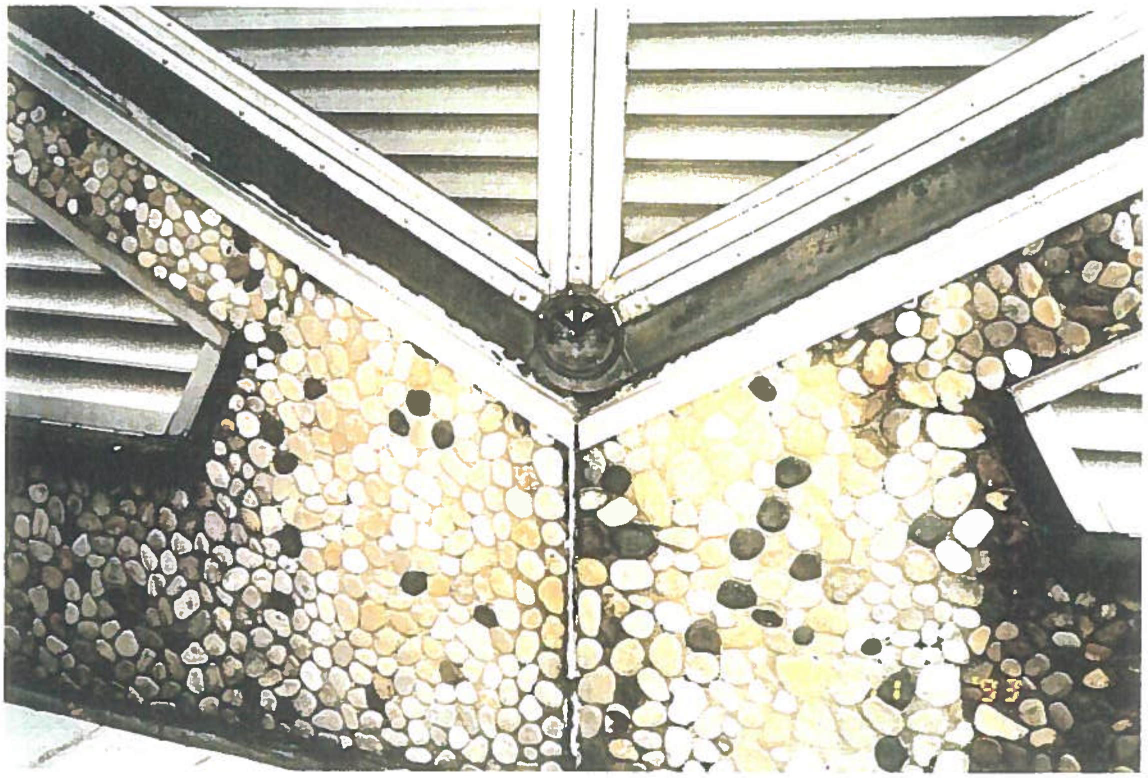


Photo No. 14
Tropical Dome

Typical missing hub

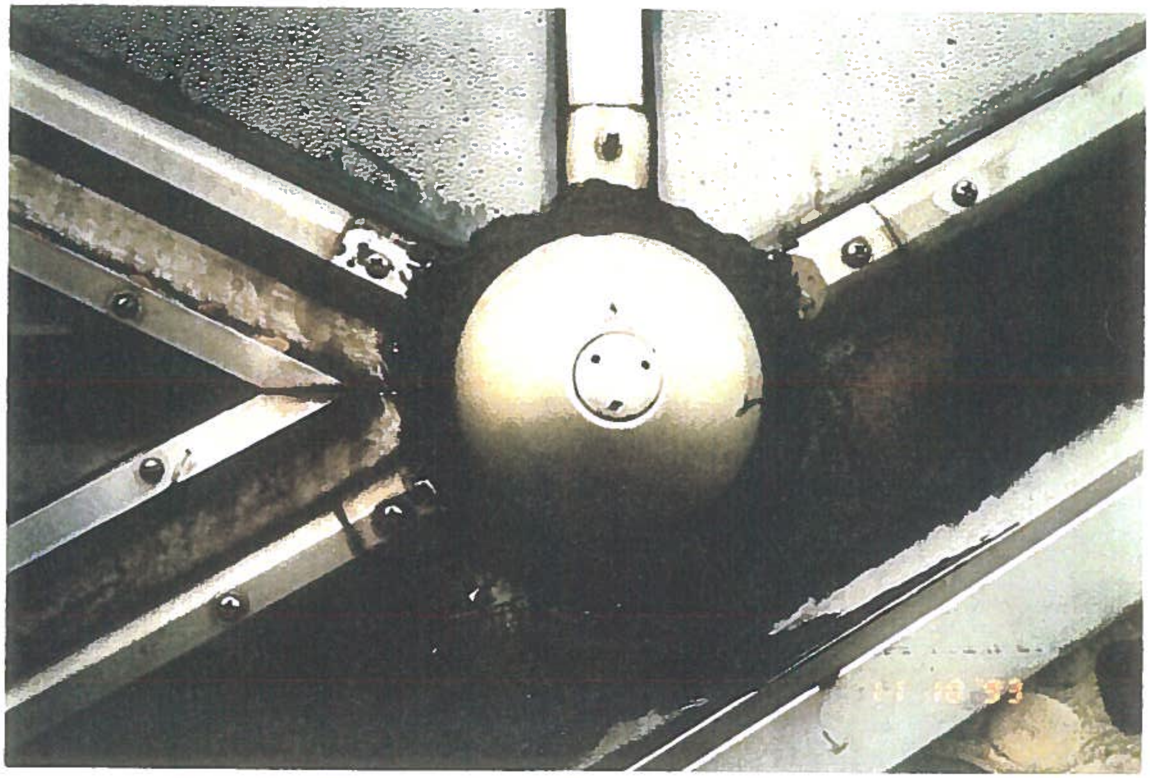


Photo No. 15
Tropical Dome - East Face

Typical hub cover that has been caulked.
Note polycarbonate glazing above hub.

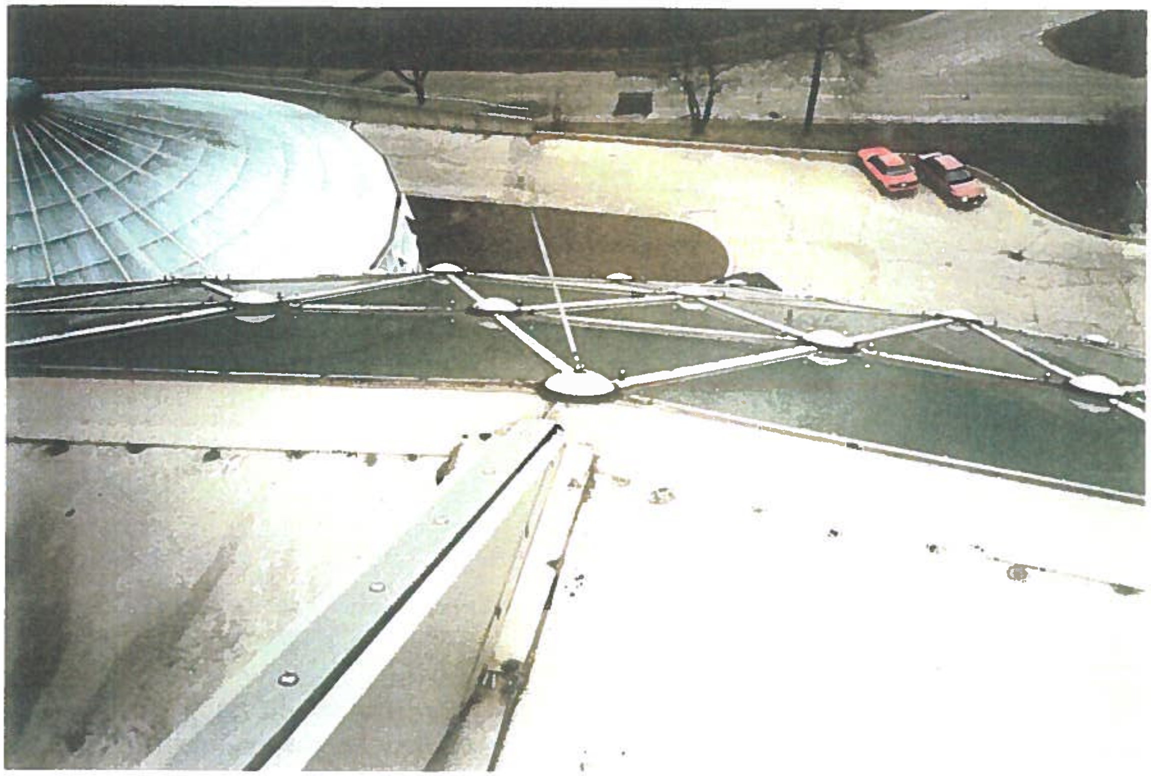


Photo No. 16
Arid Dome - North Face

Broken lightning rod

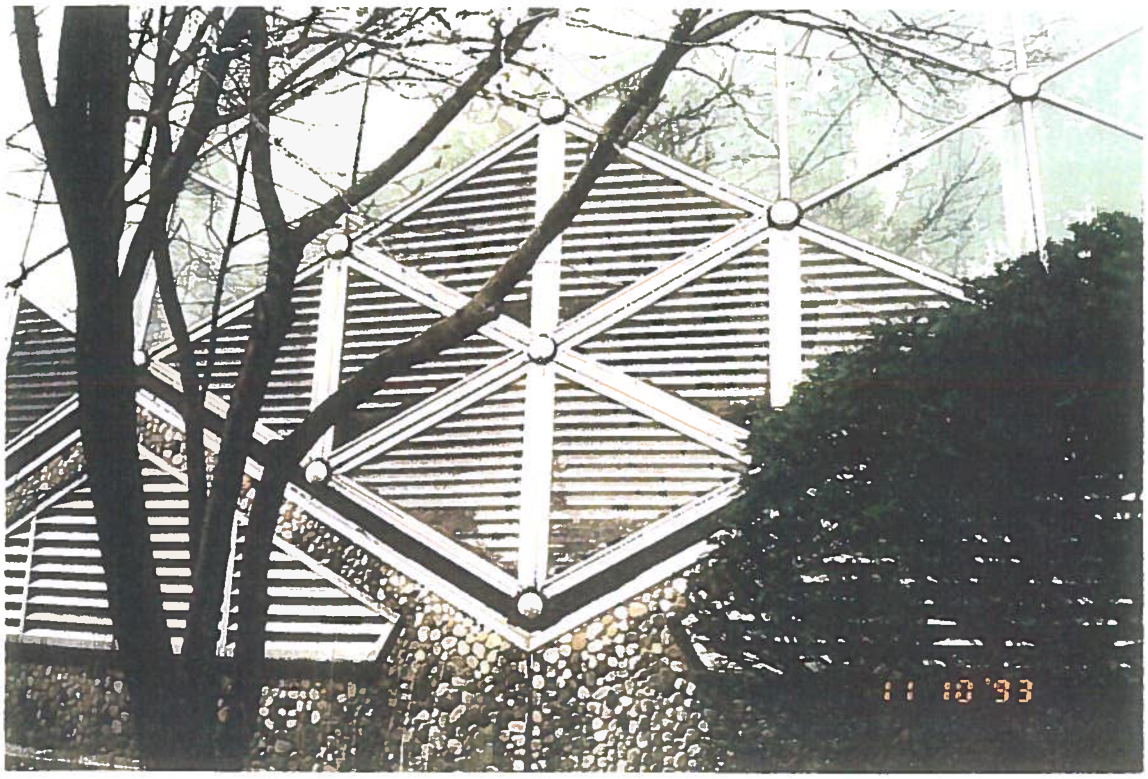


Photo No. 17
Tropical Dome - East Face

Debris between screen and louver

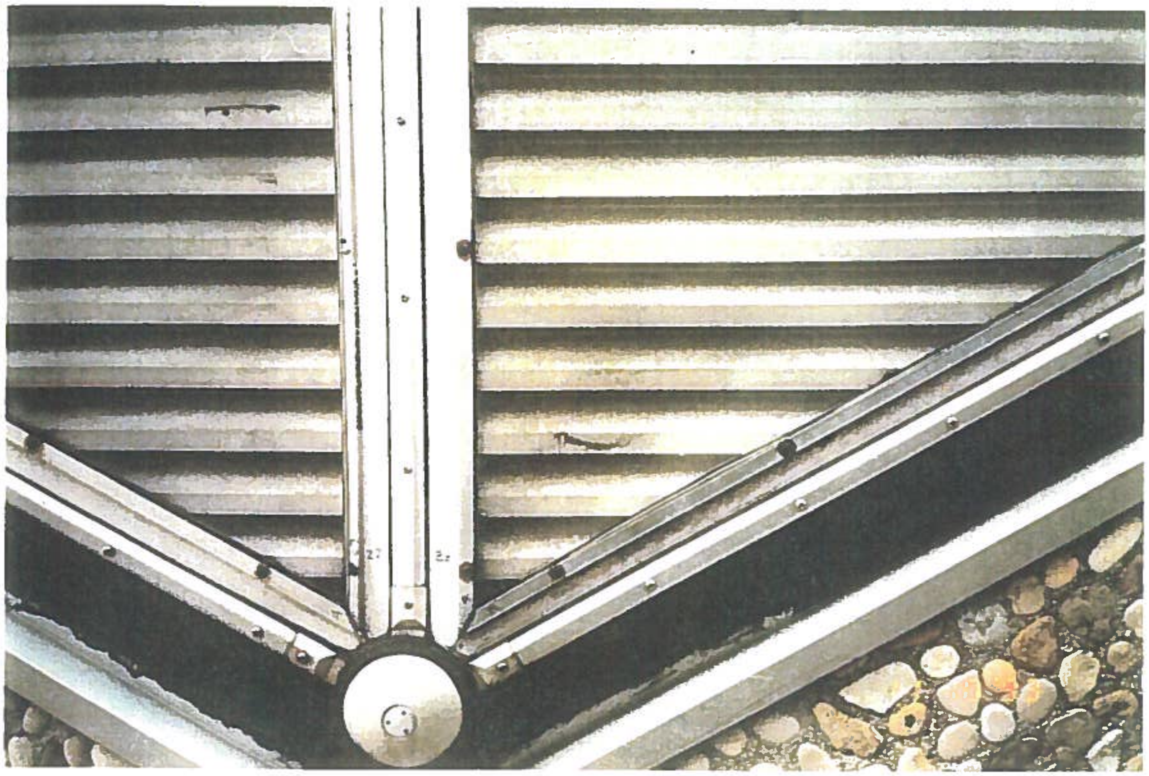


Photo No. 18
Show Dome

Replacement screws that have corroded

APPENDIX B

FIELD REPORTS

FIELD REPORT

Date:	December 1, 1993
Job No.	930639
Project:	Mitchell Park Domes Study
Location:	Milwaukee, Wisconsin
Contractor:	
Owner:	Milwaukee County
Weather:	Sunny
Temperature:	40°
Present at Site:	Richard C. Grabowski, P.E.

The following was noted:

I visited the site today to perform electrical continuity and half-cell potential testing of the uncoated reinforcing steel in the concrete members which comprise the dome support framing system.

An initial step in this process was to tour the perimeters of the Tropical, Arid, and Show Domes at the complex to locate areas of physical concrete deterioration. The perimeter tour was limited to those members which were within ladder reach of the catwalk area located at the base of the domes. Several locations within the Tropical Dome and the Show Dome were found which indicated signs of concrete deterioration due to spalling or cracking of the concrete members. No locations within reach were noted in the Arid Dome at the complex.

In order to test electrical continuity between the exposed steel plates embedded in the concrete frame and the skylight sub-framing members, small notches were made in these members with a file to expose clean, bright metal. Additionally, to check the continuity to the exposed reinforcing steel within the concrete members, a small battery-powered drill was used to grind small bright spots on the exposed reinforcing bar. This permits the electrical continuity testing of these members by ensuring quality electrical contacts.

GRAEF
ANHALT
SCHLOEMER
and Associates Inc.

In order to perform electrical half-cell potential readings of the uncoated reinforcing steel in the concrete, it is necessary to expose the concrete surface of the concrete member to perform the measurements. In the Tropical Dome, there was sufficient peeling paint which exposed the concrete surface necessary for testing. In the Show Dome, it was necessary to use a small battery-powered hammer drill to grind small spots on the concrete members which were needed to perform half-cell testing.

I began the electrical continuity testing in the Tropical Dome in the southwest quadrant of the dome. Two separate areas comprised of three hexagon panels were tested for electrical continuity and for half-cell potentials of the reinforcing steel.

Electrical continuity was tested using the DC Voltage Method and was spot-verified using the DC Resistance Method. The DC Voltage Method measures the potential difference between two pieces of steel using a high-impedance digital voltmeter set on the DC mV scale. A reading greater then 1 mV indicates steel discontinuity. The DC Resistance Method measures the resistance between two pieces of steel using a high-impedance digital voltmeter set on the ohms scale. The meter leads are then reversed and the measurement is repeated. If the two measurements differ by more than 3 ohms, or if the readings are unstable, the steel is assumed to be discontinuous.

As an initial step in the continuity testing, I made an attachment to the center point of the hexagon-shaped hub framing at a location of an exposed attachment plate on the exterior of the hexagon. Continuity was checked between this embedded plate and the members comprising the attachment for the skylight framing and at several locations of exposed reinforcing within the hexagon. Exposed reinforcing was found at locations of existing concrete spalls. I also checked continuity between the embedded plate and skylight framing attachment at the midpoint of some of the hexagon members.

In general, electrical continuity exists between the embedded plate at the midpoint of the hexagon and the exposed reinforcing steel within the hexagon members. Further, electrical continuity does generally exist between the embedded plates located at the midpoints of the hexagon framing members and the embedded plate at the center point of the hexagon. However, several locations were noted where the continuity did not exist between the embedded plates at the midpoints of the members and the embedded plate at the center point of the hexagon. In general, good continuity did exist between the embedded plates and the concrete encased reinforcing steel. In general, electrical continuity did not exist between the embedded plate at the center point of the hub framing members and the members comprising the attachment and support for the glass skylight.

In the Show Dome, it was noted that at one location (west side of the dome) at the center point of a hexagon shape, the embedded plate and attaching plates for the skylight framing had been torn out of the hexagon framing members during construction. It was also noted that there were occasional reinforcing bars which were not continuous with the reinforcing steel grid. However, in general, the reinforcing steel was continuous with the grid with the exception of the locations mentioned above.

I performed half-cell potential readings of the uncoated reinforcing steel bars in the concrete members at five hexagons within the Tropical Dome and three hexagons in the Show Dome. No continuity or half-cell potential testing was performed in the Arid Dome.

Due to the high-moisture content of the concrete in the Tropical Zone, very little additional wetting of the concrete (using tap water) was necessary to perform the half-cell testing on the concrete surfaces in the Tropical Dome. Minor wetting of the members in the Show Dome was performed to permit accurate readings of the electrical half-cell potential. ASTM C876 recommends the use of a wetting agent solution consisting of a mixture of 95 mL of liquid household detergent in 19L of potable water. Standard potable water was acceptable as a wetting agent because the measured values of the half-cell potentials did not change or fluctuate with time. The half-cell potential testing was performed in accordance with ASTM C876, "Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete."

The majority of the readings taken in both domes indicate that there is a greater than 90 percent probability that no significant reinforcing steel corrosion is occurring in the domes at the time of measurements. The majority of the readings taken were below 0.2 volts in reference to the copper sulfate electrode. Refer to the attached sheets indicating the results of the continuity and half-cell testing.

Respectfully submitted,

Richard C. Grabowski, P.E.

RCG:dkh
attachments
cc: Ken Grebe, P.E., GAS
Cindy Minshall, P.E., GAS

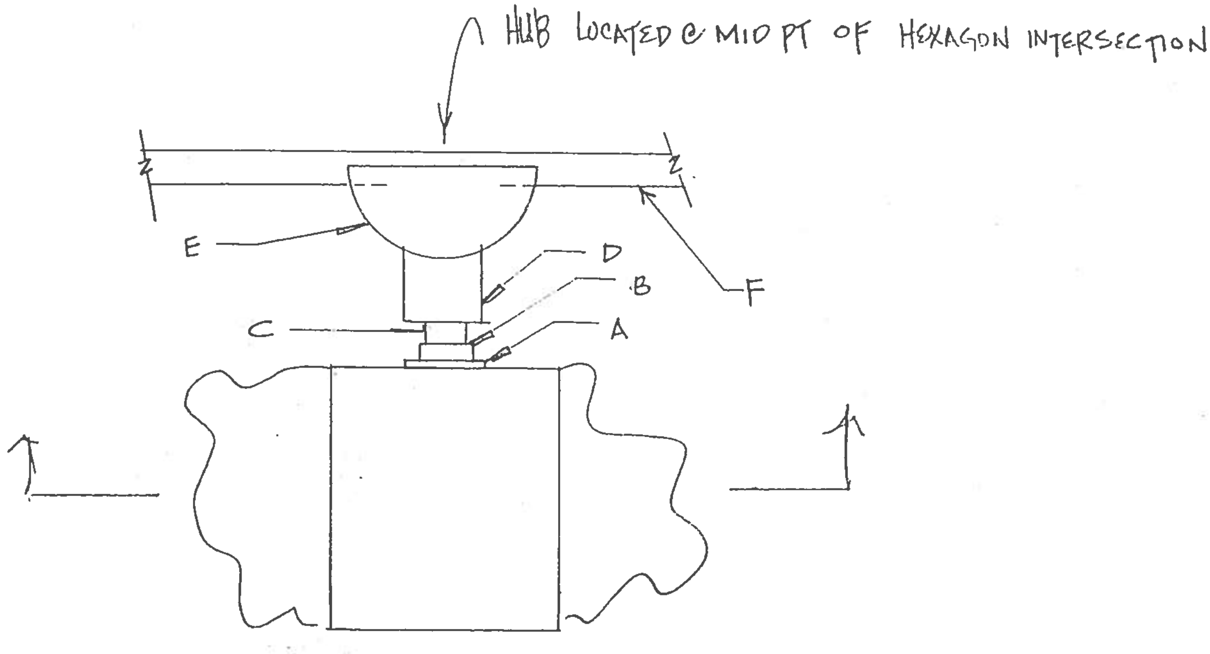
CONSULTING ENGINEERS
GRAEF ANHALT SCHLOEMER and Associates Inc
345 NORTH 95TH STREET
MILWAUKEE, WISCONSIN 53226

PROJECT NO. 930639 DATE 12/1/93 BY Kg
NAME MILW CTY DOMES EVAL
SHEET 1 / 5

TROPICAL DOME

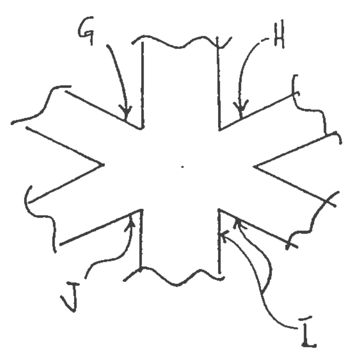
Continuity does exist btwn pt A and the same ℄ at the Hub located to each side of the hub with pt. A.

Continuity does not exist @ items A ~ F at the mid member hub and pt. A @ center hub.



A notch was filed on ℄"A" & used as a base pt.

Good continuity exists btwn pt A and pts B, C, D, & E.
Continuity does not exist between pt A & pt F.



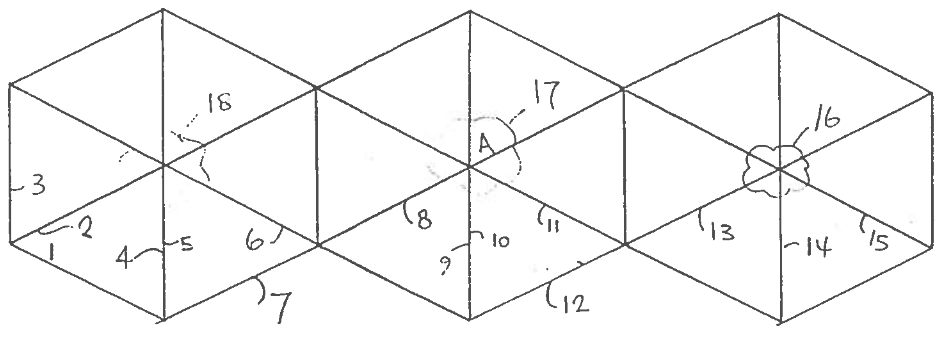
Continuity does exist btwn pt A and pts G~J (Locations of exposed rebars).

SECTION

TROPICAL DOME

Pt A is used as a base connection (@ ℙ) continuous w/ rebars.

(CONCRETE TEMP = ≈90°F)

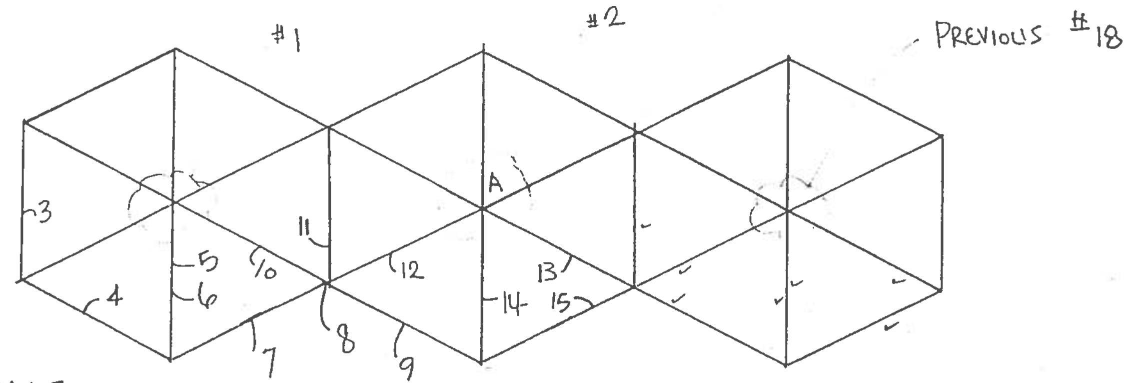


½ CELL POTENTIAL READINGS (RELATIVE TO COPPER - COPPER SULFATE ELECTRODE)

1 @ 0.101 V
2 @ 0.151 V
3 @ 0.102 V
4 @ 0.071 V
5 @ 0.102 V
6 @ 0.090 V
7 @ 0.151 V
8 @ 0.104 V
9 @ 0.154 V
10 @ 0.098 V
11 @ 0.083 V
12 @ 0.137 V
13 @ 0.012 V
14 @ 0.123 V
15 @ 0.020 V
16 @ 0.115 V
17 @ 0.080 V
18 @ 0.089 V

POINT A LOCATED TWO PANELS SOUTH OF EW PANEL

TROPICAL DOME



1/2 CELL POTENTIALS

1 @ 0.195 V	8 @ 0.241 V
2 @ 0.135 V	9 @ 0.122 V
3 @ 0.125 V	10 @ 0.104 V
4 @ 0.131 V	11 @ 0.131 V
5 @ 0.203 V	12 @ 0.115 V
6 @ 0.113 V (MIDPT)	13 @ 0.111 V
7 @ 0.167 V	14 @ 0.069 V
	15 @ 0.060 V

(READINGS ARE RELATIVE TO COPPER - COPPER SULFATE ELECTRODE)

POINT A LOCATED 4 PANELS SOUTH OF EW PANEL

CONSULTING ENGINEERS

GRAEF ANHALT SCHLOEMER and Associates Inc.

345 NORTH 95TH STREET

MILWAUKEE, WISCONSIN 53226

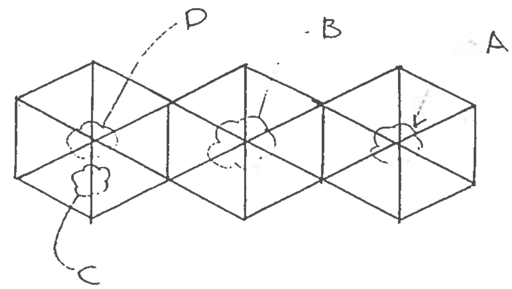
PROJECT NO. 930639 DATE 12/1/93 BY Leg

NAME MILW CTY DOMES EVAL

SHEET 4/5

SHOW DOME

CONTINUITY TESTS



Attachment to hub PL @ Location "A" (Base)

Hub assembly @ "B" not continuous w/ rebars grid (Both PL's knocked out of position) (See attached typewritten report).

Hub PL @ midpoint @ "C" continuous w/ rebars grid (Concrete spall @ PL)

Hub assembly (PL's B-F as shown on sheet 1) not continuous with rebars grid.

One vertical rebar @ outer face @ "B" not continuous with grid.

All 3 panels in SW Quadrant of Show Dome

NOTE: NO LOWER LEVEL SIGNIFICANT DETERIORATION WAS NOTED IN ARID DOME.

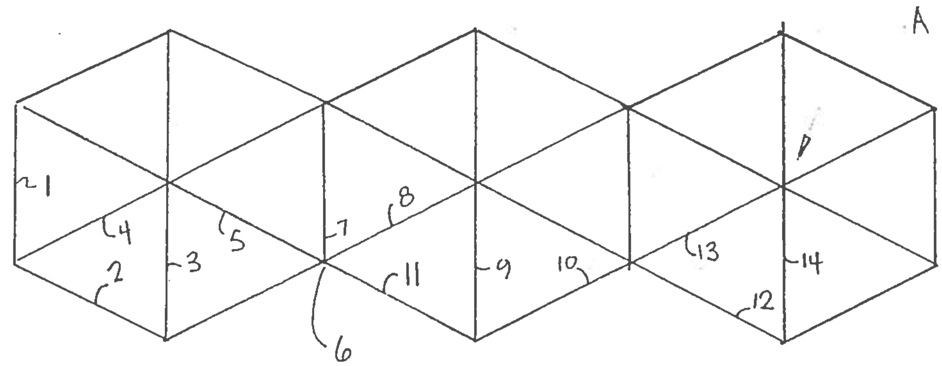
CONSULTING ENGINEERS
GRAEF ANHALT SCHLOEMER and Associates Inc
345 NORTH 95TH STREET
MILWAUKEE, WISCONSIN 53226

PROJECT NO. 930639 DATE 12/1/93 BY Reg
NAME MILW CTY DOMES EVAL
SHEET 5/5

SHOW DOME

1/2 CELL TESTS

REBAR CONNECTION @ PT "A"



1/2 CELL POTENTIAL TESTING (RELATIVE TO COPPER - COPPER SULFATE ELECTRODE)

1 @ 0.014 V	8 @ 0.094 V
2 @ 0.010 V	9 @ 0.002 V
3 @ 0.035 V	10 @ 0.117 V
4 @ 0.001 V	11 @ 0.116 V
5 @ 0.031 V	12 @ 0.164 V
6 @ 0.132 V	13 @ 0.053 V
7 @ 0.182 V	14 @ 0.025 V

(CONCRETE TEMP ≈ 60°F) (Concrete temperature approximately equals air temperature).

Designation: C 876 – 87

Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete[1]

This standard is issued under the fixed designation C 876; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

Scope

1.1 This test method covers the estimation of the electrical ılf-cell potential of uncoated reinforcing steel in field and boratory concrete, for the purpose of determining the ırrosion activity of the reinforcing steel.

1.2 This test method is limited by electrical circuitry. A ıncrete surface that has dried to the extent that it is a electric and surfaces that are coated with a dielectric aterial will not provide an acceptable electrical circuit. The ısic configuration of the electrical circuit is shown in Fig. 1.

1.3 The values stated in inch-pound units are to be garded as the standard.

1.4 *This standard may involve hazardous materials, operions, and equipment. This standard does not purport to ldress all of the safety problems associated with its use. It is e responsibility of the user of this standard to establish propriate safety and health practices and determine the licability of regulatory limitations prior to use.*

Referenced Document

2.1 *ASTM Standard:*

G 3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing[2]

Significance and Use

3.1 This test method is suitable for in-service evaluation d for use in research and development work.

3.2 This test method is applicable to members regardless their size or the depth of concrete cover over the nforcing steel.

3.3 This test method may be used at any time during the e of a concrete member.

3.4 The results obtained by the use of this test method all not be considered as a means for estimating the uctural properties of the steel or of the reinforced concrete ember.

3.5 The potential measurements should be interpreted by gineers or technical specialists experienced in the fields of ncrete materials and corrosion testing. It is often necessary use other data such as chloride contents, depth of rbonation, delamination survey findings, rate of corrosion sults, and environmental exposure conditions, in addition to half-cell potential measurements, to formulate conclusions concerning corrosion activity of embedded steel and its probable effect on the service life of a structure.

4. Apparatus

4.1 The testing apparatus consists of the following:

4.1.1 *Half Cell:*

4.1.1.1 A copper-copper sulfate half cell (Note 1) is shown in Fig. 2. It consists of a rigid tube or container composed of a dielectric material that is nonreactive with copper or copper sulfate, a porous wooden or plastic plug that remains wet by capillary action, and a copper rod that is immersed within the tube in a saturated solution of copper sulfate. The solution shall be prepared with reagent grade copper sulfate crystals dissolved in distilled or deionized water. The solution may be considered saturated when an excess of crystals (undissolved) lies at the bottom of the solution.

4.1.1.2 The rigid tube or container shall have an inside diameter of not less than 1 in. (25 mm); the diameter of the porous plug shall not be less than ½ in. (13 mm); the diameter of the immersed copper rod shall not be less than ¼ in. (6 mm), and the length shall not be less than 2 in. (50 mm).

4.1.1.3 Present criteria based upon the half-cell reaction of $Cu \rightarrow Cu^{++} + 2e$ indicate that the potential of the saturated copper-copper sulfate half cell as referenced to the hydrogen electrode is −0.316 V at 72°F (22.2°C). The cell has a temperature coefficient of about 0.0005 V more negative per °F for the temperature range from 32 to 120°F (0 to 49°C).

NOTE 1—While this test method specifies only one type of half cell, that is, the copper-copper sulfate half cell, others having similar measurement range, accuracy, and precision characteristics may also be used. In addition to copper-copper sulfate cells, calomel cells have been used in laboratory studies. Potentials measured by other than copper-copper sulfate half cells should be converted to the copper-copper sulfate equivalent potential. The conversion technique can be found in Practice G 3 and it is also described in most physical chemistry or half-cell technology text books.

4.1.2 *Electrical Junction Device*—An electrical junction device shall be used to provide a low electrical resistance liquid bridge between the surface of the concrete and the half cell. It shall consist of a sponge or several sponges pre-wetted with a low electrical resistance contact solution. The sponge may be folded around and attached to the tip of the half cell so that it provides electrical continuity between the porous plug and the concrete member.

4.1.3 *Electrical Contact Solution*—In order to standardize the potential drop through the concrete portion of the circuit, an electrical contact solution shall be used to wet the electrical junction device. One such solution is composed of

[1] This test method is under the jurisdiction of ASTM Committee C-9 on ıcrete and Concrete Aggregates and is the direct responsibility of Subcommittee 9.03.15 on Methods of Testing the Resistance of Concrete to its Environment. Current edition approved May 29, 1987. Published July 1987. Originally blished as C 876 – 77. Last previous edition C 876 – 80.

[2] *Annual Book of ASTM Standards*, Vol 03.02.

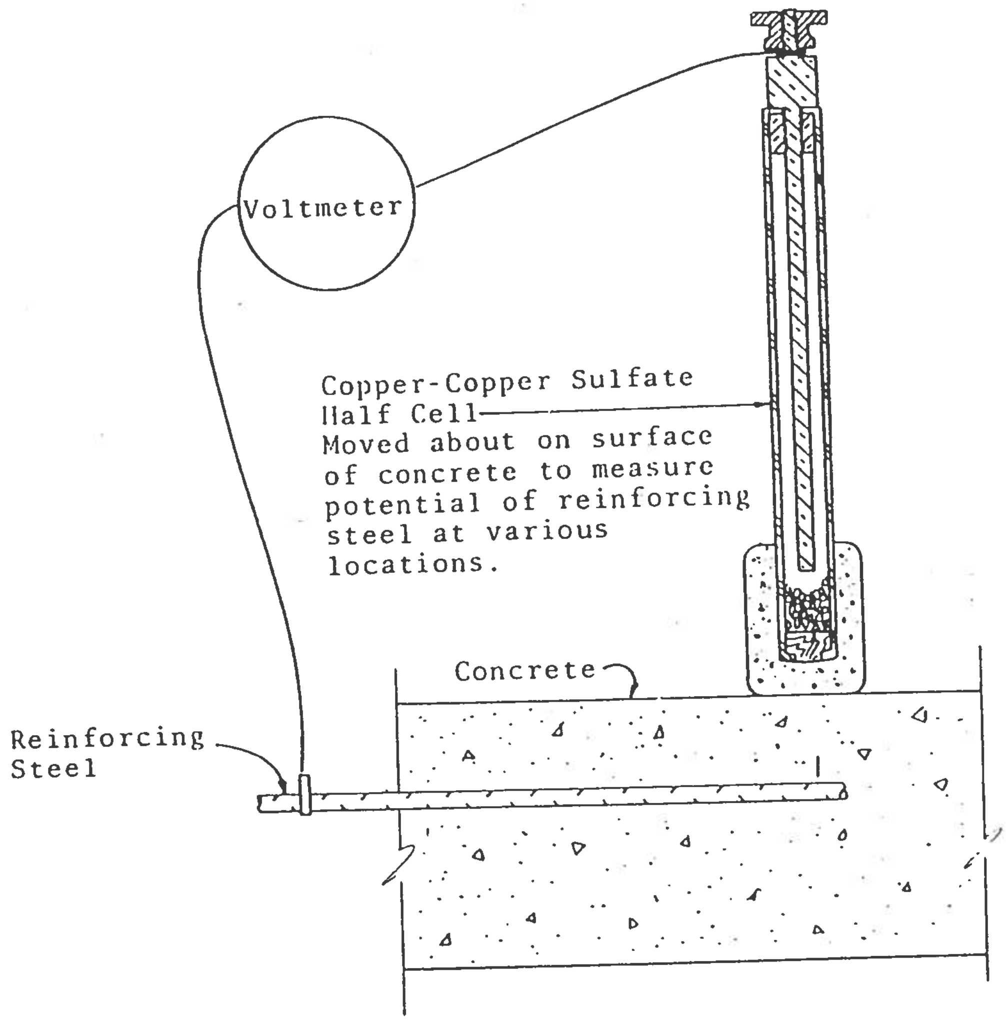


FIG. 1 Copper-Copper Sulfate Half Cell Circuitry

a mixture of 95 mL of wetting agent (commercially available wetting agent) or a liquid household detergent thoroughly mixed with 5 gal (19 L) of potable water. Under working temperatures of less than about 50°F (10°C), approximately 15 % by volume of either isopropyl or denatured alcohol must be added to prevent clouding of the electrical contact solution, since clouding may inhibit penetration of water into the concrete to be tested.

4.1.4 *Voltmeter*—The voltmeter shall have the capacity of being battery operated and have ±3 % end-of-scale accuracy at the voltage ranges in use. The input impedance shall be no less than 10 MΩ when operated at a full scale of 100 mV. The divisions on the scale used shall be such that a potential difference of 0.02 V or less can be read without interpolation.

4.1.5 *Electrical Lead Wires*—The electrical lead wire shall be of such dimension that its electrical resistance for the length used will not disturb the electrical circuit by more than 0.0001 V. This has been accomplished by using no more than a total of 500 linear ft (150 m) of at least AWG No. 24 wire. The wire shall be suitably coated with direct burial type of insulation.

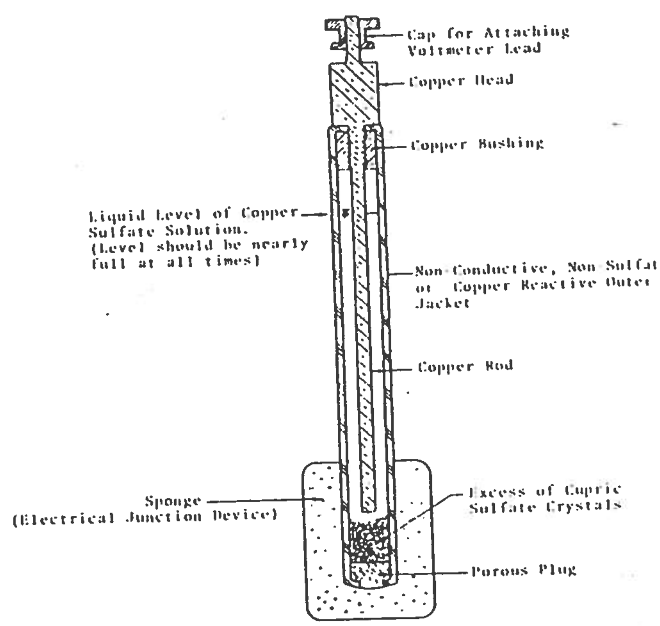


FIG. 2 Sectional View of a Copper-Copper Sulfate Half Cell

5. Calibration and Standardization

5.1 *Care of the Half Cell*—The porous plug shall be covered when not in use for long periods to ensure that it does not become dried to the point that it becomes a dielectric (upon drying, pores may become occluded with crystalline copper-sulfate). If cells do not produce the reproducibility or agreement between cells described in Section 11, cleaning the copper rod in the half cell may rectify the problem. The rod may be cleaned by wiping it with a dilute solution of hydrochloric acid. The copper sulfate solution shall be renewed either monthly or before each use, whichever is the longer period. At no time shall steel wool or any other contaminant be used to clean the copper rod or half-cell tube.

6. Procedure

6.1 *Spacing Between Measurements*—While there is no pre-defined minimum spacing between measurements on the surface of the concrete member, it is of little value to take two measurements from virtually the same point. Conversely, measurements taken with very wide spacing may neither detect corrosion activity that is present nor result in the appropriate accumulation of data for evaluation. The spacing shall therefore be consistent with the member being investigated and the intended end use of the measurements (Note 2).

NOTE 2—A spacing of 4 ft (1.2 m) has been found satisfactory for evaluation of bridge decks. Generally, larger spacings increase the probability that localized corrosion areas will not be detected. Measurements may be taken in either a grid or a random pattern. Spacing between measurements should generally be reduced where adjacent readings exhibit algebraic reading differences exceeding 150 mV (areas of high corrosion activity). Minimum spacing generally should provide at least a 100-mV difference between readings.

6.2 *Electrical Connection to the Steel:*

6.2.1 Make a direct electrical connection to the reinforcing steel by means of a compression-type ground clamp, or by brazing or welding a protruding rod. To ensure a low electrical resistance connection, scrape the bar or brush the wire before connecting to the reinforcing steel. In certain cases, this technique may require removal of some concrete to expose the reinforcing steel. Electrically connect the reinforcing steel to the positive terminal of the voltmeter.

6.2.2 Attachment must be made directly to the reinforcing steel except in cases where it can be documented that an exposed steel member is directly attached to the reinforcing steel. Certain members, such as expansion dams, date plates, lift works, and parapet rails may not be attached directly to the reinforcing steel and, therefore, may yield invalid readings. Electrical continuity of steel components with the reinforcing steel can be established by measuring the resistance between widely separated steel components on the deck. Where duplicate test measurements are continued over a long period of time, identical connection points should be used each time for a given measurement.

6.3 *Electrical Connection to the Half Cell*—Electrically connect one end of the lead wire to the half cell and the other end of this same lead wire to the negative (ground) terminal of the voltmeter.

6.4 *Pre-Wetting of the Concrete Surface:*

6.4.1 Under certain conditions, the concrete surface or an overlaying material, or both, must be pre-wetted by either of the two methods described in 6.4.3 or 6.4.4 with the solution described in 4.1.3 to decrease the electrical resistance of the circuit.

6.4.2 A test to determine the need for pre-wetting may be made as follows:

6.4.2.1 Place the half cell on the concrete surface and do not move.

6.4.2.2 Observe the voltmeter for one of the following conditions:

(*a*) The measured value of the half-cell potential does not change or fluctuate with time.

(*b*) The measured value of the half-cell potential changes or fluctuates with time.

6.4.2.3 If condition (*a*) is observed, pre-wetting the concrete surface is not necessary. However, if condition (*b*) is observed, pre-wetting is required for an amount of time such that the voltage reading is stable (±0.02 V) when observed for at least 5 min. If pre-wetting cannot obtain condition (*a*), either the electrical resistance of the circuit is too great to obtain valid half-cell potential measurements of the steel, or stray current from a nearby direct current traction system or other fluctuating direct-current, such as arc welding, is affecting the readings. In either case, the half-cell method should not be used.

6.4.3 *Method A for Pre-Wetting Concrete Surfaces*—Use Method A for those conditions where a minimal amount of pre-wetting is required to obtain condition (*a*) as described in 6.4.2.2. Accomplish this by spraying or otherwise wetting either the entire concrete surface or only the points of measurement as described in 6.1 with the solution described in 4.1.3. No free surface water should remain between grid points when potential measurements are initiated.

6.4.4 *Method B for Pre-Wetting Concrete Surfaces*—In this method, saturate sponges with the solution described in 4.1.3 and place on the concrete surface at locations described in 6.1. Leave the sponges in place for the period of time necessary to obtain condition (*a*) described in 6.4.2.2. Do not remove the sponges from the concrete surface until after the half-cell potential reading is made. In making the half-cell potential measurements, place the electrical junction device described in 4.1.2 firmly on top of the pre-wetting sponges for the duration of the measurement.

6.5 *Underwater, Horizontal, and Vertical Measurements:*

6.5.1 Potential measurements detect corrosion activity, but not necessarily the location of corrosion activity. The precise location of corrosion activity requires knowledge of the electrical resistance of the material between the half cell and the corroding steel. While underwater measurements are possible, results regarding the location of corrosion must be interpreted very carefully. Often it is not possible to precisely locate points of underwater corrosion activity in salt water environments because potential readings along the member appear uniform. However, the magnitude of readings does serve to indicate whether or not active corrosion is occurring. Take care during all underwater measurements that the half cell does not become contaminated and that no part other than the porous tip of the copper-copper sulfate electrode half cell comes in contact with water.

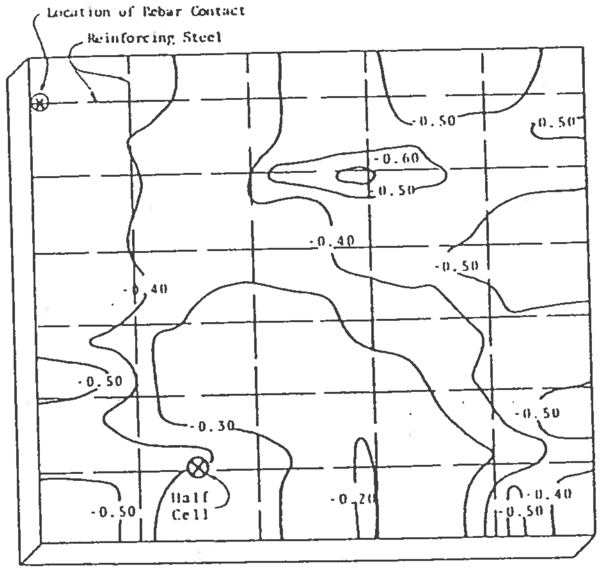


FIG. 3 Equipotential Contour Map

6.5.2 Perform horizontal and vertically upward measurements exactly as vertically downward measurements. However, additionally ensure that the copper-copper sulfate solution in the half cell makes simultaneous electrical contact with the porous plug and the copper rod at all times.

7. Recording Half-Cell Potential Values

7.1 Record the electrical half-cell potentials to the nearest 0.01 V. Report all half-cell potential values in volts and correct for temperature if the half-cell temperature is outside the range of 72 ± 10°F (22.2 ± 5.5°C). The temperature coefficient for the correction is given in 4.1.1.3.

8. Data Presentation

8.1 Test measurements may be presented by one or both of two methods. The first, an equipotential contour map, provides a graphical delineation of areas in the member where corrosion activity may be occurring. The second method, the cumulative frequency diagram, provides an indication of the magnitude of affected area of the concrete member.

8.1.1 *Equipotential Contour Map*—On a suitably scaled plan view of the concrete member, plot the locations of the half-cell potential values of the steel in concrete and draw contours of equal potential through points of equal or interpolated equal values. The maximum contour interval shall be 0.10 V. An example is shown in Fig. 3.

8.1.2 *Cumulative Frequency Distribution*—To determine the distribution of the measured half-cell potentials for the concrete member, make a plot of the data on normal probability paper in the following manner:

8.1.2.1 Arrange and consecutively number all half-cell potentials by ranking from least negative potential to greatest negative potential.

8.1.2.2 Determine the plotting position of each numbered half-cell potential in accordance with the following equation:

$$f_x = \frac{r}{\Sigma n + 1} \times 100$$

where:

f_x = plotting position of total observations for the observed value, %,

r = rank of individual half-cell potential, and

Σn = total number of observations.

8.1.2.3 Label the ordinate of the probability paper "Half-Cell Potential (Volts, CSE)," where CSE is the designation for copper-copper sulfate electrode. Label the abscissa of the probability paper "Cumulative Frequency (%)." Draw two horizontal parallel lines intersecting the −0.20 and −0.35 V values on the ordinate, respectively, across the chart.

8.1.2.4 After plotting the half-cell potentials, draw a line of best fit through the value (Note 3). An example of a completed plot is shown in Fig. 4.

NOTE 3—It is not unusual to observe a break in the straight line. In these cases, the line of best fit shall be two straight lines that intersect at an angle.

9. Interpretation of Results[3]

9.1 Laboratory testing of reinforced concrete specimens indicates the following regarding the significance of the numerical value of the potentials measured. Voltages listed are referenced to the copper-copper sulfate (CSE) half cell.

9.1.1 If potentials over an area more positive than −0.20 V CSE, there is a greater than 90 % probability that no reinforcing steel corrosion is occurring in that area at the time of measurement.

9.1.2 If potentials over an area are in the range of −0.20 to −0.35 V CSE, corrosion activity of the reinforcing steel in that area is uncertain.

9.1.3 If potentials over an area are more negative than −0.35 V CSE, there is a greater than 90 % probability that reinforcing steel corrosion is occurring in that area at the time of measurement.

9.1.4 In laboratory tests where potentials were more negative than −0.50 V, approximately half of the specimens cracked due to corrosion activity.

9.1.5 Positive readings, if obtained, generally indicate a poor connection with the steel, insufficient moisture in the concrete, or the presence of stray currents and should not be considered valid.

10. Report

10.1 The report shall include the following:

10.1.1 Type of cell used if other than copper-copper sulfate.

10.1.2 The estimated average temperature of the half cell during the test.

10.1.3 The method for pre-wetting the concrete member and the method of attaching the voltmeter lead to the reinforcing steel.

10.1.4 An equipotential contour map, showing the location of reinforcing steel contact, or a plot of the cumulative frequency distribution of the half-cell potentials, or both.

[3] The following published reports give supportive detail for interpretation of results: Spellman, D. L., and Stratfull, R. F., "Concrete Variables and Corrosion Testing," *Highway Research Record No. 423*, 1973; Stratfull, R. F., "Half-Cell Potentials and the Corrosion of Steel in Concrete," *Highway Research Record No. 433*, 1973; and Clear, K. C., and Hay, R. E., "Time-to-Corrosion of Reinforcing Steel in Concrete Slabs," Federal Highway Administration, Vol 1 and 2, *Interim Reports FHWA-RD-73-32 and 33*, April 1973.

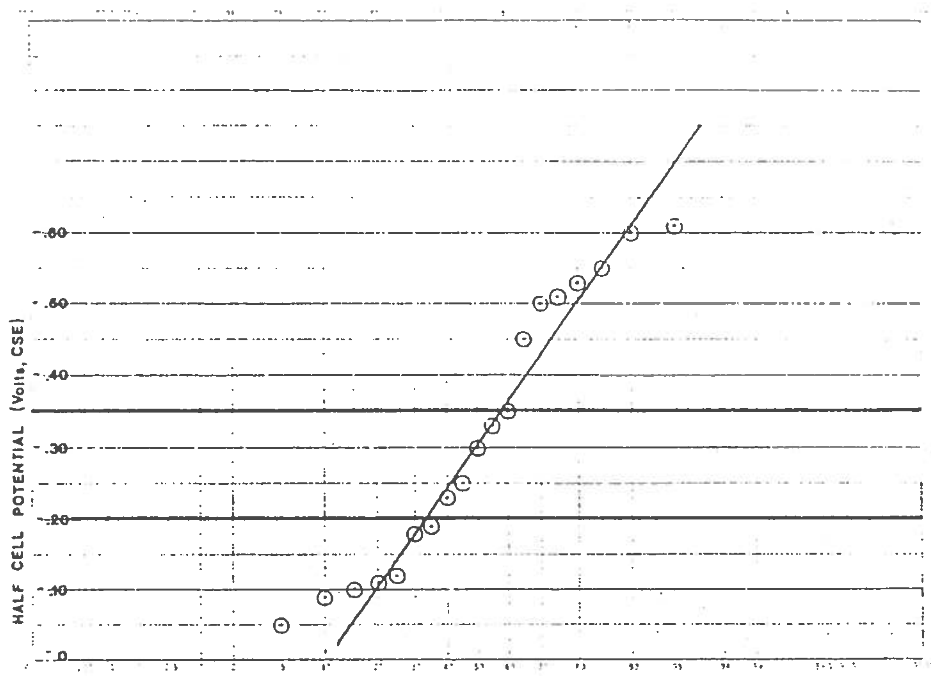


FIG. 4 Cumulative Frequency Diagram

10.1.5 The percentage of the total half-cell potentials that are more negative than −0.35 V.

10.1.6 The percentage of the total half-cell potentials that are less negative than −0.20 V.

11. Precision and Bias

11.1 The difference between two half-cell readings taken at the same location with the same cell should not exceed 10 mV when the cell is disconnected and reconnected.

11.2 The difference between two half-cell readings taken at the same location with two different cells should not exceed 20 mV.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

FIELD REPORT

Date:	December 22, 1993
Job No.	930639
Project:	Mitchell Park Domes Study
Location:	Milwaukee, Wisconsin
Weather:	Clear
Temperature:	23 degrees @ 9:30 a.m.
Present at Site:	Keith - Milwaukee County

The reason for this site visit is to determine the existing condition inside of the aluminum skylight frame hub assembly, which is an integral part of the interior drainage system.

The following was noted:

A total of 6 hubs were removed in the Tropical Dome. Three on the east side above the service door and three on the west side of the structure. The 6 locations were chosen because they were leaking water on the inside of the dome. A lift truck was used to access the area above the service door. Milwaukee County was responsible for removal and replacement of the hub covers.

All hubs (except the lowest one on the west side) had debris in them. This clogged the vertical drain pipe and water was unable to drain. The water was approximately 2" deep in the center of the hub when clogged. There was still 1/2" of water in the hub when the clog was removed and the system was able to drain. This 1/2" of water is allowed based on the system design. The debris included dirt. On the east side there was plant roots or small branches (unable to tell what they were). On the west side the two upper hubs contained paint chips.

Above the service door the lowest hub and the one directly above it were removed. The debris in the both hubs was cleared. After the debris was cleared away, a "high" water mark was left on the inside of the hub. In the upper hub, clean bottled water was poured into the open hub. Some of the clean water dripped to the inside of the building and some went down the vertical drain pipe, ran out the bottom of the hub, through a hole in the flashing and out onto the roof above the service door. It appeared that the hole in the flashing is a result of corrosion, and not part of the original design of the piece. There is plant growth on the exterior of the concrete wall above the service door, the paint has been eroded away and the concrete is beginning to show signs of deterioration.

On the west side near the intersection of the concrete walk and the pond, the lowest hub and the one directly above it had their covers removed. Water was poured into the upper hub once the debris was cleared and it ran down the vertical pipe. Some water came out underneath the base flashing and ran down the stonework wall. It was not possible to determine the exact location of where the water was leaking through the flashing. The only way to determine the water's origination is to remove the flashing and it is not practical at this time. The system is designed to have the water come out the bottom of the hub, down the flashing piece on top of the concrete base and then it is channeled through a drain pipe at the lowest point on the wall back into the building.

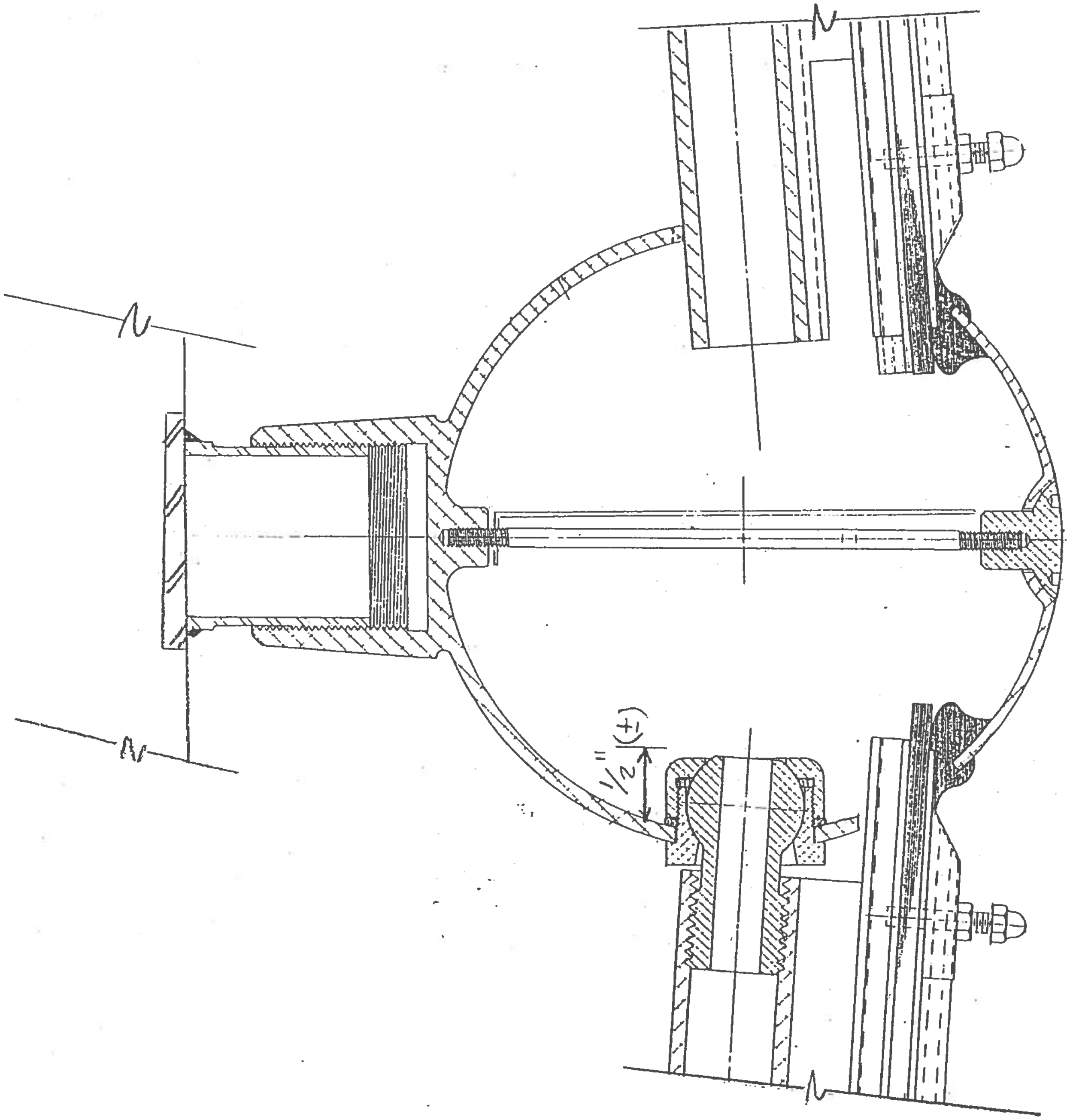
At all 6 locations, the gasket material around the hub cover was deteriorated and fell apart when the covers were removed. The perimeter of the hub covers should be caulked to eliminate water from the outside getting into the interior drainage system.

The drainage system as designed allows 1/2" of water to stay in the hub assembly, see attached drawing. The vertical drain pipe and the two lower diagonal pipes have two concealed gaskets. Their condition can not be determined without removing a portion of the skylight framing system which is not practical at this time. It appears that the gaskets may not be performing properly, allowing water to leak from the hub assemblies into the structures.

Respectfully submitted,

Cynthia Minshall, P.E.

cc: Ken Grebe, P.E. - GAS



SECTION THRU HUB ASSEMBLY

FIELD REPORT

Date: January 5, 1994

Job No. 930639

Project: Mitchell Park Domes Study

Location: Milwaukee, Wisconsin

Weather: Overcast

Temperature: 4 degrees @ 9:00 a.m.

Present at Site: Harold - Milwaukee County
Ken Grebe - GAS

The reason for this site visit is to determine the existing condition inside of the aluminum skylight frame hub assembly, which is an integral part of the interior drainage system.

The following was noted:

A total of 7 hubs were removed. Three on the east side of the show dome, two on the north side of the arid dome and 2 on the west side of the tropical dome. The locations were chosen in the show and arid domes because they had easy access and in the tropical dome because they were leaking water on the inside of the dome. All locations were accessed using a ladder. Milwaukee County was responsible for removal and replacement of the hub covers.

All hubs had debris in them. Only the hubs in the tropical dome had clogged vertical drain pipes and the water was unable to drain. The water was approximately 2" deep in the center of the hub when clogged. There was still 1/2" of water in the hub when the clog was removed and the system was able to drain. This 1/2" of water is allowed based on the system design. The debris included dirt. Debris can get into the system because the top three drainage pipes are not sealed around their intersection with the hub to allow for movement of the entire skylight frame.

In both the arid and show domes, clean bottled water was poured into the open upper hub. Some of the clean water dripped to the inside of the building and some went down the vertical drain pipe. Because the pouring technique used, it is difficult to tell where the drip originated from, the seals in the vertical pipe or from running down the face of the glass. The pouring technique was to pour water from a plastic gallon bottle into the hub opening with the center horizontal "deflector" plate still in place. This blocks a majority of the hub center opening. Not all the water went into the hub. Some ran down the inside and some ran down the outside of the glass.

On the west side of the tropical dome, the third hub cover up from the bottom and four hubs south of the intersection of the concrete walk and the pond was removed. The clog in the vertical drainage pipe was removed. The connection between the hub and vertical pipe on the inside of the building was tightened. Water was poured into the hub from the outside while the vertical pipe was clogged with paper toweling. Because the horizontal deflector plate was still in place, it was difficult to pour the water into the hub. A funnel was used to help direct the water into the hub opening. The water did drip into the building when above the top of the vertical drain pipe. It may have been running down the inside face of the glass and then to the point on the vertical pipe so that it appeared to be coming through the seal between the hub and the vertical drain pipe.

At the intersection of the concrete walk and the pond on the west side of the tropical dome, the hub cover was removed from the second hub up from the bottom. The water level was above the top of the vertical pipe and also above the circular opening in the face of the hub and there was water dripping from the hub. The water level was lowered to below the face of the hub opening, but still above the top of the vertical pipe while the clog was still in place. The horizontal deflector plate was removed at this location during testing. There was no water leakage to the inside of the building. Inside the building the connection between the hub and the vertical drain pipe was tightened. There was water leakage occurring again, but not until there was enough time passage to allow for the water level to get above the face of the opening. The water level in the hub was changing because water from condensation was dripping into the hub from the top vertical drain pipe as per the system's design. The water level was lowered, from the outside, below that of the hub circular opening numerous times and then refilled with water. When water was below the face of the opening and above the top of the vertical pipe, there was no water leakage into the building. When the water was high enough to go over the face of the circular opening, there was water leakage to the inside of the building. Finally, the clog was removed for the vertical pipe and the water drained out. Some of the water, however, came out underneath the base flashing and ran down the stonework wall. It was not possible to determine the exact location of where the water was leaking through the flashing. The only way to determine the water's origination is to remove the flashing. This is not practical at this time. The system is designed to have the water come out the bottom of the hub, down the flashing piece on top of the concrete base and then it is channeled through a drain pipe at the lowest point on the wall back into the building.

At all locations, the gasket material around the hub cover was deteriorated and fell apart when the covers were removed. The perimeter of the hub covers should be caulked to eliminate water from the outside getting into the interior drainage system.

The drainage system as designed allows 1/2" of water to stay in the hub assembly, see attached drawing. The vertical drain pipe and the two lower diagonal pipes have two concealed gaskets.

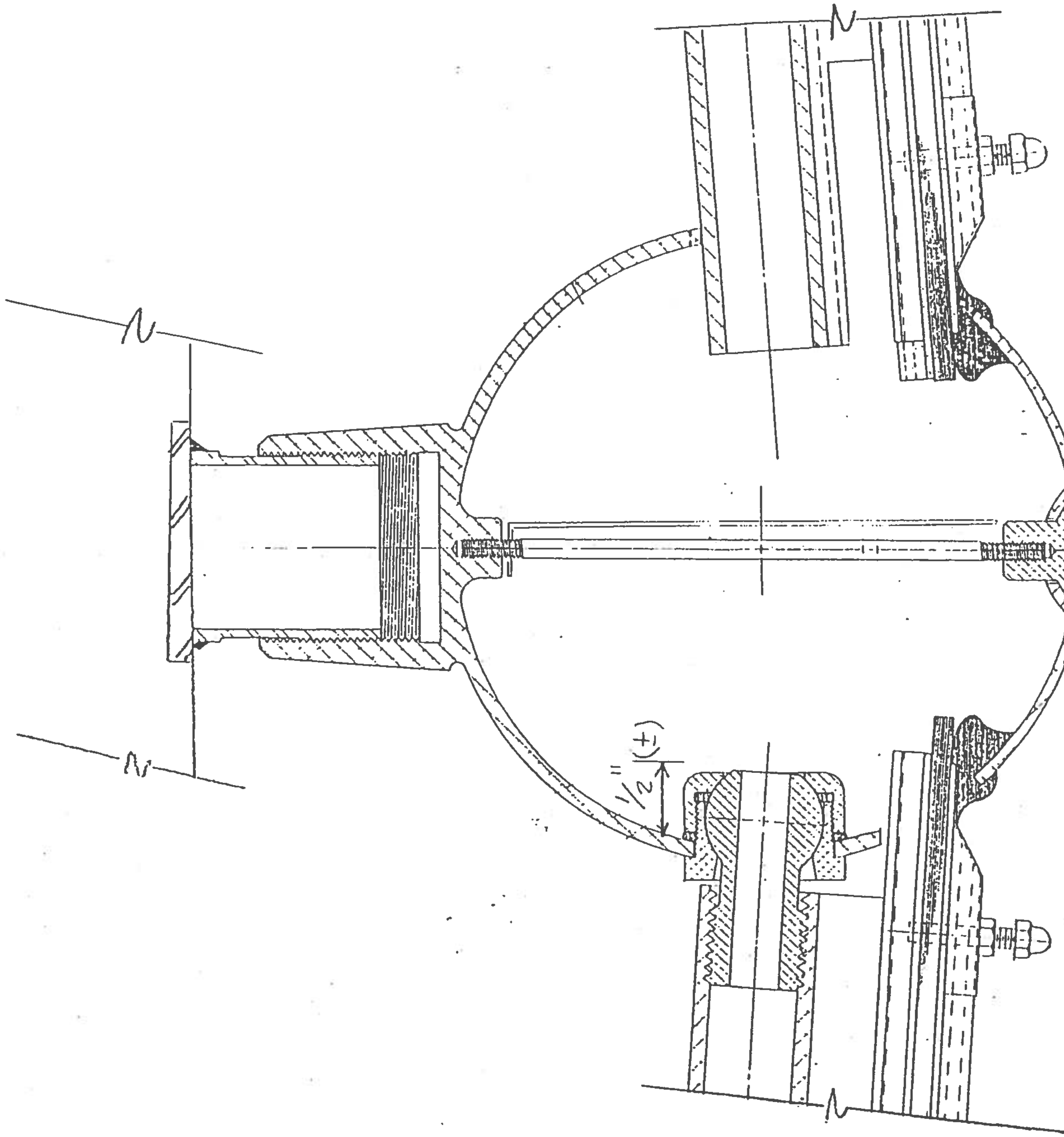
Their condition can not be determined without removing a portion of the skylight framing system which is not practical at this time. It appears that the water inside the hubs gets to a certain level and then is able to run down the inside face of the glass which takes the water to the lowest point on the hub and then it drips to the floor below.

At the locations in the tropical dome where the vertical drain pipes were unclogged on December 22, 1993, there was no dripping water into the building. Today there were numerous other locations that were dripping.

Respectfully submitted,

Cynthia Minshall, P.E.

cc: Ken Grebe, P.E. - GAS



SECTION THRU HUB ASSEMBLY

APPENDIX C

MEETING NOTES

MEETING NOTES
MITCHELL PARK DOMES STUDY
NOVEMBER 15, 1993

PRESENT:
KRISTINE COIMBOR
PAUL HATHAWAY
IVARS ZUSEVICS
LYNN GOULD
AL KRUMSEE
RICHARD RISCH
DIANE LINDSLEY
CINDY MINSHALL
KEN GREBE

ITEMS DISCUSSED:

1. The proposed schedule and scope of work were discussed and found acceptable. An intermediate report will be prepared or possibly a meeting held to show the progress of the work. This will be done early in December.

2. GAS is currently compiling information on domes and has started inspections. No interviews of people that were involved with the design or construction have been done. The County is trying to locate Tony Amato who worked for Kramer and was a key figure in the construction.

3. The observations and concerns of the attendees were as follows:

- The drainage system:
  The condition of the hubs and the hub seals are considered a possible problem in the drainage system. Dripping appears to originate at the hubs.
  There is dripping from the concrete frame that has done damage to the paved walkways, this indicates a consistent leaking pattern. The leaking is detrimental to the environmental systems established in each dome and undesirable to visitors.
  After a rain the water leakage increases dramatically. In some cases the hubs will leak when it is clear and sunny outside and there is no condensation on the inside. Is broken glass the only cause or is the drainage system a contributing factor?
  There is considerable leakage where the domes frame into the buildings. The shelves above the doors have had lights removed and deflector pieces added to channel any water away from traveled areas.
  The exterior has been accessed using a cart that rode up the side of the structure (the cart is thought to have been designed specifically for use in window washing and glazing replacement by the dome designers). Glass was broken while using the cart and the County is not sure if seals were compromised.
  Further testing of the drainage system may be required (specifically in the upper 1/3 of the domes). Testing will be discussed at a later date. It may be possible to do a die test, using a colored vegetable die (not harmful to the vegetation) to trace the actual drainage patterns.

- The condition of the concrete frame:
  There appears to be some cracking of the concrete frame. There are rust stains on the concrete frame. This is a major concern. How good is the concrete frame? If it is bad then the other items are relatively unimportant.
  The possibility of using cathodic protection for future maintenance was discussed.
  The frame is dirty and has become streaked because of water running down it. The center hoist and a fire hose have been used in the past to clean the inside frame of dust and dirt. This caused problems with the heating/ventilation and electrical systems.
  The walks were paved in the tropical and arid domes to keep dust down.
- The condition of the existing glazing:
  What type of glazing that could be used to replace broken or vandalized pieces was discussed. It was noted that Solarflex by Monsanto has been used by the University of Chicago and Ohio State and should be looked at for use here. The effects of LOW E glass on the growth of the plants must be considered.
  There was concern that if clear glass (not wire glass) is used that the difference could be seen from the inside of the domes. A pattern of clear (or tinted) vandal resistant glass could be established around the lower portion of the domes. There is glass with holes above the first few levels that may not fit a pattern. This must be studied further. At a future meeting a sample of clear and wire glass should available for inspection.

4. The County has existing drawings for the domes. Ivars Zusevics will assist GAS in obtaining drawings. Super Sky has existing drawings that GAS can use for reference, but Super Sky may not allow some drawings to be publicized.

5. In the past, some glazing has been replaced and the contractor noted that there was no uniform glazing size. Cost for the recent replacement of 8 pieces of glass was between $2000 and $3000. Replacement glazing has been Lexan or wire glass.

6. There has been work and testing done in the past, but there are no written reports for review. One test done was a small scale drainage test of the lower level hubs, Al Krumsee, Ivars Zusevics and the contractor did the work within the last year. The area tested drained properly.

7. There are electrical outlets about a third of the way up on the inside. The County would like to know what the intended purpose is. Were the outlets used only for construction or was it anticipated that they could be used over the life of the structure?

8. For access to entire structure GAS is to contact Richard Risch with at least one day's notice and then ask for him at the ticket window.

9. The County's priorities for repairs are:

- the structural support condition
- the leakage problem - horticultural concerns and dome rental concerns
- accessibility
- vandalism/security
- energy efficiency - potential cost savings and credits related to glazing

10. The domes in priority (highest to lowest) are:
- show dome - worst condition, rental revenues
- arid dome - most expensive collection
- tropical dome - energy conservation

11. The contractor will be responsible for determining the best way to replace the broken glazing, but with the nature of this structure the accessibility must be addressed. At least one option should be given to the contractors bidding on the repair work, but the contractor is free to determine a better or different means of access.
The cart that was to be used for exterior window washing is still a possibility as it has been used with some success on the lower 2/3 of the domes. Use of the cart damages the wheels which in turn damages the glazing and would indicate that frequent wheel replacement is required. On the upper 1/3, a harness could be used although working from a harness is very physically taxing.
It was noted that each dome was constructed before the surrounding buildings were erected and so access was not as big of a problem.

12. GAS asked for an idea of any future plans that may affect this study. The study will be used as a basis to determine future plans. It was brought up that a building and a tunnel from the sunken gardens to the tropical dome is under consideration.

13. GAS mentioned that their scope of work was for the area above the stonework, but that there is damage in the stonework area that should be addressed. The County is already in the process of fixing the lower areas.

14. The report will be written for the individuals attending today's meeting.

15. The next meeting should be held at the domes, so that a walk through can be done if need be.

These meeting notes reflect the interpretation of GAS. Please bring any discrepancies to the attention of Cindy Minshall at 259-1500.

cc: All participants

MEETING NOTES
MITCHELL PARK DOMES STUDY
DECEMBER 17, 1993

PRESENT:
PAUL HATHAWAY - PARKS DEPT.
IVARS ZUSEVICS - MILWAUKEE COUNTY
AL KRUMSEE - PARKS DEPT.
RICHARD RISCH - PARKS DEPT.
DIANE LINDSLEY - PARKS DEPT.
CINDY MINSHALL - GAS
KEN GREBE - GAS
JOHN GOETTER - GAS
GEORGE TAYLOR - SUPER SKY
TED GRABOWSKI - SUPER SKY

ITEMS DISCUSSED:

1. GAS gave a project progress update.

- GAS has received and reviewed copies of the original specifications and drawings from the County. Interviews with principals involved with the design and construction have not been done yet as questions were recently formulated after reviewing available information.
- Performed inspections include a count of the broken glass, half cell testing of the concrete frame, a continuity test, a visual inspection of the concrete for cracks and spalls.
- Currently investigating types of glazing to use, along with gaskets and sealants, concrete repair methods and painting.
- Beginning to get cost estimates for glazing, painting and concrete repairs.
- GAS is on schedule.

2. Ivars Zusevics indicated that the County does not have a copy of the structural calculations for the concrete frame work. GAS will pursue alternate sources.

3. Glazing options were discussed in detail.

   It was agreed that wire glass would not be pursued as an option for reglazing. Wire glass is not the state-of-the-art glazing material, it may be difficult to get, it is brittle and that may be the cause of some of the existing cracks especially in the upper 1/3 of the domes. The visual difference between the existing wire glass and any clear glazing was noted and deemed not to be a problem. The performance of the glazing system is the main concern. It was suggested that in the final report we state reasons why wire glass was eliminated as an option.

   Laminated glass is more readily available, stronger and less brittle. The initial cost of a laminated product is slightly more, but the material cost of reglazing is only one of several significant factors in the total cost of reglazing. Other significant factors include fabrication and erection costs. Laminated glass is currently allowed for use as in overhead glazing by the building code. This product should help with long term maintenance, by reducing the possibility of cracking.

- The transmission data for the different types of glazing was discussed. the County would also like information on Solarflex to do a comparison. Super Sky will get this information. The reduction of the Ultra Violet (UV) transmissions from the current 66% in wire glass to almost nothing through a laminated product is not a concern to the County. The type of foliage in the domes does not require UV rays.
- The report will narrow the extent of the glazing replacement to four options.
  1. Minimum replacement - those pieces that are leaking or have holes.
  2. Replace all cracked or broken glass.
  3. Replace all cracked or broken glass and an area around the base where vandalism is of greatest concern (i.e. the back areas of the arid and tropical domes).
  4. Entirely reglaze all three domes.
- Replacement of glass can be done with localized disturbance. Areas will have to be roped off for the overhead replacement to minimize the danger of dropping glass or tools.
- Around the base, a plastic (Lexan) product will be investigated.

4. The domes should be painted to protect the concrete from deterioration. There will be two options investigated, one for painting the entire dome and one for painting just the lower portion. To paint an entire dome will require a lift and/or scaffolding and may be a big disturbance to visitors. The lower portion has peeling and the concrete is no longer protected, especially in the Tropical Dome where moisture is a problem. The life expectancy of the current paint was 10 to 15 years, it has now been in service about 30 years. If only the lower portion is painted there will be a visual difference between the new and the existing paint. The existing paint that will remain will eventually need replacement.

5. Work schedule guidelines were discussed. Any extensive work in the Show Dome should be scheduled between May and October. During the winter the domes have a 24 hour work schedule. During the summer there is only 2 shifts. DPW can provide inspection services, Monday through Friday, 8:00 a.m. to 5:00 p.m. A detailed schedule for any repair work will be required before the commencement of work, but the County is flexible with respect to when work could take place. The County is willing to close off portions of a dome or domes so that work can be done in those areas during hours the domes are open to visitors.

6. GAS will inspect the inside of hubs known to leak. Without this inspection it is not possible to determine why there is water dripping from the bottom of hubs, especially in the Tropical Dome. The County will arrange for a lift and will be responsible for the removal and replacement of the hub covers. Several hubs will be inspected.

7. The only modification to the Proposed Report Outline is the addition of a REPAIR PRIORITIES section between Existing Conditions and Repair Options. See the attached updated Report Outline.

8. A draft of the report will be issued on Monday, January 24, 1994, and a meeting will be held to discuss revisions to the report on Friday, January 28, 1994, at 10:00 am at the Domes. The final report will be issued on February 6, 1994.

These meeting notes reflect the interpretation of GAS. Please bring any discrepancies to the attention of Cindy Minshall at 259-1500.

cc: All participants

MEETING NOTES
MITCHELL PARK DOMES STUDY
JANUARY 28, 1994

PRESENT:

PAUL HATHAWAY - PARKS DEPT.
IVARS ZUSEVICS - MILWAUKEE COUNTY
AL KRUMSEE - PARKS DEPT.
RICHARD RISCH - PARKS DEPT.
KRISTINE CIOMBOR - PARKS DEPT.
CRUZ CARRILLO - PARKS DEPT.
TED AGNELLO - PARKS DEPT.
CINDY MINSHALL - GAS
KEN GREBE - GAS
GEORGE TAYLOR - SUPER SKY

ITEMS DISCUSSED:

1. There should be emphasis on the need for the structural concerns to be addressed in the near future.

2. The following repairs are required to limit structural deterioration of the domes:
   - repair of the hub connection in the Show Dome (and similar conditions if any)
   - replacement of leaking glass
   - cleaning out the clogged hubs
   - repairing the concrete spalls and cracks
   - painting the concrete frame in the Tropical Dome
   - eliminating the water problem from above the doorways
   - repairing the screens and replacing the corroded screws

   Other repairs may be required for reasons such as aesthetics, functionality, energy efficiency, etc.

3. The report should contain under the glazing repair costs a line item if the upper 1/3 of the dome were completely reglazed along with broken and leaking glass in the lower 2/3. It is felt that while work is done in the upper 1/3 and access has been obtained that all of the glazing could be replaced.

4. There should be a stronger statement in the report about the need for vandal resistant/security glazing around the base of the structure.

5. The repair cost tables should have a column indicating the quantity of repairs per item. The reference to repairs in earlier sections is not adequate. The glazing section of the repair cost tables should indicate that the costs include cleaning of hubs and replacement of gasket material, etc.

6. The report should note that the cost of any disturbances to the Domes' have not been included in the costs of repair. For example the cost of moving plants has not been included.

7. The original structural design information has not yet been obtained from Ammann and Whitney. The County is waiting for a cost estimate for providing this information from Ammann and Whitney. The cost of services will be a reimbursable add to GAS's contract.

8. The quality of repair work to be performed is a concern if the low bidder must be selected. Many of the repairs required are unique. The specifications must be clearly written to assure quality work.

9. The final report will be issued on February 7, 1994. There will be 20 copies given to Milwaukee County. The reports will include color photocopies of the photograph pages.

   These meeting notes reflect the interpretation of GAS. Please bring any discrepancies to the attention of Cindy Minshall at 259-1500.

cc: All participants

APPENDIX D

ORIGINAL SPECIFICATIONS

PAINTING WORK

Mitchell Park Plant Conservatory
S. Twenty-Seventh and W. Pierce Streets
Milwaukee, Wisconsin

3-1 GENERAL REQUIREMENTS

(A) All work to be done subject to the requirements set forth in the PREFACE to the Specifications as they may apply to this Branch of the work.

(B) This Branch of the work will be a Separate Contract, subject to the General Conditions and other contract documents, which form a part of this Specification.

(C) Bidders are required to submit a definite work schedule with their Proposal;
- Earliest possible starting date;
- Length of time required to complete their work;
- Date and time requirements established by schedule submitted will be a deciding factor in awarding the Contract.

(D) Successful Bidder will be required to meet all the requirements as to Insurance and Performance Bond upon award of the Contract.

3-2 GENERAL SCOPE

The intent of the following specification is to provide complete painting of existing Domes A and B and new construction work, including Dome C, shown on drawings and specified as Second Stage.

(A) Work Included
Division A Special Painting (protective coating) of domes; Dome A, Dome B, Dome C.

Division B General Painting. Lower level of Transition House, Boiler Room, Garage, Stairhalls, Dome A.

(B) Work Not Included
See General Scope of Division A and Division B of this Branch of specification.

3-3 GUARANTEE

This contractor to guarantee his work and the product used for One (1) year after application and to provide the Milwaukee County Park System with a guarantee covering the paint product for the same period of time, and repair and replace any imperfections, defective material and labor, at no cost to the Owner;
Plastic coating of project to be put on by an authorized applicator with at least two (2) years experience with type of coating applied.

3-4 STORAGE OF MATERIALS

Take special care in sorting and handling of inflammable materials to avoid fire hazard;

- If practicable, store outside of building;
- If not feasible store paint away from the building, store equipment and materials in room provided and keep locked;
- Consult Architect relative to available room or storage space; Provide own storage shed;
- Containers which are empty used on job to have labels cancelled and be clearly marked as to contents;
- Remove wiping cloths, oily or greasy waste and rags daily before leaving work.

3-5 EXAMINATION OF SURFACES

Before starting, inspect all surfaces to be finished;

- Report (in writing) to Architect any unsatisfactory conditions;
- Starting of work will be considered as acceptance of surfaces as being satisfactory;
- Contractor's work removed and replaced to correct surface defects due to procedure on unsuitable surfaces will be at Contractor's expense.

3-6 PATCHING UP AND TOUCHING UP

Touch up all plastic paint process and Tnemec painted work after other trades have completed their work; leave all work in perfect condition;

- Patching and touching up not due to carelessness of other workmen to be done without expense to the Owner;
- Touching up required by damage due to carelessness will be charged to Contractor responsible.
- In case responsibility cannot be fixed, the cost of repairing will be pro-rated among all contractors in proportion to their activities in the building at the time the damage was done, as approved by the Architect.

3-7 SAFETY PRECAUTIONS

Enforce special safety precautions in handling of toxic paints as recommended in manufacturer's printed instructions.

3-8 FINALLY

- Cooperate with the various contractors;
- Store material where directed and in orderly manner;
- Remove any rubbish, debris, etc. (resulting from this Branch of the work) from the premises;
- Keep job and premises in a neat orderly condition at all times.

* * * * *

DIVISION A

SPECIAL PAINTING (Protective Coating) of CONCRETE DOMES

3A-1 GENERAL SCOPE

(A) Work Included

Without intending to limit or restrict the volume of work required by this Branch and solely for the convenience of the Contractor, the Work comprises the complete Special Painting of Concrete Domes, Dome A, Dome B and Dome C, as follows:

(1) All four (4) sides of precast concrete dome members;
(2) Interior concrete surfaces of dome foundation walls down to pipe trench floors;
(3) Interior pipe trench wall, concrete surfaces facing trench, soffits of floor slabs at entrances;
(4) Interior exposed concrete surfaces at entrances: soffits and tops of interior decks, walls above entrance decks;
(5) Exterior concrete walls above entrance decks;
(6) Exterior and interior walls of service entrances Dome A, WP 15; Dome B, WP 16; Dome C, WP.23, in addition to items 4 and 5;
(7) Work Point identification marking;
(8) Pipe trench floors and mechanical equipment pads.

(B) Work Not Included

(1) Painting of interior pipe trench wall surfaces facing dome interior; (this work will be performed at later stage)
(2) Painting of ducts - See General Painting, Div. 3B.
(3) Touch up as caused by damage done by Glass and Glazing contractor or other sub-contractors on job;
(4) Painting of steel welding plates and inserts provided for support of skylight work; (include in this Bid - masking; see Article 3A-4 (C).)
(5) Painting of exterior gutter; This work will be performed at later stage.

3A-2 MATERIALS

(A) For precast Concrete Dome Members and exposed surfaces (concrete) listed in General Scope, Work Included, Article 3A-1 (A) as items No. 1 to 6 inclusive.

Material Must meet the following requirements:

(1) Cover with not less than 5 mils (dry) thickness depending on material, in two or three coat job;
(2) Be resistive to abrasion;
(3) Be resistive to fungi and mold (but not harmful to plants, flowers, foliage, etc.)
(4) Be easily cleaned with water and brush;
(5) Be capable of filling and spanning 1/8" to 3/16" voids or air holes in surface of concrete;
(6) Permit normal expansion and contraction of concrete without cracking or spawling off or causing concrete to spawl off;
(7) Allow heat of sun through glass to withstand temperatures of 130° without causing stickiness or decomposition;
(8) Will permit ease of patching for areas accidentally damaged by rough treatment;
(9) Have a longevity of ten (10) to fifteen (15) years;
(10) Must permit breathing of concrete and withstand high humidities without harm to concrete surfaces;
(11) Must withstand effects of ultra-violet light, without discoloring or decomposing;
(12) Must not chalk excessively at any time.

Following manufacturers and protective coating systems are suggested, recommended and/or used for preparation of Base Bids:

(1) AMERCOAT CORPORATION
4809 Firestone Blvd., South Gate, California;
AMERCOAT 64/66/72, 3-coat, high build epoxy;
10 mils dry film thickness, color as selected.

(2) CERESIT CORPORATION
3227 S. Shields Ave., Chicago 16, Ill.
PROPOX, Epoxy two component coating,
3-coats, not less than 10 mils total thickness;
Color as selected.

3A-2 MATERIALS (A) Continued

(3) ENTERPRISE PAINT MFG. CO.
Ashland Ave. at 29th St., Chicago 8, Illinois;
3-coat, 15 mils total dry film thickness,
1-coat No. 11077 white P/A activated;
1-coat No. 11077 tinted with EA-4-206 Black
1-coat No. 11077

(4) GLIDDEN COMPANY
900 Union Commerce Bldg., Cleveland, Ohio;
1-coat Nu-Pon Swimming pool paint, white Y-5540
1-coat Nu-Pon Primer type III, 287-G-500
1-coat Vyn-al white

(5) PITTSBURGH GLASS COMPANY
P. O. Box 724, Milwaukee, Wisconsin
UC-9630, high solid epoxy coating
2 coats minimum 10 mils dry film thickness, white.

(6) SEC MANUFACTURING COMPANY
Miami, Florida
1 coat SEC epoxy kote, flat finish, No. 1217; formula;
1 coat SEC epoxy kote, semi gloss finish, No. 1217 formula;
Minimum 5 mils total dry film thickness.
Color as selected.

(7) WEST CHESTER CHEMICAL COMPANY
Box 39, West Chester, Pennsylvania
Maintz-Hypalon, 3-coat, 15 mil dry thickness;
Color as selected.

(B) Painting of Concrete Pipe Trench Floors and Equipment Pads

(1) CERESIT Cerrock Epoxy Compound, extend with sand blast sand and silica sand in proportion of 54 lbs. sand to 1 gallon to Cerrock; or

(2) SEC Epoxy Floor Surfacer, SE-400; or

(3) SIKA Chemical Corporation, 35 Gregory Ave., Passaic, New Jersey;
Sika Epoxy Surface Cote, extended with Silica sand in ratio of 1 to 1 by volume;
or proven equal.

- Clean and prepare existing concrete floors as recommended by manufacturer. Etch concrete with a 10 to 15 percent solution of muriatic acid. Follow by flushing with clear water, dry completely.

3A-2 MATERIALS (B) Continued

- Application, by trowel, to total thickness not less than 1/8". Slope to existing floor drains.

(C) Substitute Protective Coating Systems Meeting Requirements of paragraph 3A-2 (A) - Bidder's Option.

3A-3 SAMPLES

Samples of work and paint finish as instructed by Architect;

- Painting Contractor to make test samples on concrete test cylinders; and provide whatever testing laboratory data tests are needed together with six (6) copies of test lab reports - prior to acceptance by Architect;
- Provide as many samples as required to provide sample satisfactory to Architect;
- Approved sample kept on site for comparison;
- Provide sample and test painting of all sides of three precast concrete members forming one triangular section;
  Use approved cylinder sample as base.

3A-4 WORKMANSHIP

(A) To be of highest grade;
By approved first class mechanics and applicators, authorized;
Dome Painting to be put on by an authorized applicator with at least two (2) years experience in applying protective coating.

(B) Application
Plastic painting process shall be applied in accordance with the manufacturer's specifications in color as selected by Architect;
Plastic painting process to be applied in temperatures as recommended by manufacturer.

(C) Surface Preparation - Precast Concrete Dome Members

- Painting contractor shall visit site, inspect surfaces of existing structures Dome A and Dome B, erected during first stage construction. Include in bid any surface preparation (washing, sand blasting, wire brushing, etching, priming, etc.) to remove remaining surface form oil, bond separators, loose particles, dust and dirt;
- As recommended by paint manufacturer in his latest printed specifications;
- To provide proper coating needed to meet requirements of Article 3A-2 Materials and 3-3 Guaranty;
- Clean and mask all steel welding plates inserted in concrete for future attachments of skylight work.

3A-4 WORKMANSHIP Continued

(D) Right of Observation by Manufacturer
All phases of the work shall be available to a representative of the coating manufacturer for observation.

3A-5 PROTECTION

Cover with drop cloths or canvas all material and surfaces adjoining or below work in progress. Mask all welding plates embedded in concrete;

- Keep all containers covered when not in use;
- Remove empty containers, paper, oil rags, etc., from the building daily before men leave the job;
- Painter will be held responsible for damage to other finished work, and will be required to make the necessary repairs or adjustments to the satisfaction of the Architect.

3A-6 BASE BIDS (3A-1 to 3A-21 inclusive)

- Include all labor, materials, equipment, scaffolding, etc., required to provide complete Special Painting of domes using the following protective coating systems:

Amercoat 64-66-72	Ceresit Propox
Enterprise 11077/11077/11077	Glidden Nu-Pon
Pittsburgh UC-9630	SEC Epoxy Kote
Maintz Hypalon	

  specified in article 3A-2, Materials.
- Insert in proper spaces provided in Proposal Form quotation for each item specified;
- Earliest possible starting date;
- Length of time required to complete their work.

* * * * *

SKYLIGHT WORK

GEOMETRIC TRANSPARENT DOME COVER

1U-1 GENERAL REQUIREMENTS

(A) All work to be done subject to requirements set forth in the PREFACE to the Specifications as they may apply to this Branch of the Work.

(B) The Successful Bidder, at the Owner's option, may be required to:
- Work in cooperation with and under the supervision and control of the Contractor for the GenEral Construction Work selected by the Owner.

(C) Work Schedule
Bidders are required to submit a definite work schedule with their Proposal in spaces provided in the Proposal Form:
- Earliest possible starting date;
- Length of time required to complete their work;
- Dates and time requirement established by schedule submitted will be a deciding factor in awarding the Contract.

(D) Successful Bidder will be required to furnish a performance Bond to the Contractor for General Construction Work upon award of the Contract.

(E) The work under this division must be supplied, installed and guaranteed by the Dome Skylight Contractor.

1U-2 GENERAL SCOPE

(A) Work Included
Without intending to limit or restrict the volume of work required by this Branch of the specifications and solely for the convenience of the Contractor, the work comprises the following:
- Furnishing, erection and glazing;
- Self-supported dome skylight at dome apex;
- Dome exhaust fan panels and enclosures;
- Dome glass and glazing - supported by concrete space framework;
- Flashings at dome bases;
- Samples, tests and engineering;
- Aluminum finishing and Painting;
- Working unit - full size erected on one section of dome;
- Cleaning;
- Installation of summer air intakes and exhaust grilles;

1U-2 GENERAL SCOPE (Paragraph A continued)

- Shop drawings;
- Surveys;
- Scaffolding, scaffolds, and erection equipment;
- Test;
- Touch up painting of concrete space frame;
- Survey of coordinate points and location plan for glass and framing members.

(B) Work by Others
- Concrete space framework and welding insets;
- Furnishing of Aluminum air-intakes and exhaust grilles

(C) Special Notes
- Contractor shall visit the job site before submitting his bid;
- Check drawings and specifications for other trades to properly correlate the work;
- Lack of information will not be deemed a valid cause for additional compensation of the work;
- Glass and settings to be installed after painting and in accord with schedule of General Construction Work.

1U-3 MATERIALS

(A) Rafter Bars, Interior Glazing Mouldings
- Extruded aluminum, type 6063-T5;

(B) Exterior Glazing Mouldings
- Extruded aluminum

(C) Exhaust Ornamental Grilles, Side Panels
- Flat sheet aluminum;
- Alloy 6061-T6;
- .250 inch thick;
- As shown on drawings.

(D) Aluminum Flashing - Seam Covers - Closure Panels
- Sheet aluminum - bent as shown on drawings;
- Gauge No. 18 B & S (.040) alloy 3003-H14
- Minimum gauge No. 20 (.032).

(E) Hubs and Assemblies
- Fabricated or cast aluminum;
- Minimum tensile strength of 24,000 psi;
- Minimum wall thickness of 3/16";
- Where loads to be transferred;
- Contractor must submit structural calculations for Hub Assembly with bid.

1U-3 MATERIALS Continued

(F) Flashing - Lead Coated Sheet Copper
- Gauge - as shown on drawing, but not less than 16 oz.;
- Conforming to Federal Specifications QQ-C-501a of hardest temper consistent with required forming operations;
- Lead coated in accordance with Copper and Brass Association Standards - 12 to 15 lb.

(G) Weather Proofing Gaskets
- Extruded Neoprene
- Shapes and sizes designed by Skylight Contractor, approved by Architect;
- Applied above and below, both glass and plastic sub-ceiling;
- Applied at edges (all edges) of glass.

(H) Water-proofing Sealant, Caulking Compound
- Thiocol mastic filler or Hypalon Plastic Caulking Compound;
- Color as selected by Architect;
- Applied by gun in strict conformity with latest manufacturer's specifications;
- Submit samples and test data specified under article entitled SAMPLES, this division, for Architect's approval.

(J) Glazing Compound
- Extruded mastic sealer;
- Non-hardening, resistant to weathering agents and cycles, with low absorbtion;
- Color as selected by Architect;
- Applied by hand in strict conformity with manufacturer's specifications.

(K) Glass

(1) Lower Dome Portion
- Base Bid - clear crystal sheet glass, 1/4"
- Lustraglass - American Glass Company or a proven equal;
- Light transmission - 92.6%
- Ultra violet - 313 milli microns - 24.8%
  325 " " - 55.9%
  Infra red - 1000 " " - 90%

(2) Upper Dome Portion, as detailed - Clear Misco wire glass, 1/4",
- or clear Nu-weld wire glass, 1/4" thick;
- Maxi mum light transmission required.

1U-3 MATERIALS Continued

(K) Glass Cont'd

(3) Alternate for Dome Skylight and areas shown with wire glass, see article entitled Alternate Bids, this division.

All tempered glass as shown on the drawings shall be fabricated from Flat Drawn 1/4" thick Heavy Sheet Glass, "B" quality, as defined by Federal Specification DD-G-451a and which meets the following specifications:

- All tempered glass must be certified by the manufacturer as fully tempered and must comply with all tests and specifications contained in the American Standard Code for Glazing Materials for Motor Vehicles Operating on Land Highways;
- Submit three (3) copies of test data;
- Tensile strength should approximate 36,000 psi;
- Impact resistance;
  2 lb. steel ball - approximately 44"
  11 lb. shot bag - approximately 96"
- All items shall have seamed edges and shall bear the identifying label of the manufacturer.

(L) Plastic Sub-Ceiling (double glazing at apex skylight)
- Plexiglas, 0.250 inch thick;
- Transparent flat sheet;
- Attached to rafters by means of removable extruded aluminum caps;
- With Neoprene vaporproofing gaskets, see paragraphs 2-3 (G).

(M) Insulation
- Where shown or required in closure panels;
- Mineral wool or glass fiber.

(N) Bolts, Anchors, Spacers, Other than Aluminum
- Stainless steel, type 302;
- Designed by Skylight Fabricator.

(P) Nuts
- Self sealing type hexagonal, non-corrosive weather resistive and vandal-proof.

1U-4 FINISHES

(A) Exterior (Exposed to Weather)
- Extruded aluminum glazing frame, molding, hubs, etc.;
- Sheet aluminum flashing, closure panels.

1U-4 FINISHES Continued

Base Bid: Alcoa Architectural Alumilite Treatment #215 R-1 for all dome hub caps and #215 R-5 for all bar caps;
- Furnished in accordance with standards established by Aluminum Company of America;
- Applied by approved processor;
- With minimum Anodic oxide coating of .0008 inch and a coating weight of 35 milligrams per square inch;
- Protected with two (2) coats of clear Methacrylate Lacquer dusting type, minimum thickness of .0006 inch, Du Pont 1234 or proven equal;
- Finish shall meet test requirements in accordance with ASTM specifications;
  ASTM B-137-45 coating weight;
  ASTM B-244-49 coating thickness;
  ASTM B-136-45 sealing.
- Available from the American Society of Testing Materials, 1916 Race Street, Philadelphia, Pa.
- See sample requirements.

(B) Interior
- All extruded aluminum rafters, bottom caps, hub assemblies, ornamental exhaust grilles and side panels;
- Sheet aluminum closures;
- Verson coating;
- Manufactured by Phelan Faust Paint Manufacturing Company, St. Louis, Missouri;
- Applied by dip method, to cover all metal inside and out;
- In strict conformity with manufacturer's specifications.

1U-5 GENERAL DESCRIPTION
- The glass and glazing of each of the domes of like structures is designed for the maximum amount of light needed in a plant conservatory;
- The glazing system must include careful considerations of the following factors:

(1) Removal of condensate with no drippage from interior surfaces;
(2) A tightly sealed structure to eliminate dust and exterior water;
(3) An easily cleaned structure;
(4) Materials resistive to chemicals, rust and corrosive free;
(5) Use of long lasting durable materials;
(6) Ease of replacing elements; viz. glass, etc.;

1U-5 GENERAL DESCRIPTION Continued

(7) Allowance for a free circulation of air over transparent surfaces and settings;
(8) Use of a glass or material that will not break causing danger to people below.

1U-6 STRUCTURAL REQUIREMENTS

(A) Extruded Aluminum Rafters Designed to:
- Support snow load of 30 lbs. psf and dead load of glazing and mechanical equipment;
- Resist effect of wind load of 20 lbs. psf;
- Care for and support vibration load of exhaust fans.

(B) Hub Assembly, Cover Nuts
- To resist moment of 500 lbs. live load of future glass replacement and cleaning equipment;
- Safety factor of two and one-half ($2\frac{1}{2}$).

(C) Submit structural calculations attached to shop drawings. Must be by a reputable structural engineer licensed in the State of Wisconsin.

(D) Hubs which receive seven (7) members can be larger in size than detail 11/A-5 of standard hub.

1U-7 SELF-SUPPORTED SKYLIGHT - AT APEX OF DOME

Extruded aluminum dome-like skylight as manufactured by Super Sky Products Company, Incorporated, P. O. Box 113, Thiensville, Wisconsin;
- As shown on drawings.

(A) Putty-less Rafter Bar Construction
- Complete with continuous cover and bottom caps, end covers; non-corrosive carriage bolts and nuts, glazing spacers.

(B) Glass
- 1/4" clear Misco Wireglass or,
- 1/4" clear Nuweld Wireglass;
- 1/4" clear tempered glass (Alternate for Wireglass);
- See sheet A-4 II and the alternate in this specification for locations;
- All glass to sustain a uniform load of 30 lbs.per square foot normal to the plane of glass.

Light Transmission Table

			preferred
Light Transmission			92.6 %
Ultra Violet	313	milli microns	24.8 %
	325	" "	55.9 %
Infra Red	1000	" "	90.0 %

1U-7 SELF-SUPPORTED SKYLIGHT - AT APEX OF DOME

(C) Plastic Sub-Ceiling
- 0.250" plexiglas, clear, colorless, with hard tempered surface to resist scratching.

(D) Exhaust Fan Panel
- Complete with ornamental exhaust grilles and side panels;
- Wood curb and anodized aluminum flashing.

(E) Fabrication, Erection and Installation
- In strict conformity with manufacturer's specifications.

1U-8 DOME GLAZING - SUPPORTED BY CONCRETE SPACE FRAME

Extruded aluminum frame as manufactured by Super Sky Products Company, Incorporated, P. O. Box 113, Thiensville, Wisconsin;
- The design shown on drawings and herein specified is to provide:

(A) Watertight, Leakproof Glazing System
- Putty-less, tubular rafters;
- Exterior metal caps and covers;
- Neoprene glazing gaskets with air cushion easy to remove for glass replacement;
- 1/4" thick wire glass, clear, or
- See alternate for tempered glass, Alternate Bids, this Division.

(B) Condensate Water Drainage
- By gravity;
- Thru continuous system of tubular rafters, with weep holes and connecting hub assemblies;
- Terminated with drain pipe at hubs at lowest level;
- Drainage system will be furnished by Owner;
- See Test Requirement specified.

(C) Allowance: for thermal and structural movements without accumulated expansion and contraction distorting dome glazing;
- Rigid hub anchorage to precast concrete space frame - provide structural stability and adjustments for regularity of shape;
- Rafter ends entering hubs sealed leakproof with Thiokol mastic filler;
- One rafter end restrained by hub assembly;
- Neoprene glazing strips and gaskets with air cushion providing rocker action which allows for dihedral angle variance at points of contact.

1U-9 TEST OF CONDENSATE WATER DRAINAGE

(A) Perform:
- In the presence of Owner's representative and Architect;
- When ready for glass installation.

(B) This test is to check:
- Leakproof drainage of condensate water;
- Thru tubular rafters and hubs;
- Leak-free location of weep holes;
- Before application of glass.

(C) Test Should Consist Of:
- Continuous gravity water flow;
- Supplied by hose at all highest level hubs;
- For thirty (30) minutes.

1U-10 SAMPLES

Before ordering any materials:
Submit to Architect for approval:

(A) Glazing Compound and Waterproofing Sealant
- Actual commercial packaged form;
- Small size;
- Include report by recognized Testing Laboratory, showing physical properties;
- Adhesive strength, resistance to weathering agents, and cycles, stability under infra-red and ultra violet light, water absorbtion.

(B) Exterior Aluminum - receiving architectural finishes:
- Submit three (3) sets of samples of actual material and sections;
- After approval by Architect and Owner, submit one (1) set to Alumilite Finisher to be used for comparison purposes during production finishing.

1U-11 TESTS

Tests for anodized or coated materials;
Six (6) copies of tests shall be furnished to the Architect;
- Tests made by a recognized Testing Laboratory for all anodized or coated materials;
- For one (1) part or piece in each one hundred (100) prior to installation or delivery to job site;
- The tests shall show depth or thickness of coating and compliance with standards set by The Aluminum Company of America.

1U-12 SHOP DRAWINGS

(A) Submit six (6) copies to Architect for approval.

(B) Showing:
- Details of construction;
- Method of anchoring;
- Glass pattern and sizes;
- Full size sections of glazing members and strength computations.

1U-13 SURVEY AND LOCATION DRAWINGS

This Division Contractor to submit six (6) copies of survey of all coordinate points for each dome to compare coordinates with dome curvature;
- This Contractor, also, to provide six (6) copies of diagram drawings showing coded parts of framework and coded glass lites - this diagram to be used for future repair or replacement of glass and aluminum members.

1U-14 ERECTION AND WORKMANSHIP

(A) General

Work in this Branch shall be performed:
- After proper erection, curing and painting of pre-cast concrete space frame specified in other Branches;
- By first class mechanics, skilled in this type of work;
- In strict conformity with manufacturer's specifications;
- And meet safety requirements.

(B) Skylight Contractor is responsible for all field measurements, surveys and adjustments required to obtain:
- Uniform glass pattern and
- Regular exterior shape outline.

(C) General Contractor shall furnish one (1) copy of a survey as-built, specified in Branch No. 1, Division D, paragraph 12, to be used as guide only.

(D) Allowable tolerances are shown on drawings and herein specified;
- Notify Architect in writing if the tolerances are greater than one (1) inch from shown on drawings.

1U-15 ERECTION EQUIPMENT AND SCAFFOLDS

(A) Furnished and maintained by Skylight Contractor;

(B) To meet all safety code requirements issued by
- The Industrial Commission of the State of Wisconsin;
- The Milwaukee City Building Codes; for the safety and the protection of the building property and workmen during the erection.

(C) Submit a complete plan showing erection procedures; materials and methods of control;
- For Architect's and Engineer's approval;
- Before starting erection;
- NOTE: the approval to proceed will not release the Contractor of his responsibility.

(D) Check and cooperate with other contractors to avoid any interference with their work.

(E) See alternate 2-C.

1U-16 TOUCH-UP PAINTING

Concrete space framework will be painted by others and welding inserts will be masked to provide clean surface for welding;
This Contractor shall include in his bid the cost of touch-up painting. See Special Painting for type to be used.

1U-17 GUARANTEE

(A) Structural Frame
- For a period of one (1) year after date of acceptance;
- Against leakage, excessive deflection, material failure;
- Caused by defective design, material, fabrication or workmanship.

(B) Glazing Compounds
- For a period of five (5) years;
- Against leakage;
- Caused by defective material or workmanship, excessive shrinkage, poor resistance to weathering agents and cycles.

(C) Neoprene or rubber and/or plastic settings and gaskets:
- For a period of ten (10) years or more;
- Against leakage;
- Against forming a set or hardness, or shrinkage;
- Caused by age or exposure to greenhouse temperatures, humidity and/or chemical sprays, etc.

1U-18 WORKING UNIT OF SKYDOME SECTION

- Contractor to furnish at site for approval of Architect and Owner a full size working unit of the skydome mounted on the concrete framework;
- See Sheet A-4 II for location and size of unit to be built;
- Portion to be complete with hubs (seven), rafters, glazing and color and types of aluminum as specified;
- Bottom hub to have condensate leader to check water flow in rafters, as indicated on Sheet A-5, Detail 3/A-5.
- This working unit must receive approval by Architect and Owner before ordering any glass and aluminum parts for this contract division.

1U-19 CLEANING GLASS AND SKYLIGHT FRAMING MEMBERS

- Provide final cleaning inside and out for acceptance of Owner and Architect;
- This cleaning to be done after Architect has inspected and approved the in-place work of the Skylight Contractor.

1U-20 CLEANING AND PRIMING OF WELDED JOINTS

After welding skylight frame to concrete dome plates, chip all welded joints before re-priming all plates with prime paint recommended by Painting Contractor of Concrete Domes.

1U-21 CONSERVATORY DRAINAGE HOOKUP

- Connect and supply plastic or rubber hoses to fit condensate drain tubes at base of dome to complete drainage system of condensate;
- Lead hoses to one (1) foot above floor of pipe tunnel trenches and secure hoses in flexible supports at wall.

1U-22 SUBSTITUTE BID FOR GLASS

- If the Bidder submits a substitute bid with a material other than glass for the glazing of the Domes, the Bidder must meet the following requirements:
- Provide the Owner with a twenty (20) year bond guaranteeing the following:
- Have a minimum of 92% light transmission;
- Must be clear and colorless;
- Resist scratching and abrasives equal to glass;
- Meet the structural requirements of glass;
- Must not bow or bulge;
- Must be electro-static free.

If material is accepted by Architect upon review of samples, shop drawings and test data, this Contractor shall agree at no additional cost to the Owner, to furnish any structural framing members or sash members as determined structurally necessary by the Architect.

1U-23 FINALLY

- Cooperate with the various contractors;
- Store material where directed and in orderly manner;
- Remove any rubbish, debris, etc., (resulting from this Division of the work) from the premises;
- Keep job and premises in a neat, orderly condition at all times.

1U-24 ALTERNATE BIDS

- Submit with Base Bid;
- Stating ADDITION to or DEDUCTION from Base Bid in the spaces provided in the proposal form:

Alternate Bid No. 1U-1

- Affecting exterior finish of exterior aluminum glazing molding, flashings, closure panels;
- In place of Alcoa 215 R-1 and 215 R-5 Alumilite Finish
- Furnish:
- Verson Coating as manufactured by Phelan-Faust Paint MFG. Company, St. Louis, Mo.;
- Applied by dip method, inside and out;
- In strict conformity with manufacturer's specifications;
- Color: as selected, gray, as approved by Architect.

Alternate Bid 1U-2

- Affecting glazing of self-supporting skylight at dome apex;
- In place of 1/4" Misco wireglass or 1/4" Nuweld wireglass
- Furnish and Install:
- 1/4" thick tempered sheet glass "Marsco" by American St. Gobain Glass Co.

Alternate Bid 1U-3

- All interior aluminum dome framework, hubs, tubular rafter bars, to receive Duranodic finish as per following: Duranodic Medium finish, coating thickness - .002", min. edge radius required - 1/16";
- This finish to be applied in place of Verson coating. Quote DEDUCTION from or ADDITION to Base Bid for this application.

1U-25 BASE BID

Submit figure on complete skylight work for Dome A only;

- Include the following unit prices in this Bid:

1U-25 BASE BID Continued

(A) Cost of glass set in place for Dome A.

(B) Cost of framework, hubs, etc., in place.

(C) Cost of erection device, or scaffolding, in place.

(D) Extra unit cost for each part of aluminum assembly, Neoprene gaskets and lites of glass in units of one (1) dozen.

1U-26 SEPARATE BID NO. 1
Submit figure on complete skylight work for Dome A plus Dome B.

1U-27 SEPARATE BID NO. 2
Submit figure on complete skylight work for Dome A plus Dome B plus Dome C.

1U-28 QUALIFICATION OF SUB-CONTRACT BIDDER (if a substitution is made for Super Sky framing system as shown on drawings; the following requirements will be mandatory prior to submitting a bid for this division of the work;

(1) Bidder must be a qualified contractor having at least ten (10) years experience in skylight construction work;

(2) The Bidder of a substitute must submit to the office of Donald L. Grieb, Architect, at least six (6) days before closing of bids,

(a) Two (2) sets of shop drawings showing framing system, glass and glazing, etc.;

(b) Full sized assembly of framing members;

(c) A letter showing skylight construction and qualifying experience information.

(d) If necessary, the Bidder shall employ the services of a reputable structural engineer registered in the State of Wisconsin, to check all details of his dome skylight framing to show compliance with specifications and local codes in accord with the Architect's requests.

* * * * *

DIVISION "D"

PRECAST CONCRETE UNITS FOR DOMES

1D-1 GENERAL SCOPE

(A) Work Included
Without intending to limit or restrict the volume of work required by this section of the specifications and solely for the convenience of the Contractor, the work comprises the following:
- Precast units for domes;
- Grouting of pre-cast units;
- Scaffolding;
- Erection of precast units;
- Welding;
- Survey of "in place" work;

(B) Work Not Included
- Floor slabs;
- Concrete stairs;
- Driveways and walks;
- Precast aggregate surface concrete;
- Damp proofing of precast units.

1D-2 EXPERIENCE
- The precast concrete work shall be performed by an organization that has successfully executed installations of a similar nature or complexity;
- Evidence to this effect must be submitted to the Architect with the bid.

1D-3 DESIGN
- Erection and reinforcing details other than shown on the plans must be submitted to the Architect and/or the Engineer for study and approval;
- "Tentative Recommendations for Thin-Section Reinforced Precast Concrete Construction" ACI Committee 324 shall become a part of these specifications and are in full force as if written herein.

1D-4 GROUND CONTROL
- The General Contractor will furnish a permanent bench mark in the center of each dome as specified under Concrete Work Branch No. 1 Division (B);
- This Contractor to have full use of these references and is expected to assist in their protection and provide access to all users;
- If additional ground controls are required in the erection of the Precast domes, they will be provided by this contractor.

1D-5 SHOP DRAWINGS

- The plans show all the necessary controls to establish the exact dimensions of all units and their locations in the dome;
- Five (5) sets of shop drawings shall be submitted showing all dimensions for casting as well as all horizontal and vertical controls for erection;
- These drawings must be checked and approved before manufacturing is begun;
- The contractor shall decide for himself what tolerances are required in the manufacturing of the units to provide for erection and shrinkage of concrete and these shall be noted on the shop drawings.

1D-6 CONCRETE MATERIALS

(A) Aggregate: Natural sand and crushed stone or gravel. Maximum size of the aggregate shall be 3/4".

(B) Cement:
- Portland cement types I or III may be used with accelerated curing;
- Same brand shall be used thru any one dome.

(C) Admixtures:
- Manufacturer shall be responsible for any admixture he adds to precast units;
- The following admixtures are prohibited;
- Air-entrained agents; calcium chloride;
- Manufacturer must receive permission from Architect before placing any admixtures in any concrete.

(D) Quality of Concrete
- All units shall be manufactured with concrete capable of obtaining a minimum strength of 5000 psi in twenty-eight (28) days;
- Manufacturer shall be responsible for the design of the concrete.

(E) Inspection of Tests

Standards
Abbreviation ASTM in connection with number of a specification refers to standard or tentative specification of American Society for Testing Materials designated by that number, including all amendments or revisions in effect on date contract is awarded.

Testing Laboratory
Retain and pay for services of an approved testing laboratory whose Inspection Engineers will be required to:
1. Take samples;
2. Mold, cure and break standard test cylinders.

1D-6 CONCRETE MATERIALS (E) Inspection of Tests Cont'd

3. Make tests of materials in accordance with the specifications and applicable standard tests of ASTM;
4. Act under Architect's instructions;
5. Make and submit in triplicate (or more as directed) to Architect reports showing results of inspections and tests.

Cement

For each carload or part thereof make complete physical tests.

Organization

Organize work to allow ample time for sampling and testing eliminating the possibility of incorporated untested materials.

At the Contractor's expense an approved laboratory shall be employed to mold and make the tests. Test cylinders shall be made and proportioned by number for each of the following conditions: Each days pour, each class of concrete and each change of supplier or source of materials.

1D-7 FORMS

(A) Material

- Molds shall be made of steel, plastic, concrete or other suitable material that will produce a smooth surface without any leakage.
- Furnish and install in forms the steel plate as shown and detailed on sheet A-5, detail marked Typical Hub Assembly;
- Plates upon erection covered with a water-resistive adhesive type tape;
- For sizes and shapes of various precast units, see sheet S-11.

(B) Reinforcing

- ASTM A-305-43T for deformation control;
- ASTM A-15-54T for quality control;
- See structural drawings for bar sizes;
- All reinforcement to be entirely free from rust, scale, grease or other coatings which might prevent proper bond;
- Placing:
- Accurately, as shown on detailed drawings and rigidly secured against displacement during construction operations.

(C) Ownership

- In the event one or more domes are left out of any contract, the forms shall become the property of the Owner and shall be delivered to a point of storage selected by Owner;

1D-7 FORMS (C) Ownership Cont'd

- In the event concrete forms are used, the pattern used in such form making shall be of such a design that they can be saved and turned over to the Owner.

1D-8 ERECTION

(A) Responsibility
- This Contractor shall assume all responsibility for the safety and protection of the building property and workmen during the erection of the precast units and shall cooperate with other trades in letting them use the scaffolding.

(B) Procedure
- A complete plan showing erection procedures, material and methods of control shall be submitted to the Architect and/or Engineer for approval to proceed; This must be done before erection shall begin;
- Any such approval to proceed will not release the Contractor of his responsibility.

(C) Tolerances
In order that other trades also may plan their work and have it fit the assembled dome, this Contractor must plan to have his finished assembly to be within one (1) inch plus or minus of the plan dimension at all points on the dome.

1D-9 WELDING

(A) Material
- Arc welding electrodes shall conform to the "Specifications for Iron and Steel Arc Welding Electrodes" of the American Welding Society;
- Electrodes shall be suitable for the position and other conditions of intended use.

(B) Workmanship
- All operators performing any part of the welding of reinforcing bars on this job shall exhibit proper papers to the effect that they are licensed operators within the State in which he resides. Such licensee shall have been given his papers, after having passed his procedure qualifications outlined by the "American Welding Society" covering the type of work to be performed, and witnessed and tested by an independent testing laboratory. The test shall have taken place within a years time of the beginning of the work.

1D-9 WELDING Continued

(C) Responsibility
This Contractor shall be responsible for the quality of all welding, however, if in the opinion of the Architect and/or Engineer, there is reason to believe that any operator is performing subquality work he may be asked to have the operator suspended and order his work tested.

1D-10 GROUTING

(A) Material
Grouting material shall be of the same sand and cement proportion as used in the precast units with sufficient water to make the mortar workable.

(B) Work
- All assembly connections and joints shall be grouted and smoothed before the completed assembly is allowed to carry its own weight as a complete unit;
- Work in close harmony with other trades informing them of erection schedules.

(C) Grouting
All grouting of joints, etc., shall be applied after coating with an epoxy bonding agent for concrete such as Truscon Epoxy Bonding Compound, or Sta-Crete by Sta-Crete, Inc., 115 New Montgomery Street, San Francisco.

1D-11 SURVEY: AS-BUILT DRAWINGS

(A) Contractor erecting precast concrete units for domes to furnish a coordinate system of points showing the relationship of inplace precast concrete members and their relation to the outside curve surfaces of each dome; This survey, as per this Division, is to be used by the Owner and Architect for further bid data (Third Stage) and to assure that proper uniformity of Structure is maintained in the erection of the units.

(B) Furnish six (6) copies to the Owner and Architect.

(C) Survey is to locate all dimensions of segments of precast concrete members and all center points of hubs (where steel plates are set for fastening glazing-dome hubs.)

1D-12 FINALLY

- Cooperate with the various contractors;
- Store materials where directed and in orderly manner;
- Remove any rubbish, debris, etc., (resulting from this division of the work) from the premises;
- Keep job and premises in a neat, orderly condition at all times.

1D-13 BASE BID

To include all labor, material, equipment, etc. required to:

- Complete all work under this Division as shown on the drawings and heretofore specified for the erection of Dome "C".

* * * * *

APPENDIX E

DRAWING LIST

MITCHELL PARK HORTICULTURAL CONSERVATORY
LIST OF EXISTING DRAWINGS
November 30, 1993

Documented by Graef, Anhalt, Schloemer & Associates Inc.

These drawings are pertinent to the structural investigation. There are other architectural and structural drawings for the conservatory available through Milwaukee County.

I. Partial set of Architectural Drawings (not marked "As Built") consisting of:

DRAWING NUMBER	DESCRIPTION
A	Index Sheet
A 1 -	Site Plan
A 3 -	Building Sections
A 4 -	Orientation Diagram, Framing Diagrams of 1/5 sector of Dome C.
A 5 -	Orientation Diagram of Dome Framing, Base Details of Louvers and Exhaust Fan.
A II 5 -	Proposed Typical Glazing Details and Hub (not actual), Lightning Wire Holder Detail.
A 7 -	Lobby Floor Plan.
A 19 -	Roof Plan.
A IV 21 -	Proposed Glazing Details and Hub, Steel Imbeds in Concrete.
A 22 -	Glazing Details, Lightning Protection Details.
A IV 22 -	Hatchway and Exhaust Vent Details.
A 23 -	"Roof Plan" and Typical Elevation with Locations of Vents, Lightning Protection, etc., Drainage Diagram.
A 24 -	Top of Dome Ventilation Details.
A 25 -	Fan Panel, Apex Lightning Road and Conduit.
A VII 27 -	Dome Ceiling Plan.

II. Partial Set of Structural Drawings consisting of:

DRAWING NUMBER	DESCRIPTION
S 1 -	Foundation Plan of Transition House, Partial Plans of Domes A and C.
S 2 -	Lobby Foundation Plan.
S 3 -	Foundation Plan Domes A and B.
S 4 -	Foundation Plan Dome C, Wall Sections.
S 6 -	First Floor Framing Plan - Lobby Area (1-15-59).
S 6 -	First Floor Framing Plan - Lobby Area (1-15-59) and Stair Sections (6-15-62).
S 10 -	Partial Framing Plan of Domes A, B, and C.
S 11 -	Typical Precast Units 1 to 11 Inclusive for Dome Assembly.
S 12 -	Details of Entrance at Working Lines 5 and 7, Sections.
S 13 -	Details of Entrance at Working Line 15, Section.
S 14 -	Details of Entrance at Working Lines 0 and 16, Sections.

GRAEF
ANHALT
SCHLOEMER
and Associates Inc.

III. Set of Super Sky Products' production drawings, including "AS BUILT" drawings, consisting of:

Milwaukee County's Record Set of Drawings.

DRAWING NUMBER		DESCRIPTION
S-3201	-	Sphere Hub Std.
S-3240-M	-	Aluminum Sphere Cover.
S-3241-M	-	Adjustable Support.
S-3242-M	-	Tamper Proof Cover Nut.
S-3243-M	-	Connecting Rod.
S-3244-M	-	Spherical Bolt.
S-3245-M	-	Compression Collar.
S-3246-M	-	Compression Nut.
S-3247-M	-	Cap End.
S-3248-M	-	Inner Gasket.
S-3249-M	-	Outer Gasket.
S-3251-M	-	Drain Stop.
S-3252-M	-	Sphere Cover Gasket.
S-3253-M	-	Neoprene Glazing Strip (w/gutter).
S-3254-M	-	Neoprene Glazing Strip (plain).
S-3255-M	-	Glazing Strip (top).
S-3259-M	-	Extended Aluminum Rafter Cap.
S-3260	-	Dome "A" Rafter Cap Schedule (Machining and Cutting Lengths).
S-3266	-	Extruded Aluminum Tabular Rafter.
S-3267	-	Dome "A" Rafter Cap Schedule (Machining and Cutting Lengths).
S-3273-M	-	Special Machine Screw.
S-3277	-	Extruded Aluminum Louver: Louver No. 1.
S-3278	-	Extruded Aluminum Louver: Louver No. 2.
S-3279	-	Extruded Aluminum Louver: Louver No. 3.
S-3280	-	Extruded Aluminum Louver: Louver No. 4.
S-3295	-	Lighting Protection System: Domes A, B, and C.
S-3297	-	Extruded Aluminum Louver: Louver No. 5.
S-3298	-	Extruded Aluminum Louver: Louver No. 6.
S-3301	-	Dome Plan View and Elevation, Dome A Section 2 to 11
S-3302	-	Dome Plan View and Elevation, Dome A Section 12 to 21
S-3303	-	Dome Plan View and Elevation, Dome A Section 22 to 31
S-3304	-	Dome Plan View and Elevation, Dome A Section 32 to 41
S-3305	-	Dome Plan View and Elevation, Dome A Section 41 to 1
S-3306	-	Dome Plan View and Elevation, Dome B Section 1 to 10
S-3307	-	Dome Plan View and Elevation, Dome B Section 11 to 20
S-3308	-	Dome Plan View and Elevation, Dome B Section 21 to 30
S-3309	-	Dome Plan View and Elevation, Dome B Section 31 to 40
S-3310	-	Dome Plan View and Elevation, Dome B Section 41 to 50
S-3311	-	Dome Plan View and Elevation, Dome C Section 2 to 11
S-3312	-	Dome Plan View and Elevation, Dome C Section 12 to 21
S-3313	-	Dome Plan View and Elevation, Dome C Section 22 to 31

DRAWING NUMBER	DESCRIPTION
S-3314	- Dome Plan View and Elevation, Dome C Section 32 to 41
S-3315	- Dome Plan View and Elevation, Dome C Section 42 to 1
S-3317	- Sphere Assembly (Sections A-A, B-B, and C-C)
S-3318	- Sphere Assembly: Top view (6 Rafters)
S-3319	- Sphere Assembly: Top view (7 Rafters)
S-3320	- Bill of Material (Glazing System)
S-3321	- Sphere Chart
S-3321	- Sphere Chart.
S-3322	- Code Drawing: 1/25 Geometric Dome Section; Sphere, Rafter, and Glass Locations.
S-3323	- Sample Unit (A46A)
S-3325	- Flashing Details for Base of Dome.
S-3337	- Apex Dome: Stage 4-A, Branch 10 General Construction: 1 of 6 (Hoist and roof access hatch locations, all 3 domes).
S-3338	- (" - framing details of above) 2 of 6.
S-3339	- (" - framing details of above) 3 of 6.
S-3340	- (" - framing details of above) 4 of 6.
S-3341	- (" - framing details of above) 5 of 6.
S-3342	- (" - framing details of above) 6 of 6.
S-3345	- I-Beam Hanger Frame Dimensions.
S-3352	- Section Thru Area (sic: Apex) Dome (Cable Car and Lift Mech.)
S-3353	- Flashing Details for Above Doors.
S-3354	- Section of Dome Showing Car Travel.
S-3356	- Base Drain Hook-up.
S-3356	- Base Drain Hookup.
S-3502	- Glass Schedule Dome "A" Unit "A" Jig.
S-3503	- Glass Schedule Dome "A" Unit "B" Jig.
S-3504	- Glass Schedule Dome "A" Unit "C" Jig.
S-3505	- Glass Schedule Dome "A" Unit "D" Jig.
S-3506	- Glass Schedule Dome "A" Unit "E" Jig.
S-3507	- Glass Schedule Dome "B" Unit "A" Jig.
S-3508	- Glass Schedule Dome "B" Unit "B" Jig.
S-3509	- Glass Schedule Dome "B" Unit "C" Jig.
S-3510	- Glass Schedule Dome "B" Unit "D" Jig.
S-3511	- Glass Schedule Dome "B" Unit "E" Jig.
S-3512	- Glass Schedule Dome "C" Unit "A" Jig.
S-3513	- Glass Schedule Dome "C" Unit "B" Jig.
S-3514	- Glass Schedule Dome "C" Unit "C" Jig.
S-3515	- Glass Schedule Dome "C" Unit "D" Jig.
S-3516	- Glass Schedule Dome "C" Unit "E" Jig.
S-3517	- Glass Schedule Dome "A" Unit "A" Intermediate.
S-3518	- Glass Schedule Dome "A" Unit "B" Intermediate.
S-3519	- Glass Schedule Dome "A" Unit "C" Intermediate.
S-3520	- Glass Schedule Dome "A" Unit "D" Intermediate.
S-3521	- Glass Schedule Dome "A" Unit "E" Intermediate.
S-3522	- Glass Schedule Dome "A" Unit "F" Intermediate.
S-3523	- Glass Schedule Dome "A" Unit "G" Intermediate.
S-3524	- Glass Schedule Dome "A" Unit "H" Intermediate.
S-3525	- Glass Schedule Dome "A" Unit "J" Intermediate.

DRAWING NUMBER	DESCRIPTION
S-3526	- Glass Schedule Dome "A" Unit "K" Intermediate.
S-3527	- Glass Schedule Dome "A" Unit "L" Intermediate.
S-3528	- Glass Schedule Dome "B" Unit "A" Intermediate.
S-3529	- Glass Schedule Dome "B" Unit "B" Intermediate.
S-3530	- Glass Schedule Dome "B" Unit "C" Intermediate.
S-3531	- Glass Schedule Dome "B" Unit "D" Intermediate.
S-3532	- Glass Schedule Dome "B" Unit "E" Intermediate.
S-3533	- Glass Schedule Dome "B" Unit "F" Intermediate.
S-3534	- Glass Schedule Dome "B" Unit "G" Intermediate.
S-3535	- Glass Schedule Dome "B" Unit "H" Intermediate.
S-3536	- Glass Schedule Dome "B" Unit "J" Intermediate.
S-3537	- Glass Schedule Dome "B" Unit "K" Intermediate.
S-3538	- Glass Schedule Dome "B" Unit "L" Intermediate.
S-3539	- Glass Schedule Dome "C" Unit "A" Intermediate.
S-3540	- Glass Schedule Dome "C" Unit "A" Intermediate.
S-3541	- Glass Schedule Dome "C" Unit "B" Intermediate.
S-3542	- Glass Schedule Dome "C" Unit "C" Intermediate.
S-3543	- Glass Schedule Dome "C" Unit "D" Intermediate.
S-3544	- Glass Schedule Dome "C" Unit "E" Intermediate.
S-3545	- Glass Schedule Dome "C" Unit "F" Intermediate.
S-3546	- Glass Schedule Dome "C" Unit "G" Intermediate.
S-3547	- Glass Schedule Dome "C" Unit "H" Intermediate.
S-3548	- Glass Schedule Dome "C" Unit "J" Intermediate.
S-3549	- Glass Schedule Dome "C" Unit "K" Intermediate.
S-3550	- Glass Schedule Dome "C" Unit "L" Intermediate.
S-3738	- Wiring Diagram: 3-Phase A.C.; Hoist, P.B. and Limit Switches.
S-4174	- Glass and Sub-Ceiling Apex Dome.
S-4175	- Index to "As Built Drawings"

APPENDIX F

TECHNICAL DATA

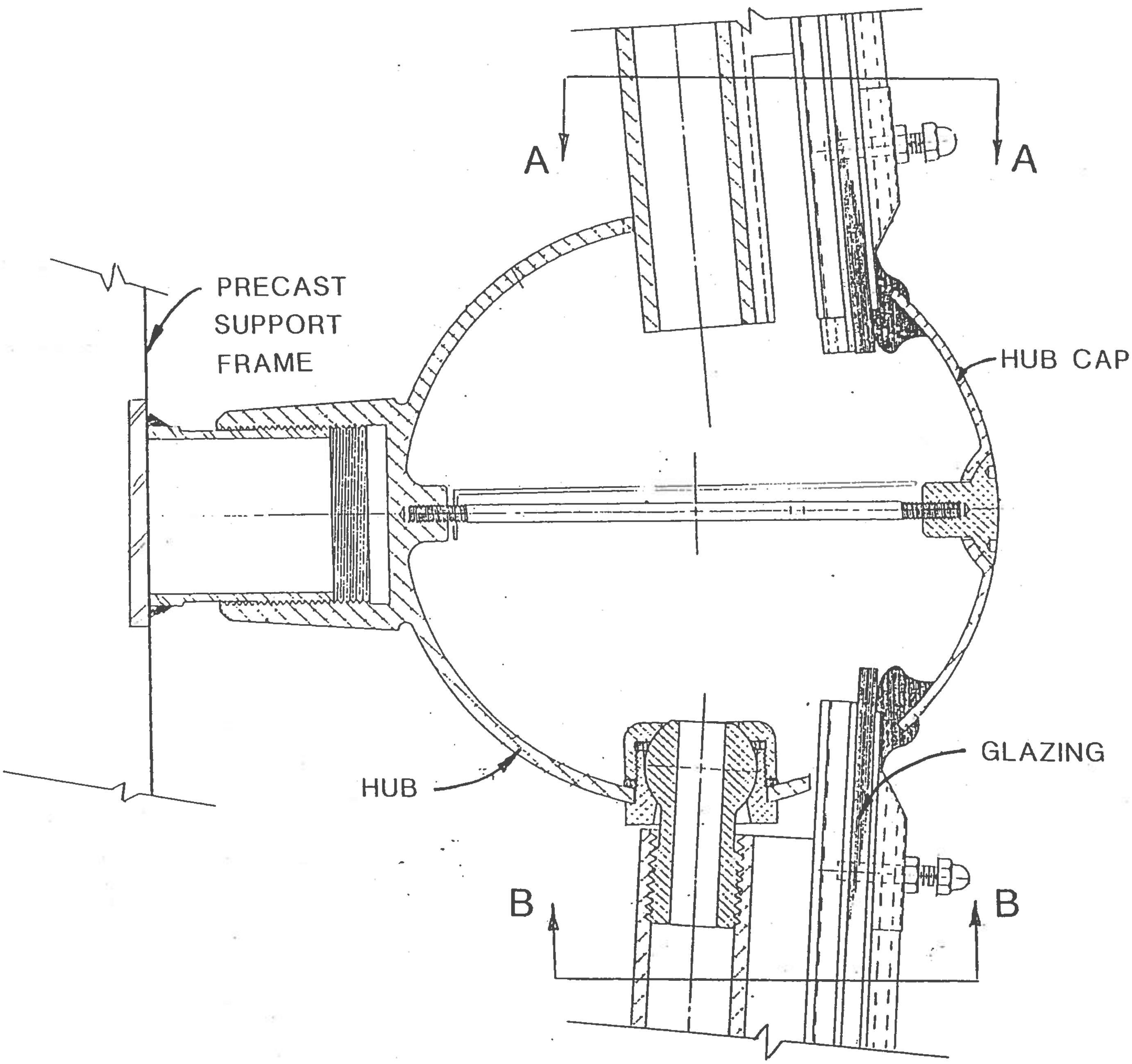
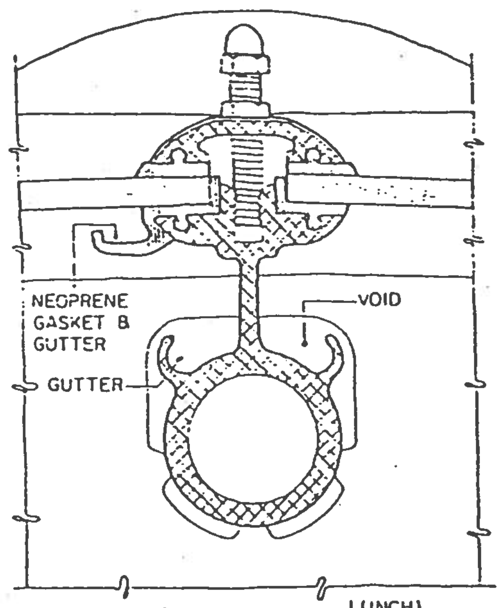
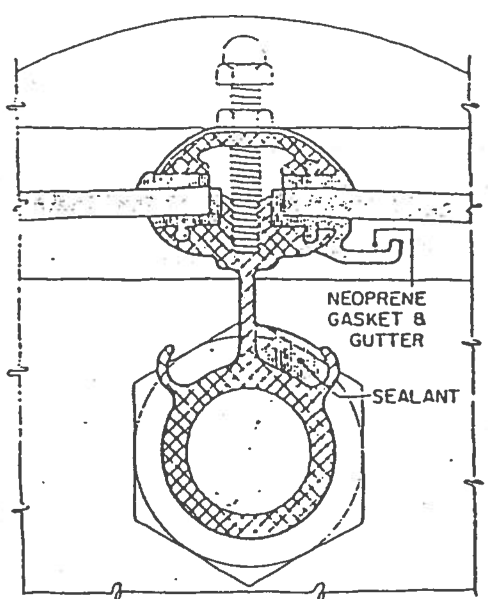


DIAGRAM NO. 1

SECTION THRU HUB ASSEMBLY



SECTION A-A



SECTION B-B

DIAGRAM NO. 2

SECTIONS THRU ALUMINUM RAFTERS

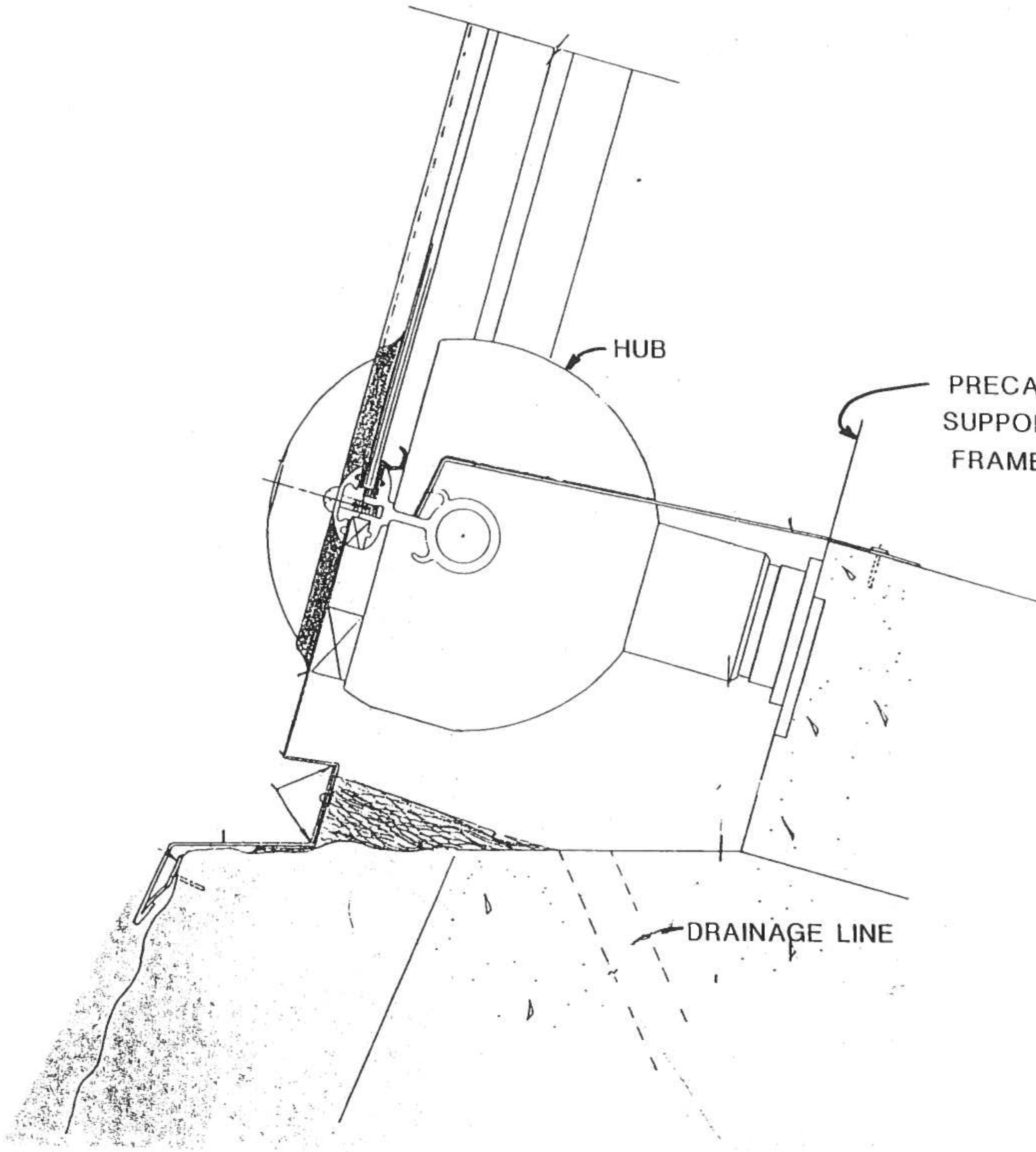


DIAGRAM NO. 3

.SECTION THRU DRAINAGE SYSTEM AT LOW POINT

SOLAR/OPTICAL AND THERMAL PERFORMANCE DATA

	1/4-inch Clear Wire (Misco)	3/16 Clear .030" Cl pvb. 3/16 Clear	3/16 Clear .060" Cl pvb 3/16 LOF Low-E #4	3/8-inch Poly-carbonate
Visible Light Transmission:	84%	85%	78%	79%
Reflectance Out:	8%	8%	12%	10%
Reflectance In:	8%	8%	11%	10%
Solar				
Transmittance:	74%	67%	56%	84%
Reflectance Out:	7%	6%	8%	11%
Winter Nighttime U-Value:	1.08	1.04	0.72	0.88
Summer Daytime U-Value:	1.03	1.01	0.67	0.83
Shading Coefficient:	0.92	0.86	0.72	1.02
Relative Heat Gain:	198	186	153	210

VIRACON

"The Leader in Glass Fabrication"™

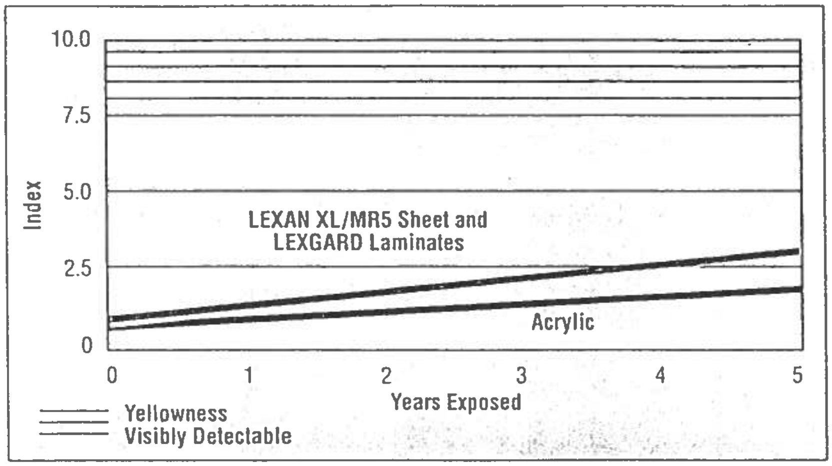
VIRACON
800 PARK DRIVE
P.O. BOX 248
OWATONNA, MN 55060
507-451-0666

Transmittance by Wavelength

Wavelength	3/16" Clear .030" Cl pvb. 3/16" Clear	3/16" Clear .030" Cl pvb. 3/16" LOF Low-E#4	Wavelength	3/16" Clear .030" Cl pvb. 3/16" Clear	3/16" Clear .030" Cl pvb. 3/16" LOF Low-E#4
300 nm	0%	0%	1400 nm	60%	43%
350 nm	0%	0%	1450 nm	58%	40%
400 nm	75%	87%	1500 nm	65%	43%
450 nm	84%	74%	1550 nm	68%	42%
500 nm	87%	79%	1600 nm	70%	41%
550 nm	86%	79%	1650 nm	71%	39%
600 nm	84%	76%	1700 nm	45%	23%
650 nm	80%	71%	1750 nm	45%	22%
700 nm	75%	66%	1800 nm	57%	27%
750 nm	69%	61%	1850 nm	60%	27%
800 nm	65%	56%	1900 nm	58%	24%
850 nm	61%	52%	1950 nm	68%	23%
900 nm	60%	50%	2000 nm	60%	22%
950 nm	60%	48%	2050 nm	49%	17%
1000 nm	58%	47%	2100 nm	49%	16%
1050 nm	58%	46%	2150 nm	52%	16%
1100 nm	58%	45%	2200 nm	50%	14%
1150 nm	57%	45%	2250 nm	32%	9%
1200 nm	54%	41%	2300 nm	2%	1%
1250 nm	58%	45%	2350 nm	7%	2%
1300 nm	61%	46%	2400 nm	9%	2%
1350 nm	62%	46%	2450 nm	5%	1%

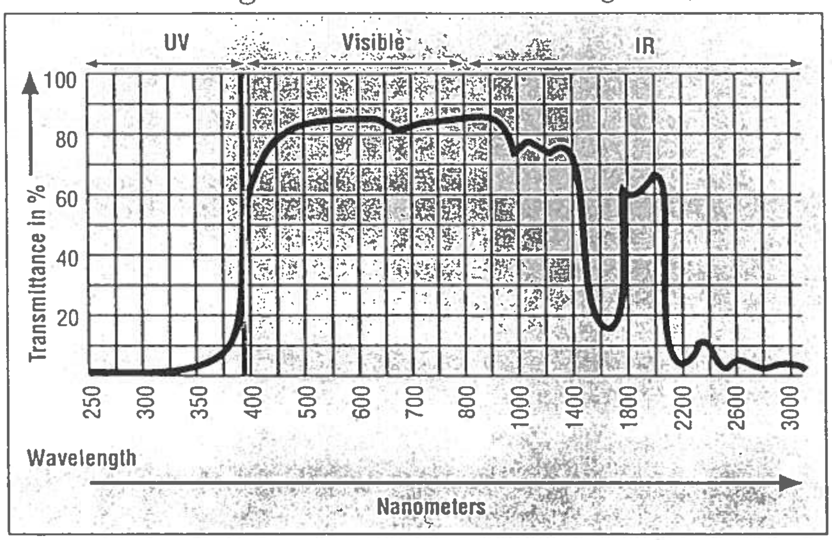
LIGHT TRANSMISSION DATA
FOR VIRACON LAMINATED GLAZING

Yellowness Index* (LEXAN XL/MR5 Sheet)



*Values shown are average ranges from groups of individual samples exposed concurrently at 45 degrees, south facing. All values are from original unweathered samples and do not represent absolute haze, yellowness or light transmission. Yellowness Index determined per ASTM D 1925 using a Gardner colorimeter.

Ultraviolet Light Transmission* (Figure 3)



*All grades of LEXAN sheet are essentially opaque at all wavelengths below 385 nanometers, making LEXAN sheet excellent for protecting art objects, display merchandise and fabrics from damaging effects of UV light.

YELLOWNESS AND LIGHT TRANSMISSION DATA
FOR LEXAN (A POLYCARBONATE PRODUCT)

APPENDIX G

CONVERSATION NOTES

CONVERSATION NOTES

INDIVIDUALS: W.R. Prokopowicz
Kenneth E. Grebe--Graef, Anhalt, Schloemer & Associates Inc.

DATE: January 26, 1994

RE: Mitchell Park Domes

Mr. Prokopowicz worked as supervising architect for Donald L. Grieb Associates, Architects during design and construction of the Mitchell Park Domes.

Comments and recollections of W.R. Prokopowicz:

GLAZING

- Various glazing types were considered during design.
- Plastic materials were considered because of good breakage characteristics. Plastic materials were not chosen because it was a relatively new material with unproven history, it is subject to large thermal movements and there were concerns about the effects of pollutants from adjacent industries.
- Insulated glass was not deemed cost effective since energy was inexpensive.
- Glass with stainless steel wire was used so that broken glass would not fall out of the frames and would not need replacement if not leaking.
- Some glazing was installed on the aluminum frame on the ground before being lifted into place. Other glazing was installed in place using a working platform. Movement around the precast frame was often accomplished by climbing on the precast frame without being tied off.
- Cleaning glazing from the inside was not considered to be necessary.
- Cleaning glazing from outside and glass replacement was to be accomplished using a cart designed for that purpose.
- The cart ride was very bouncy due to the irregular surface of the outside of the Domes. Riders of the cart did not feel safe. Glass breakage was not a problem.
- If laminated glass without wire pattern were used as the replacement glazing, it may not be noticed by the general public, but it would probably be noticed by architects.

PAINT

- Not painting the precast frame was considered when Domes were being designed. It was considered that future painting would be difficult if the precast frame were painted.

- A Primer, plus two coats of epoxy were used to paint the precast framing. Epoxy paints were a relatively new product at the time.

- There was some difficulty in getting paint manufacturers interested in this project. They saw it as difficult, high profile, and risky work. The paint manufacturers were fearful that if the paint did not perform properly there would be plenty of unwanted costs and bad publicity.

DRAINAGE SYSTEM

- It was anticipated that the internal drainage system may need cleaning in the future.

- The system can be flushed by connecting a hose to the frame at the top of the Dome.

- The hubs were designed to be accessed from the outside via the removeable hub covers. This would allow the hub to be cleaned out.

MISCELLANEOUS

- The structural calculations were submitted to the city with the plans for approval. It is his understanding that the City did not review the calculations.

- The mechanical system was altered greatly in the field from the original design.

- The outlets on the precast frame located approximately one-half the height of the Domes were installed to provide power for illumination. These outlets were connected to a timer.

- No structure should be built in front of the Dome entrance. This would likely adversely affect the architecture of the Domes.

- He has numerous photographs and slides of construction of the Domes.

CONVERSATION NOTES

INDIVIDUALS: Donald L. Grieb
Kenneth E. Grebe--Graef, Anhalt, Schloemer & Associates Inc.

DATE: January 27, 1994

RE: Mitchell Park Domes

Mr. Grieb worked as chief architect for Donald L. Grieb Associates, Architects during design and construction of the Mitchell Park Domes.

Comments and recollections of Donald L. Grieb:

GLAZING

- Some glazing was installed on the aluminum frame on the ground before being lifted into place. Other glazing was installed using a working platform attached at the hubs.
- A cart was provided for cleaning and replacing glazing. The cart functioned adequately.

DRAINAGE SYSTEM

- It was anticipated that the internal drainage system may need cleaning in the future.
- The system can be flushed out by connecting a hose to the frame at the top of the dome.

MISCELLANEOUS

- The structural design of the domes was a challenge. An engineer working under Charles Whitney wrote a thesis on the design of the domes.
- He may have copies of the structural calculations for the domes.
- The outlets on the precast frame located approximately one-half the height of the domes might have been used for construction or may be part of the lightning protection system.
- He has numerous photographs of construction of the domes.

KEG:pkf

October 11, 2007

FILE: 07-128
REF.:
REF.:

Graef, Anhalt, Schloemer & Associates, Inc.
125 South 84th Street
Suite 401
Milwaukee WI 53214

Project: Mitchell Domes Spall Repair and Paint
(P040-06421)

SUBJECT: DCREASE IN CONSULTANT'S FEE

☒ Actual Cost Not-To-Exceed Fee

Agency: <u>**120**</u> **Org. Code:** <u>**1400**</u> **Object:** <u>**6146**</u> **Project Code:** **WP040011**

FEE DECREASE NO. 1

We have reviewed your correspondence, concerning reduced work for the above project.

The following is approved as listed:

1. Additional Services .... ($168,920.00)

Your total fee will be as follows:

a. Original Design Fee $308,920.00
b. Fee Increase Amount .... <u>($168,920.00)</u>

REVISED TOTAL $140,000.00

If you have any questions regarding the above fees, please contact Walter Wilson at 278-4854.

Department of Transportation and Public Works

SB:

cc: W.Wilson
R. Tracy J. Morice File
S. Bennett G.High K. Angeli F. Renner