EXTERIOR REDWOOD PRESERVATION AT SCOTTY'S CASTLE DEATH VALLEY NATIONAL PARK

PILOT TREATMENT of SELECT REDWOOD ELEMENTS

Prepared for

National Park Service

by

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EXECUTIVE SUMMARY

The Death Valley Ranch, located in Death Valley National Park, was built by Chicago millionaire Albert Mussey Johnson in the 1920s. The building complex, more popularly known as Scotty's Castle, includes nine extant historic buildings. Most of the wooden architectural features on the building exteriors are made of redwood and date from the time of original construction. The redwood woodwork, most of which was originally coated with a transparent finish, in many instances reflects a high level of craftsmanship and is a character-defining feature of the buildings in the National Register district.

More than 80 years of exposure to the harsh desert environment has taken its toll on the exterior woodwork, and the Park in cooperation with the School of Engineering at the University of Vermont has been investigating transparent treatments that will offer some protection from weathering associated primarily with ultraviolet exposure. To achieve this goal, the University of Vermont and Park staff participated in a conditions survey and assessment of exterior redwood elements on each of the nine buildings. Based on the conditions encountered in the field, the University conducted a review of current literature on photo-degradation and photo-protection of wood. The results were used to develop a testing program for evaluation of potential treatments / finishes that included accelerated and natural weathering tests. Results of the investigation are summarized in *Exterior Redwood Preservation at Scotty's Castle (*revised 2/2010).

Following the comprehensive conditions survey and assessment of redwood elements at Scotty's Castle in 2007, and testing of potential treatments and finishes conducted 2008-2010, the University of Vermont and the park conducted a pilot treatment program of select architectural elements *in situ* between April 18 and May 1, 2010. During this time, Park staff joined UVM staff and interns for a two-day hands-on workshop on preparation methods, finishes composition, and application procedures.

The goals for *in situ* treatment testing were to determine how new finishes interact with existing finishes, what sorts of surface preparation are necessary for applying new finishes, and what impacts new finishes have on the visual appearance of historic woodwork. Specifically, treatment testing addressed cleaning, surface preparation, the consolidation of friable wood and flaking or peeling finishes, selective removal of existing finishes, and the application of new finishes. The materials and techniques developed in treatment testing were used in the pilot treatment of an area in the complex for full-scale evaluation of treatment impact and performance.

Elements chosen for the pilot treatment were the east and west gates of the Stables, along with four shutters from the Hacienda. In addition, in work not related to the UV treatment, a failing door on the Annex was removed, disassembled, repaired and reinstalled. Element numbers given in this report are taken from the original conditions assessment and survey keys found in *Exterior Redwood Preservation at Scotty's Castle.* The following report discusses the door repair and the treatment program in detail, describes the preparation processes for each element, and gives the composition and mix directions for each of the treatments employed.

Partly because of the proliferation of unpainted wooden decks on contemporary homes, paint and varnish chemists are currently focused on development of clear and semi-transparent finishes for exterior wood that offer protection from the effects of ultraviolet light. Many of them make use of some form of UV absorber, an additive that converts harmful ultraviolet light to caloric energy.

The candidate treatments tested in this study are based primarily on clear synthetic resins, most of

them thermoplastic, that can be used to formulate surface consolidants as well as film-forming finishes, that are soluble in a variety of solvents, and that provide protection against photo-degradation of the substrate by incorporating ultraviolet absorbers and/or other light stabilizers. Candidate resins and finishes for testing were selected on the basis of several criteria:

1. Candidate resins should support the formulation of wood consolidants, film-forming coatings, and perhaps consolidants for failing historic finishes. Because of the broad range of conditions of the woodwork on the buildings, it is important that candidate resins demonstrate good performance in more than one role. Where wood surfaces have been badly damaged by the sun, resins can be applied in low-viscosity mixtures to consolidate and improve the mechanical properties of the degraded surfaces. The best candidates will have moderate to good penetration of the substrate, even distribution of the resin, with some filling of cell lumens in the consolidated area. Resin solvents should not dissolve historic finishes, and solvent selection should minimize reverse migration of the resin to the substrate surface on evaporation. Where building detailing provides some protection of the surface from UV exposure, candidate finishes will be used as film-forming coatings to repair historic finishes. In places where historic finishes survive but are not well attached, there are advantages to using the same resin to consolidate detached finish coatings as well.

2. Synthetic resins are preferred over natural resins and, of these, thermoplastic resins are preferred over thermosetting resins. While natural consolidants (waxes, glues, drying oils, and natural resins) have a long history of use, penetration and surface improvement is typically limited, and the consolidants are prone to pronounced embrittlement over time. Of the synthetic resins, thermosetting resins (like epoxies and cross-linking polyurethanes) are not typically reversible; thermoplastic resins soften when heated and remain soluble (to varying extents) in solvents, and many resist photo-oxidation.

3. Candidate resins should demonstrate good photo-stability, and formulations based on them should provide UV protection to the substrate. The failure of clear coatings on UV-exposed wood typically involves the embrittlement of the coating *and* the weathering of the substrate surface through the coating, leading to detachment. Successful treatment, therefore, will require consolidants and coatings that are resistant to UV degradation and which also provide some photo-stability to the wood surface, typically by incorporating UV light stabilizers and HALS of some sort.[1]

4. Candidate consolidants and finishes should have minimal impact on substrate appearance. It is doubtful that the Park will elect to restore all of the weathered wood in the Scotty's Castle complex to a condition resembling its original appearance. Finish repairs on protected wood, where substantial portions of original or early finishes survive, may seek to replicate the appearance of original finishes to some extent. For more severely weathered wood it is likely that the Park will implement maintenance procedures designed to preserve

[1] The performance of UV absorbers is sometimes enhanced by the addition of Hindered Amine Light Stabilizers (HALS), which are radical scavengers that combine with oxygen to form stable nitroxyl radicals when exposed to light. These "trap" free radicals formed by photo-degradation of binders and lignin. Photo-oxidation produces stable nitroxyl radicals that trap carbon-centered radicals from resin degradation. Additional reactions with side chains from the binder result in re-release of nitroxyl radicals so that each is able to neutralize several hundred radicals. This has the dual effect of preventing photolytic decomposition of binder and substrate, helping to prevent discoloration of coating and substrate, erosion of the wood surface, and embrittlement of the coating. This topic is treated in more detail in *Exterior Redwood Preservation at Scotty's Castle.*

the wood in its current condition. Therefore, candidate consolidants and finishes will have minimal impacts on gloss and color, and should not obscure the grain and other surface characteristics under heavy or partially opaque films. Given the bleached condition of most of the weathered wood, some darkening with application of a treatment may be acceptable.

5. Candidate consolidants and finishes should be reversible to some extent, or at least allow for retreatment. The treatments will have a limited service life, so it is important to be able to remove them, or re-treat without damaging the wood or surviving historic finishes.

Of the formulations selected for treatment testing and pilot treatment, two were mixed by combining a polyvinyl butyral resin (Butvar B-98) with commercially available light stabilizers. The third was prepared from a proprietary varnish (General Finishes 450), based on an acrylic polymer soluble in water, and containing a proprietary UVLA. These resin-UVLA mixtures were among the high performers in the weathering tests conducted by UVM, and are soluble in solvents that do not dissolve the historic finishes encountered in the pilot treatment area. Of these, conservators preferred the consolidants based on B-98 for the natural appearance and what was considered to be superior penetration and surface improvement of the treated wood.

PILOT TREATMENT

Shutters, Hacienda

Element Number(s)

010E1SH001 / 010E1SH002 / 010N1SH001 / 010E1SH003

Description

Three-board shutters with horizontal battens bolted together with carriage bolts and square-headed nuts. Boards are 4/4 thick, random width (ranging from 6-10 inches); rails are nominally 8- and 6-inches wide. Boards are gapped and appear to have had wooden spacers at the rails, though not all of them survive. Board faces have been gouged and charred to give a rustic texture and appearance. Strap hinges and catches are hand-wrought iron.

General Condition

The weather-exposed surfaces (with shutters in the open position) have been badly damaged. Finishes, where they survive, are characterized by loss of sheen, yellowing, crazing, and detachment, and the wood substrate is characterized by bleaching, iron- and water-staining, surface erosion, checking (in general, checks pass through the entire thickness of the affected members and so are visible on both surfaces), and mechanical losses. The level of erosion in most cases is particularly severe, with preferential erosion of early wood by UV exposure and wind-borne grit leaving a distinctive 'washboard' surface. The protected surfaces are generally in fair to good condition, with tooling and charring of the surfaces still visible, mild erosion concentrated at the ends of members, and the color brighter and more saturated than on the bleached exterior. There are dark iron stains around hardware and fasteners, as on the weather-exposed surfaces. Mildew growth is evident where boards and battens intersect, and on the interior face of 010N1SH001.

Gates, Stables

Element Number(s)

110W1GA001 / 110W1GA002 / 110E1GA001 / 110E1GA002 / 110E1GA003 / 110E1GA004

Description

Vertical boards are of random width and graduated lengths (roughly 6-8 inches and 7-9 feet respectively), held together primarily by decorative, iron strap hinges wrought into scrolled sections and depicting a variety of animal forms. Boards are gapped and spacer blocks are mortised into the sides. Board faces are gouged and charred to give a rustic texture and appearance. Hinges are attached with carriage bolts and square-headed nuts.

110W1GA001 & 110W1GA002, view NE.

110E1GA001, 110E1GA002, 110E1GA003, & 110E1GA004, view W.

General condition

The west gates are significantly weathered on all faces, though surfaces that face south in the opened position are more severely deteriorated. Finishes, where they survive, are characterized by loss of sheen, yellowing, crazing, and detachment, and the wood substrate is characterized by bleaching, iron- and water-staining, surface erosion, checking, and mechanical losses. The level of erosion in most cases is particularly severe, with preferential erosion of early wood by UV exposure and wind-borne grit leaving a distinctive 'washboard' surface. Tops of vertical elements show significant erosion and deep checking. There are traces of red paint that survive in deep asperities on these top surfaces, suggesting a protective paint layer was applied at some time in the past to slow further loss (the park might consider reinstating this opaque coating on just these surfaces). It is not known whether this is an historic treatment.

The east gates, which are sheltered on the west by the interior courtyard roof and are rarely opened, retain their historic finish and color on the west (courtyard side) face. The east face, which

is exposed to the weather, shows similar deterioration of substrate and finish as is found on the west gates, though in general conditions are not as severe. Two of the vertical elements show evidence of an earlier termite attack, a condition that is relatively rare at Scotty's Castle. There is evidence of a protective paint layer on the ends of vertical elements; the brown color matches paint used elsewhere on the site and suggests a relatively recent application date.

Treatment Procedures

Dry Cleaning

Rationale: To remove loose varnish and debris

Process: Use a coarse nylon bristle brush in the direction of the grain.

Acetone Spray

Rationale: To remove loose varnish that did not come off readily with a brush

Process: Spray the acetone through an airbrush (a sprayer or spray bottle may also be used), allow to dry, and then dry brush away the varnish. This can be done multiple times until no more can be removed.

Acetone Solvent Gel[2]

Rationale: Gel provides a means for increasing the dwell time of the acetone on the surface. Also keeps the acetone at the surface rather than penetrating the wood. To remove heavy varnish that doesn't come off with the brush or acetone spray.

Process: Apply a thick layer (1/4") with a spatula or brush. Gel can be left on until the varnish easily separates from the substrate (1-2 hours) and can be repeated on damp (but not waterlogged) surfaces. The gel needs to be kept moist by misting frequently with water through a spray bottle or airbrush; alternatively, cover the wet gel with plastic wrap. Gel can be removed with a combination of running water and a sponge, depending on the size of the work area, and the sensitivity of the surrounding material to acetone and/or water. While the wood is wet from the gel it is susceptible to damage, so care must be taken not to scrape or gouge the surface. Collect the runoff.

Gel cleaning cannot be done in direct sun because the gel dries too quickly. The gels need to be completely removed before refinishing before proceed to the next step.

Removal of the varnish releases wood fibers that should be brushed away before consolidation. Brushing is done when completely dry and with a nylon-bristle brush in the direction of the grain. Brushing while the wood is wet will result in damage.

[2] See mixes on page 8 for proportions.

Wet Cleaning

Rationale: to remove loose embedded dirt, bird droppings, mildew, and other accretions

Process: Use a coarse nylon bristle brush with water in the direction of the grain. If mildew is present, do additional cleaning with a 2% Vulpex solution in H20 and rinse thoroughly.

Consolidation

Rationale: To consolidate friable wood and crazed varnishes.

Process: Make sure the surface is free of dust, debris and loose fibers (dry-brush bare wood or vacuum/sponge varnished surfaces). Cut in around the hardware using a trim brush. If B-98 gets on the metal it can be removed with ethanol. Evenly coat the wood with the consolidant, adding a heavier application to dry areas. Allow the consolidant to dry for half an hour before applying the second coat.

Consolidants Used

Two of the consolidant mixtures evaluated in accelerated and natural weathering tests were mixed in the laboratory by combining a polyvinyl butyral resin (Butvar B-98[3]) with commercially available light stabilizers (Ciba Tinuvin 292[4], 5151[5], 5236[6]). Butvar B-98 has been used as a consolidant for wooden cultural objects for decades, and a great deal of information exists on its performance, including its photo-stability and reversibility. Additionally, the resin is soluble in ethanol, a solvent that had no observable impact on historic finishes during treatment testing. One of the proprietary varnishes tested, General Finishes 450 (an acrylic polymer) is soluble in water. These resin-UVLA mixtures were among the high performers in the weathering tests conducted by UVM, and were selected for *in situ* treatment testing.

Resin-solvent concentrations were manipulated to achieve reasonable improvement of the consolidated surface while managing impacts on saturation and gloss. Weathering test results did not indicate particular advantages associated with either of the UVLA/HALS blends, each giving equally satisfactory performance. Blends and proportions were adjusted during treatment testing to determine impacts on application. The consolidant mixes used in treatment testing include:

[3] Butvar B-98 is a thermoplastic polyvinyl butyral resin that offers a unique combination of properties for coating applications. PVB is soluble in the lower alcohols for reduced toxicity in handling and use. The aging characteristics of PVB are considered good. When used as a consolidant, Butvar B-98 (and PVB in general) satisfactorily strengthens the wood while producing little change in appearance. It is also reversible and can be removed from treated wood (Unger, et al; p451, ff.).

[4] Ciba Tinuvin 292 is a HALS (hindered amine light stabilizer) developed as a coating additive and intended to be used in combination with a UV absorber. For this test, Tinuvin 292 was combined with Tinuvin 5236 (a UV absorber) in a polyvinyl butyral resin.

[5] Ciba Tinuvin 5151 is a liquid light stabilizer blend formulated for extreme environmental conditions. The blend combines a UV absorber with a HALS and is intended for use with varnishes and other low-pigment finishes.

[6] Ciba Tinuvin 5236 is a liquid UV absorber developed for substrates requiring protection from UV-A radiation. Performance in outdoor applications is enhanced by combining with a HALS. For this test, Tinuvin 5236 was combined with Tinuvin 292 (a HALS) in a polyvinyl butyral resin.

5% B-98 (g/ml) in ethanol (ETOH) w/ 10% Tinuvin 5151 by volume of B-98

3.5% B-98 (g/ml) in ethanol (ETOH) w/ 8% Tinuvin 5151 by volume of B-98

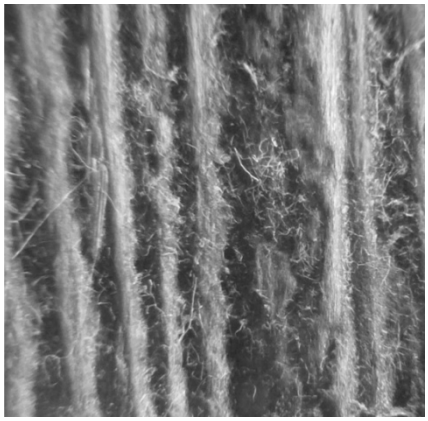
2.5% B-98 (g/ml) in ethanol (ETOH) w/ 8% Tinuvin 5151 by vol of B-98

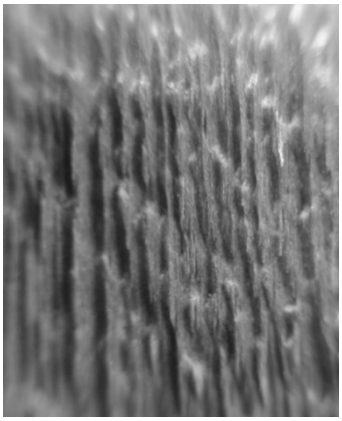
2.5% and 3.5% B-98 (g/ml) in ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (1:1) by vol of B-98

50%, 33% and 25% General Finishes Exterior 450 Satin in water (v/v)

Consolidant Impacts


Redwood prior to treatment


After drybrushing


Consolidated state


Before consolidation


After consolidation


After B-98 removal

Areas with varnish removed

Initial test areas were created on shutter 010E1SH002, on both the interior (side that faces the wall when open) and exterior (side that faces out when open). This was in order to determine consolidant appearance and surface consolidation (extent of coverage) prior to comprehensive treatment of the entire element.

5% (one coat): left a saturated appearance and looked like a film rather than a consolidant; level of consolidation was good: the loose fibers on the surface were laid down and consolidant was visible in some of the fissures; there was a consistent color between the high and low points; wood felt smooth, rather than rough in texture, to the touch. The surface was strengthened (rubbing a finger

across the grain of the untreated wood, resulted in lifted fibers whereas on the treated wood rub did not result in any breakage or splintering.

3.5% (two coats): Improvement of the surface strength similar to the 5%; less saturation of the surface and no obvious film or build up of consolidant on the surface. The disgregate surface was consolidated but there was obviously less material on the surface than the 5%. Consolidant penetrated the wood, rather than sitting on the surface, and all the fibers were laid down.

3.5% (one coat): the visual impact was most like the untreated wood, but the consolidation of the surface was incomplete (i.e. there were still loose fibers in both the high and low sections).

Test treatment areas on 010E1SH002

Areas with varnish intact
Control: without magnification, the panel retained some of its original appearance with a carved undulating surface, pronounced difference between late and early wood, as well as some blackening from a torch. When looking at the magnified surface, the coating/varnish exhibited crazing. These cracks become an avenue for water infiltration and mildew growth.

3.5%: the crazed surface of the existing finish was still visible (did not dissolve/solubilize with application of the new consolidant) but the consolidant was visible in the fissures, though it did not entirely fill them. The consolidation had virtually no visual impact.

3.5%: one coat applied and removed with ethanol—no visual impact; there was no consolidant in the fissures—removal was completed successfully: proving reversibility on an existing finish (without removing that existing finish).

Mixes

Acetone Solvent Gel

- 20g Carbopol 934
- 70 ml Ethomeem C 25
- 1000ml acetone
- 160ml water

1. Mix the Carbopol 934 and Ethomeem C 25 together quickly to completely wet the Carbopol 934 and remove lumps
2. Add the acetone and shake until thoroughly mixed
3. Add water incrementally (30 ml at a time) and shake vigorously until the desired consistency is achieved.

Consolidant: 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 8% Tinuvin 5151 by vol of B-98 (in other units this is a 13% v/v solution of B-98 in Ethanol (ETOH) w/ added UVLA/HALS)

- B-98 260ml (or 70g)
- Ethanol (ETOH) 2000ml
- Tinuvin 20.8ml

1. Add dry B-98 slowly to ethanol (ETOH) and mix thoroughly (do not let the B-98 clump)
2. Allow to sit for 30 minutes
3. Add Tinuvin and mix thoroughly.

Elements Treated

010E1SH001

Cleaned with a combination of acetone spray and multiple coats of acetone gel to completely remove existing finish.

Consolidated with:

- 3.5% B-98 (g/ml) in ethanol (ETOH) w/ 8% Tinuvin 5151 (2 coats) on both sides

(N.B. Tested at 3.5% on bare wood, which did not produce a change in wood color or gloss)

010E1SH001, exposed face, before treatment

010E1SH001, wall face, before treatment

010E1SH001, exposed face, after treatment

010E1SH001, wall face, after treatment

<u>010E1SH002</u>

Cleaned with Acetone spray (no gel)

Consolidated with:

- 2.5% B-98 (g/ml) in Ethanol (ETOH) w/ 8% Tinuvin 5151 (2 coats) on varnished wood
- 2.5% B-98 (g/ml) in Ethanol (ETOH) w/ 8% Tinuvin 5151 (3 coats) on bare wood

(N.B. Tested a 5% on bare wood, but it produced a glossy film, so 2.5% was used)

010E1SH002, exposed face, before treatment

010E1SH002, wall face, before treatment

<u>010N1SH001</u>

Cleaned with:

- combination of Acetone spray and Acetone gel along the edges; one board appeared to be saturated with a heavy red varnish (possibly linseed oil) and resisted Acetone cleaning;
- mildewed areas were additionally cleaned with 2% Vulpex solution and a soft brush

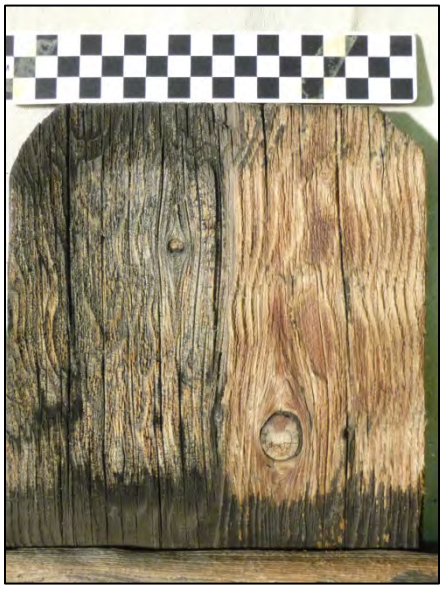
Consolidated with:

- 33% GF450 (2 coats) on two bare wood boards
- 25% GF450 (2 coats) on varnished side of boards and on both sides of the smaller, varnish saturated plank
  (N.B. bare wood tested with 50% produced a glossy film; 33% did not. A varnished section tested w/33% resulted in too high a sheen; reducing it to 25% produced better results.)

010N1SH001, exposed face, before treatment

010N1SH001, exposed face, after treatment

Application of consolidant to non-exposed surface of 010N1SH001



Mildew removal on exposed face of 010N1SH001

010N1SH001, wall face, before treatment

010E1SH003

Cleaned with a combination of Acetone spray and multiple coats of Acetone gel (varnish was red and difficult to remove)

Consolidated with:

- 2.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (2 coats) on varnished wood
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (2 coats) on bare wood and edges

010E1SH003, exposed face, before treatment

010E1SH003, exposed face, after treatment

010E1SH003, wall face, before treatment

010E1SH003, wall face, after treatment

110W1GA001

Both faces cleaned by dry brushing. West side additionally cleaned with acetone spray and multiple coats of Acetone gel. Varnish was extremely resistant in places and impossible to remove completely.

East (courtyard) face consolidated with:

- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 8% Tinuvin 5151 (1 coat) on all wood surfaces.
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (1 coat) on all wood surfaces

110W1GA001, east face before treatment

110W1GA001, east face after treatment

West face consolidated with:

- 3.5% B-98 in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (2 coats).[7]

110W1GA001, west face before treatment

110W1GA001, west face after treatment

Acetone gel removal on west face of 010W1GA001.

[7] Second coat was the final batch of consolidant made, and was created by diluting the remaining 25% B-98 into a 3.5% solution, and adding the last remaining Tinuvin 292 and 5236.

110W1GA002

Cleaned by dry brushing.

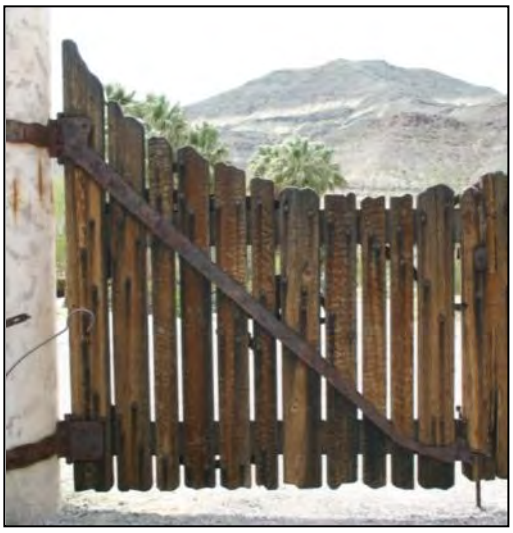
Consolidated with:

- Blend of 25% B-98 in Ethanol (ETOH) w/ 8% Tinuvin 5151 and 50% B-98 in Ethanol (ETOH) w/ 8% Tinuvin 5151 on top faces of vertical boards.[8]
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 8% Tinuvin 5151 (1 coat) followed by 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (1 coat) on all remaining wood surfaces.


110W1GA002, West face before treatment


110W1GA002, West face after treatment


110W1GA002, East face before treatment


110W1GA002, East face after treatment

[8] This was applied during the afternoon, in direct sunlight. The B-98 bubbled and dried to a thick crust with a heavy sheen. This was subsequently brushed first with ETOH then Acetone until a more appropriate appearance was achieved.

110E1GA001 (east face only)

Cleaned by dry brushing.

Consolidated with:

- 25% B-98 in Ethanol (ETOH) w/ 8% Tinuvin 5151 on top faces of all vertical boards.
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (2 coats) on all wood surfaces.

010E1GA01 before treatment

010E1GA01 after treatment

110E1GA002 (east face only)

Cleaned by dry brushing.

Consolidated with:

- 25% B-98 in Ethanol (ETOH) w/ 8% Tinuvin 5151 on top faces of all vertical boards.
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (1 coat by HVLP spray and 1 coat by brush) on all remaining wood surfaces

010E1GA02 before treatment


010E1GA02 after treatment

110E1GA003 (east face only)

Cleaned by dry brushing.

Consolidated with:

- 25% B-98 in Ethanol (ETOH) with 8% Tinuvin 5151 on top faces of all vertical boards.
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (4 light coats by HVLP spray and final, heavier coat by HVLP spray, brushed) on all remaining wood surfaces.

010E1GA03 before treatment


010E1GA03 after treatment

110E1GA004 (east face only)

Cleaned by dry brushing.

Consolidated with:

- 25% B-98 in Ethanol (ETOH) on top faces of all vertical boards.
- 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 5% Tinuvin 292 and 5236 (4 light coats by HVLP spray and final, heavier coat by HVLP spray, brushed) on all remaining wood surfaces.

010E1GA04 before treatment

010E1GA04 after treatment

Dry brushing 010E1GA01.

Applying consolidant with HVLP unit on 010E1GA03.

Door Repair

Element Number(s)

- Door, W side, 020AE1DO004.

Description

- Left hand (west) leaf in an arched door pair.
- Stock is 10-quarter redwood.
- Mortise waste was removed with auger and the ends of the mortises were chopped out by hand.
- Tenons are 7/8-inch thick and were originally haunched.
- X-munts in each of the paneled openings have stub tenons that engage the panel groove
- Hardware is one-off package consisting of rosettes (cast), wrought surface latches, bolts, pulls and hinges, all decoratively profiled. Made of iron that is rusting.
- Constructed without adhesive; hardware studs function as draw pins.
- Door has been shortened so that all the relish has been removed below the bottom rail (undermining the bottom rail tenons)
- West stile (the shorter stile) has large losses at bottom rail joinery
- Bottom rail has large area of decay, losses around hardware

020AE1DO004

Consolidated soft (incipient decay) wood at lower ends of stiles with:

- Blend of 12% B-98 in ethanol (ETOH)

Relish at right-hand (east) stile replaced with dutchman insert
Dutchman extension of left-hand (west) stile to replace decayed wood
Dutchman repair of bottom rail to replace decayed / fractured wood

02AE1DO004 before repair

Loss of relish in stiles at bottom rail location due to trimming of the door. This undermines support for bottom rail tenons.

Large loss at east stile-bottom rail connection (bottom left). Bottom rail has been removed.

Disassembly of door at arch and lock rail.

Right-hand (east) stile and bottom rail removed. Stub tenon at lower end of X-munt visible (lower right).

B-98:ethanol mix.

Dutchman extension of east stile prior to assembly. Note the 'biscuit' mortises to strengthen half-lap connections at joint shoulders. The end of the tenon in the historic stile forms the upper mortise shoulder in the repaired assembly.

The bottom rail and dutchman insert prior to glue-up.

The assembled door showing stile and rail repairs on the door interior at time of reinstallation.

The assembled door showing stile and rail repairs on the door exterior at time of reinstallation.

CONCLUSIONS

Because of the quantity of wood to be treated at the site, it was important to develop techniques that facilitate treatment on a large scale. This was accomplished within the limited context of the area and elements selected for pilot treatment. Failure of historic finishes on whole surfaces meant that whole surfaces could be treated uniformly. This is likely to be the case for many of the redwood elements in the Scotty's Castle complex that are the highest priorities for treatment. These are elements having the greatest UV exposure (typically on south- and west-facing facades), where wholesale failure of historic finishes makes for simplified surface preparation and application of consolidants.

Treatment of surfaces having varying exposure levels, however, will probably not be so simple. In many instances (typically where building geometry affords partial protection from weather), redwood elements display a range of conditions over a single surface that can include bright and intact finished surfaces in protected areas to surface losses and/or colonization by mildew in areas exposed to weather. This is characteristic of many of the most significant redwood features (e.g., doors at main entrances on primary facades featuring carved work, decorative painting, and one-of-a-kind hand-forged hardware). Treatment protocols have not been established for these elements, and it is unlikely that treatment by dry- and solvent-cleaning followed by wholesale application of a surface consolidant will be appropriate in these instances.

The National Park Service is interested in adapting the pilot treatments implemented at Scotty's Castle to other park sites, for good reason. The deterioration processes encountered at Scotty's Castle typically afflict exterior architectural woodwork in arid environments. In cases where the wood cannot be painted, finding transparent treatments that provide some degree of surface consolidation while offering some protection from UV exposure is desirable. In considering the feasibility of using the treatments described in this report in other contexts, it is important to recall the process architectural conservators followed in designing the treatments, and to evaluate the results of treatment testing to date.

At Scotty's Castle, there is a desire to preserve the surviving historic finishes wherever possible. This has required the development of cleaning and surface preparation techniques that will not damage those finishes, and the selection of consolidants that are soluble in solvents that do not dissolve the historic finishes. Conditions assessment included a finish analysis using cross-section microscopy to identify the existing coatings and provide basic guidance in developing conservation methods.

Resin selection (for consolidant and coating formulation) was based on past performance in conservation contexts, photo-stability, the range of solvents that can be used, achievable surface improvements, reversibility and the potential for retreatment, visual and aesthetic impacts, and the level of protection provided against weather.

Butvar B-98 has been used as a consolidant for wooden cultural objects for decades, and a great deal of information exists on its performance. The resin exhibits good photo-stability, and coatings formulated from it for accelerated and natural weather testing were still soluble after significant UV exposures. The resin is soluble in a range of solvents, including ethanol. In treatment testing, we

found that ethanol did not dissolve the historic finishes in our test area,[10] and ethanol has a relatively low toxicity so that consolidants and coatings can be safely handled in bulk.

B-98 has a high glass transition temperature (TG), an important consideration for use in the hot climate of Scotty's Castle. Resins with lower TG are more likely to soften and pick up grime at higher temperatures. Penetration of low-viscosity mixtures is moderate, and consolidated areas are typically satisfactorily strengthened. Viscosity can be lowered (to improve penetration) through the use of solvent blends, though once again the interaction of existing finishes with the solvent blends can only be determined through testing. Treated wood has a natural appearance, and the aging properties of B-98 are considered good.[11] All of these characteristics were considered in selecting the resin. Similarly, UVLA / HALS blends are formulated for different applications, are soluble in different solvents, mix well with different resins, and sometimes have methods of application that are specific to them.

With respect to the level of protection that polyvinyl butyral-based formulations provide against the weather, results at Scotty's Castle are still preliminary. Sample coupons treated with coatings based on B-98 weathered at slower rates than untreated control samples in both accelerated and natural weather tests. However, the accelerated weather test was of limited duration (1500 hours), and it is not at all clear how accelerated weathering rates compare to real-time rates. Sample coupons were placed in an outdoor test rack at Scotty's Castle in March 2009. The samples were evaluated in April 2010, at the time of pilot treatment. They have not been formally examined since. At this point, investigators cannot predict the service period of the treatments. Examination of the test samples and the elements subjected to pilot treatment are an important next step in evaluating the effectiveness of the treatment.

In summary, treatment at any site will require condition assessment, finish analysis, treatment testing, and pilot treatment before methods for wholesale treatment of architectural woodwork can be considered, and where treatment is to include clear finishes amended with UVLA / HALS blends for improving photo-stability, insufficient data exists for predicting periods of service and completing cost-benefit analyses.

[10] Many of the spirit varnishes used historically for the clear finishing of wood are soluble in ethanol, and in those instances the use of this solvent may be inappropriate.

[11] This topic was treated in greater detail in *Exterior Redwood Preservation at Scotty's Castle.* There the reader will find a summary of the current literature, pp.74-ff.