Daylight Dividends

Field Test Shade Control and DaySwitch: Final Report on Shade Control Project

Shade Control Device Prime Grant No. DE-FC26-02NT41497
SubFund No. A30449

Field Test Shade Control and DaySwitch
Purchase Order No. P0052476

April 2006

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EXECUTIVE SUMMARY

The goal of this project was to develop a low-cost Venetian shade control that is powered by the action of the user shutting the blind. The shade control device automatically opens the shades after a set amount of time has passed. Because people often leave their shades closed when they do not need to be closed, opening the shades automatically will allow sunlight into the space and reduce the energy needed for lighting. The shade control device is a mechanical device designed to be mounted on existing shades. We had three project objectives: 1) to develop specifications for size, configuration, actuation force, and components, and use the specifications to build shade controls; 2) evaluate the performance of the control integrated with shades in the laboratory and the field; and 3) develop manufacturing strategies and cost estimates, and identify potential business partners. We successfully completed all three of these. These tasks are ongoing, and we anticipate filing a patent application for the device.

During this project the shade control device went through many design and test cycles. We succeeded in developing a device that operated correctly and robustly during limited field testing. The device can be mounted on existing, off-the-shelf shades and installed in windows with no modifications to the manufacturer's installation system.

Two shade control devices were mounted on sets of 1" aluminum Venetian blinds and sent to Rensselaer Polytechnic Institute for installation and testing. Two other shade control devices were mounted in rooms on the campus of the University of Oregon. This report details efforts at the University of Oregon. No major issues were encountered during installation. One minor issue is that in most cases, shims had to be placed under the mounting brackets to ensure that the wand of the shade control device hung vertically.

The shade control device that was installed in 103 Pacific Hall opened the shades consistently after four hours. The average time until opening was four hours and forty-six minutes. The shortest opening time was four hours and twenty-three minutes, while the longest opening time was five hours and twenty-three minutes. The shade control device that was installed in 312A Allen Hall was less consistent. The average opening time was three hours and fifty-three minutes. The shortest opening time was two minutes, and there were three instances when the shades opened in forty-nine minutes or less. The longest opening time was five hours and six minutes.

There are several issues with the operation of the shade control device that must be resolved. When the shades open, they make a loud, sudden noise that tends to startle room occupants. The opening must be slowed down, or the sound must somehow be eliminated. A manual override would be helpful. Another useful feature would be to allow users to change the angle of the shade slats.

We estimate the energy savings potential of the shade control device to be 60% on east facing windows, 50% on west facing windows, and 17% on south facing windows, assuming photocontrolled electric lighting.

INTRODUCTION

The purpose of this report is to document issues with installation of the shade control device, determine how well the shade control device functioned within its specifications, and gauge user satisfaction with the operation of the device.

The shade control device was developed by the Energy Studies in Buildings Laboratory at the University of Oregon. It is a device that automatically opens shades after a set period of time once they have been closed. The idea behind it is that when people close their shades to block the sun and reduce glare, they often neglect to reopen the shades for long periods of time, sometimes days. If the shades are closed, it means that lights must turn on, even if there is sufficient daylight outside to light the space. Significant energy savings can result when the electric lights are photocontrolled by automatically opening the shades after the time has passed when glare is an issue.

Throughout the development process, many revisions have been made to simplify the device and optimize the components, while making it more rugged and reliable. These tasks are ongoing. We anticipate filing a patent application for the device.

Two shade control devices were installed on the University of Oregon campus. One device was tested in order to determine how the device would stand up to repeated open/close cycles, while the other was tested by a user in a private office who was supposed to operate the shade control device as conditions warranted. Data on shade operation was collected with HOBO data loggers.

Note that confidential information has been omitted from this report in order to protect our intellectual property rights.

DEVELOPMENT AND DESIGN

This is a strictly mechanical device and meant to be a simple and inexpensive modification to existing shades. The shade control device has undergone more than 100 design–manufacturing–testing cycles. In addition to simplifying the mechanism and optimizing components, installation of the device and intuitive operation have been taken into consideration in the shade control design. Maintaining a rugged and robust mechanism that provides reliable operation has been a constant aim of the shade control design. In-house testing included timing and shade operation. The development of this product is ongoing and continued improvements are currently underway.

TESTING

One shade control device was installed on the shades in 103 Pacific Hall, where the Energy Studies in Buildings Laboratory is located. The device was installed on an east facing window. The second shade control device was installed in Room 312A of Allen Hall. This is a private office with a window that also faces east.

Data was collected using a HOBO recording device. A limit switch was attached to the shaft inside the shade's head rail. An open limit switch meant that the shades were closed, and a closed limit switch meant that the shades were open. A HOBO data logger measured voltage through the switch. When the switch was open, the HOBO read .63 V. When the switch was closed, the HOBO read 2.48 V. The HOBO in 103 Pacific Hall recorded data every one minute, while the HOBO in 312A Allen Hall recorded data every two minutes. Data from the HOBO devices was downloaded and analyzed weekly.

Additionally, shade positions at various buildings around campus were visually checked during a period of about two weeks to attempt to get a sense of how often the shades were operated. The shades were not moved frequently, and when they were moved, they often remained in the same position for days. See Appendix C for the data collected.

103 Pacific Hall

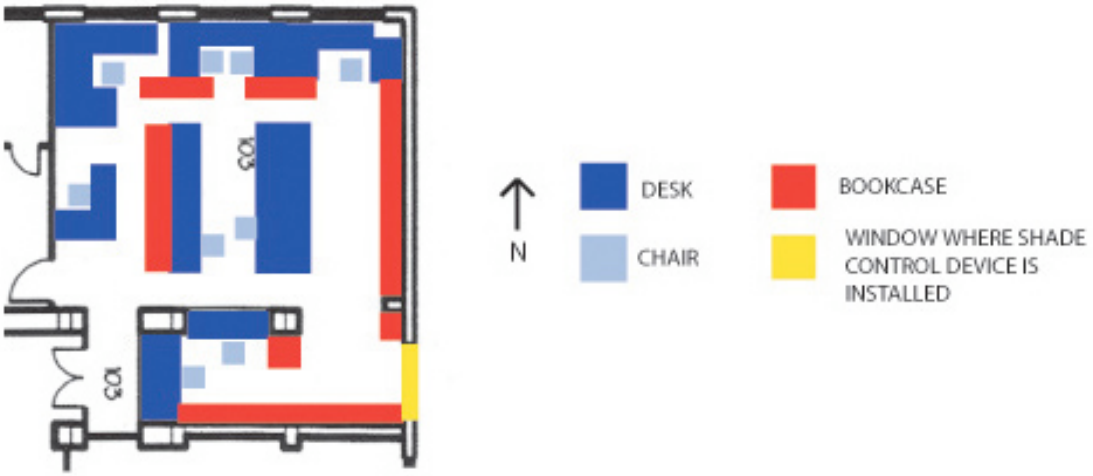

Figure 1: 103 Pacific Hall Plan

This site is an office space that is inhabited by 4 to 8 people most of the time. The shade control device is mounted on a window that faces east. Direct sunlight comes through this window during early morning hours between the spring and autumn equinoxes. An adjacent building (seen to the right in Figure 2) shades the window during the late morning. There is no workspace near the window. The dimensions of this room are approximately 38' by 33', with a 10' ceiling

height. The window that the shade control is installed on is 77.5” wide by 68.5” high. The shades are 1” aluminum Venetian blinds, and their dimensions are 76.5” wide by 67” high.

Figure 2, Shades in 103 Pacific open

Figure 3, Shades in 103 Pacific closed

Figure 4, Head Rail
(Confidential information blacked out)

The Shade Control Device was installed in 103 Pacific Hall with the intention that it would not be operated as a normal shade. Occupants were asked to close the shades whenever they were open. This way, we could maximize the number of open/close cycles to test the consistency of the timing mechanism and robustness of the device with regard to breakage. Also, this location allowed many different people to operate it.

312A Allen Hall

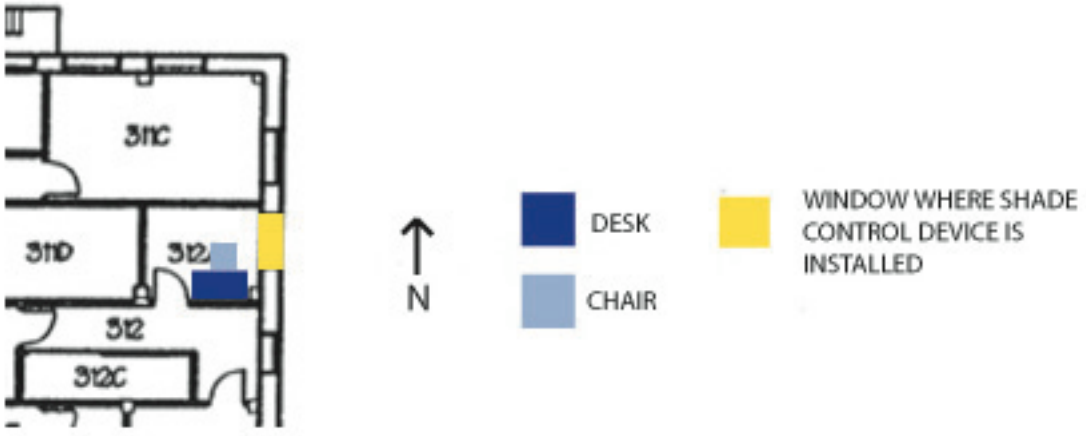

Figure 5, 312A Allen Hall Plan

This site is a private office space with one occupant. The shade control device is mounted on the only window, which faces east. The work surface is in the corner between the east wall and south wall, so glare on the computer screen is a major issue during the morning hours. The room dimensions are 9'-3" by 8'-0", with a 13'-6" ceiling. The window dimensions are 52" wide by 100" high. The dimensions of the shades are 51" wide by 75" high. They are shorter than the window because this set of shades was not custom made for this space. When fully extended, they were 25" above the window sill. However, under normal circumstances, the user does not usually have the shades lowered all of the way. This should not be a significant problem, as the occupant reports that the sun only comes in through the window high above the sill.

The occupant has the following characteristics: he is between 35 and 44, does not wear glasses, and considers himself to be sensitive to light. He works in the space six to eight hours per day, Monday through Friday, year round. He works primarily on the computer.

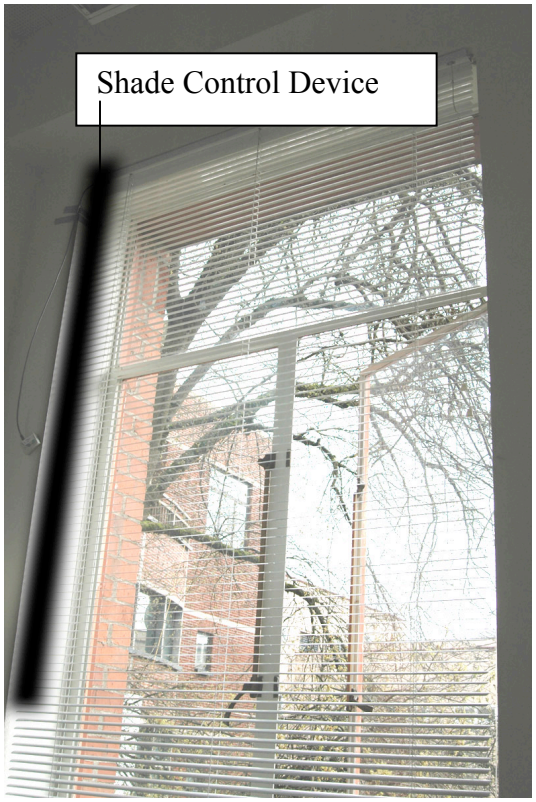

Figure 8: Shades in 312A Allen Hall open
(Confidential Information blacked out)

RESULTS

The opening mechanism that we tested in 103 Pacific Hall worked well and was operated without failure. In 312A Allen Hall, it is not clear whether the shades opened before they should have because of a problem with the opening mechanism or because of a problem with the release timing.

When the shade control timer is set for four hours, the range of opening times is acceptable in the shade control device installed in 103 Pacific Hall. The range of times is also acceptable in 312A Allen Hall, except for the three instances where the shades opened in less than an hour.

Based on user surveys, the shade control device could be improved if the shades were quieter when they opened, so as to not startle the room occupants.

A more easily adjustable timing mechanism would be desirable, along with a more reliable override. Also, it would be beneficial to be able to set the blades of the shades at different angles, so they could be partially closed, rather than fully closed all of the time. We feel this can be

accomplished easily, although it was not part of our specifications for the shade control device for this project.

Testing of the shade control device with different timer settings is necessary. It is also very important that the shade control device opens the shades in such a way that it does not startle the room occupants.

INSTALLATION

103 Pacific Hall

The key installation issue for the shade control device is that the location of the shade control device prevents side mounting brackets from being used; the shade must be mounted with top or back mounting brackets. In 103 Pacific an issue came up with regard to the levelness of the headrail installation. Shims had to be placed under the brackets in order to tilt the headrail so that the shade's wand would hang plumb. If the wand is not plumb, it could impede the rotation of the shade's blades, and might also impact the operation of the shade control device. This may only be an issue in installations where the window is not plumb or the shade has not been mounted level, and would not be a problem for the shade control device in most cases.

312A Allen Hall

The main installation issue in 312A Allen Hall was attaching the shade brackets securely. The building has a steel frame with about an inch of plaster over it at the window head. The window itself had a metal frame as well, so we could not attach the brackets to the window frame. The best option seemed to be to use four brackets to distribute the weight of the shades. Each bracket was attached to the plaster using four screws. This is not a problem with the shade control device however, since we do not believe our device puts any additional stress on the shade and it's attachment that conventional shades and their operation would.

OPERATION

103 Pacific Hall

This shade control device was operated eighty-three times between February 16, 2006, and April 5, 2006. It was set to open the shades after four hours. The average time to open was four hours and forty-six minutes. The quickest opening time was four hours and twenty-three minutes, while the longest opening time was five hours and twenty-three minutes. The standard deviation was ten minutes. See Appendix A for the data.

The only problem with the operation occurred when people did not realize how to close the shades in order to activate the shade control device. In one instance, the user consistently had difficulty activating the device until lab personnel demonstrated how to operate it.

One comment was, "… it didn't stay closed. I tried several times, then someone else (who was familiar with the operation) tried … and it worked." Another time, it took someone two tries to get it closed, and they noted that they were nervous about using too much force.

312A Allen Hall

The shade control was operated sixteen times between March 7, 2006 and April 11, 2006. Based on the times of the day that it was operated, it appears that it was operated nine times in order to block the sun, while it was operated seven times because the room occupant was asked to operate it when he left in the evening or by staff from the Energy Studies in Buildings Laboratory. The reason for this was so that we could increase the number of open/close cycles. If the shade was closed in the evening, it should have reopened by the morning, thereby having no effect on the testing during occupied hours.

The open/close timing of this shade control device was less consistent than the one installed in 103 Pacific Hall. The shade control device was set to open the shades after four hours. The average opening time was three hours and fifty-three minutes. The shortest opening time was two minutes, and there were three instances where the shades opened in forty-nine minutes or less. The longest opening time was five hours and six minutes. Because of the three times where the shades reopened very quickly, the standard deviation was one hour and forty-six minutes. See Appendix B for the data.

Additionally, there was one time when the HOBO indicated that the shades stayed closed for nine hours and twelve minutes. Because this amount of time has never elapsed during any other tests, we are reasoning that the shades were closed again within two minutes after they opened up. The HOBO in 312A Allen Hall recorded data every two minutes, so if they were closed again during that interval, it would not show in the data.

Similar to the 103 Pacific installation, the user did not initially realize how to activate the shade control device until it was demonstrated for him.

Based on the survey information collected, the user was slightly satisfied with the shade control device (a rating of 4 on a scale of 1 to 6). He was also slightly satisfied (4 out of 6) with the ease of operating the shade control. He rated the convenience of the shade control when compared to a conventional wand as 3 on a scale of 1 to 6. He indicated that the shade control did not function properly all of the time, because the timing of the release was too long or too short, and it took too much force to operate. He gave the shade control device an overall rating of 3 out of 6.

Through the survey, the occupant reported that, while the shades did reopen as expected, it was "startling" when the shades automatically reopened. It was also reported that it took the occupant longer than five minutes to become comfortable with operating the shade control.

He also commented that, "The approx 4 hour setting was much too long, especially on "variably sunny" spring days when I only needed to block real sun for fifteen minutes sometimes. I'd prefer something that would automatically adjust to compensate for variable exterior light."

ENERGY SAVINGS

The energy savings due to the shade control device occurs when it automatically reopens the shades during times when people might ordinarily leave them closed. For example, the shades might be closed during the morning hours to block the sun, but they could be left closed for several more hours or perhaps even days. If the shades are closed, it means that the lights must be on, even if there is sufficient daylight outside to light the space. Significant energy savings can result by automatically opening the shades up after the direct sunlight has passed.

The approximate energy savings due to the shade control device are: 60% for windows facing east, 50% for windows facing west, and 17% for windows facing south. See figure 7.

Hours per day that sun shines in window between 8 AM and 6 PM				
	21-Jun	21-Dec	21-Mar/Sep	
East window	4	4	4	
West window	6	4	5	
South window	8	8	9	

Max % of time shades should be closed between 8 AM and 6 PM				
	21-Jun	21-Dec	21-Mar/Sep	
East window	40	40	40	
West window	60	40	50	
South window	80	80	90	

% Energy savings when shades are reopened				
	21-Jun	21-Dec	21-Mar/Sep	Average savings
East window	60	60	60	60
West window	40	60	50	50
South window	20	20	10	17

Figure 7, Approximate Energy Savings due to Shade Control Device

APPENDIX A:

103 Pacific Hall Shade Test -
East window

Min	Max	Mean	Mode	Δ+ (max-mean)	Δ- (mean-min)	Standard deviation
4:23	5:13	4:46	4:40	0:26	0:23	0:10

Note: all durations in h:m.

Test #	Duration		Test #	Duration		Test #	Duration
1	4:34		31	4:38		61	4:46
2	4:41		32	4:35		62	4:38
3	4:41		33	4:41		63	5:00
4	4:36		34	4:50		64	4:41
5	4:54		35	4:59		65	4:39
6	4:39		36	4:37		66	4:49
7	4:42		37	4:49		67	4:52
8	5:05		38	5:11		68	4:49
9	5:13		39	4:35		69	5:00
10	5:06		40	4:23		70	4:48
11	5:08		41	4:30		71	4:45
12	4:40		42	4:57		72	4:38
13	4:40		43	4:57		73	4:41
14	4:52		44	4:43		74	4:45
15	4:54		45	4:46		75	4:46
16	4:58		46	4:48		76	4:43
17	4:44		47	4:49		77	4:44
18	4:49		48	4:24		78	4:37
19	5:09		49	4:32		79	4:51
20	5:01		50	4:35		80	4:46
21	4:57		51	4:40		81	4:45
22	4:52		52	4:41		82	4:58
23	4:45		53	4:35		83	4:50
24	4:51		54	4:46			
25	4:52		55	4:40			
26	4:56		56	4:43			
27	4:56		57	4:34			
28	4:57		58	4:37			
29	4:57		59	4:40			
30	4:52		60	4:46			

APPENDIX B:

312A Allen Hall Shade Test - East Window

Usable set #	Set by	Day	Date	Time (h:m)
	Tom	Tuesday	3/7/06	0:49
1	User	Thursday	3/9/06	4:28
2	User	Friday	3/10/06	4:34
3	Jason	Tuesday	3/21/06	4:43
4	User	Friday	3/24/06	4:34
5	User	Tuesday	3/28/06	5:06
6	User	Wednesday	3/29/06	4:36
*7	User	Tuesday	4/4/06	4:36
*8	User	Tuesday	4/4/06	4:36
9	User	Wednesday	4/5/06	4:46
10	User	Thursday	4/6/06	**0:14**
11	User	Friday	4/7/06	4:48
12	User	Friday	4/7/06	4:42
13	User	Monday	4/10/06	4:46
14	User	Monday	4/10/06	**0:02**
15	User	Tuesday	4/11/06	4:38
		Mean	3:53	
		Min	0:02	
		Max	5:06	
		Std Dev	1:45	

* These two events were originally recorded as a single 9 hr and12 min. event. Based on the fact that this timing is approximately twice the length of any other timing, and that there were no other timings this length, we believe the data represented 2 cycles, where the occupant reset the shade control device within the 2 minute sampling frequency of the HOBO data logger.

APPENDIX C:

Shade position survey

	139 Law School		102/103 Esslinger		736 PLC	
10/31/2005	11:30 a.m. partly cloudy	a,b,c open	11:50 a.m. partly cloudy	a 100% down but open, b, c open	11:40 a.m. partly cloudy	a2 down but open, all others open
11/4/2005	11:25 a.m. cloudy	a,b open; c down approx 1/3 and closed	11:35 a.m. cloudy	Same as above		a1 down 25% and closed, a2 down 75% but open, b1 25% down, b2 10% down, c1 25% closed, c2 open
11/4/2005	3:34 p.m., raining	Same as above	3:23 p.m. raining	Same as above	3:48 p.m. raining	Same as above
11/7/2005	9:24 a.m. cloudy	a,c completely closed, b 40% closed	9:18 a.m. cloudy	Same as above	9:44 a.m. cloudy	Same as above
11/10/2005	10:35 a.m. sunny	a,c completely closed, b 85% closed	10:30 a.m. sunny	a1 100% down but open, a2 20% down but open, b,c open	10:18 a.m. sunny	a1 up, a2 down 85% and open, b1 open, b2 down 50% and closed, c1 down 75% and closed, c2 open
11/10/2005	1:29 p.m., sunny	Same as above	1:24 p.m. sunny	same as above but a1 is closed slightly more	1:41 p.m. sunny	Same as above
11/14/2005	11:03 a.m. sunny	a 30% closed, b same as above, c 100% open	10:58 a.m. sunny	Same as above	11:16 a.m. sunny	a1 25% down and closed, a2 80% down and closed, b1 25% down and closed, b2 100% open, c1 100% open, c2 15% closed

APPENDIX D:

Energy Studies in Buildings Laboratory
Center for Housing Innovation, University of Oregon
Shade Control User Satisfaction Survey

PLEASE NOTE: **Your participation is voluntary.** This survey will take between 3 and 5 minutes to complete. Your decision whether or not to participate will not affect your relationship with the University of Oregon. If you decided to participate, you are free to withdraw your consent and discontinue participation at any time without penalty. All survey responses will remain confidential. All participants in this survey will remain anonymous. To maintain your anonymity and confidentiality, please do not write your name on any of these survey sheets. **When you are finished, please return this sheet to the person administering the survey, or in the enclosed campus mail envelope.**

On average, how satisfied were you with the shade control device? Please indicate how satisfied you are with the following aspects of the shade control device by circling the number that best reflects how you feel, corresponding to the list below:

6 very satisfied
5 moderately satisfied
4 slightly satisfied
3 slightly dissatisfied
2 moderately dissatisfied
1 very dissatisfied

1. Did you operate the shades during the test period?
   Yes
   No
   If no, why not?
   Shades weren't required
   Didn't know how to operate shades
   Couldn't access the shade control device
   Other: _____

2. Overall, how satisfied were you with the shade control device?

very dissatisfied					very satisfied
1	2	3	4	5	6

3. How satisfied were you with the ease of operating the shade control?

very dissatisfied					very satisfied
1	2	3	4	5	6

4. In comparison to conventional shade controls (wands), how satisfied were you with the convenience of the shade control?

very dissatisfied					very satisfied
1	2	3	4	5	6

5. Did the shade control function properly?

Yes
No

If not, what problems did you have (circle all that apply):

It broke
Timing of release was too long or too short
It took too much force to operate
Did not understand how to use it
Other: _____

6. Overall, how satisfied were you with the automatic opening feature of the shade control?

very dissatisfied 1 2 3 4 5 6 very satisfied

7. When the shades automatically opened back up, was it (circle one):

Not noticeable
Noticeable but not distracting
Distracting
Startling

8. Did the shades reopen as expected?

Yes
No

9. How long did it take you to be comfortable with using the shade control?

< 1 min
between 1 min and 5 min
> 5 min
still do not feel comfortable

Do you have additional comments?

_____
_____
_____
_____
_____
_____

THANK YOU FOR PARTICIPATING IN THIS SURVEY

(Please return this survey to either the person who administered the survey, or via campus mail to the Energy Studies in Buildings Laboratory, using the provided campus mail envelope.)