MODERNIZATION OF HOUSE #3:

Improving greenhouse cut flower production and students' experience by modernizing house #3

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By

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Improving greenhouse cut flower production and students' experience by modernizing house #3

This paper documents the modernization of one of Cal Poly's on-campus, student operated cut flower production greenhouses by highlighting problems with the old systems, explaining design requirements and considerations for new systems, listing various designs considered, and describing the chosen designs while evaluating how well they fulfill the design requirements.

Modernization of house #3

IMPROVING GREENHOUSE CUT FLOWER PRODUCTION AND STUDENTS' EXPERIENCE BY MODERNIZING HOUSE #3

WHAT IS HOUSE #3?

Greenhouse #3 is a student run cut flower production house. The following two flowering plants are grown in house # 3:

- Gerberas

  In house #3, Gerberas are grown hydroponically in a system of raised pots filled with a growing medium. The hydroponic system in house #3 is a good small-scale example of what a student would see in a commercial greenhouse.

  Gerberas are an important plant for students to have experience with from a market standpoint. Growing Gerberas is also a good introduction to hydroponic cut flower production, which is almost exclusively used in commercial cut Gerbera and Rose industries

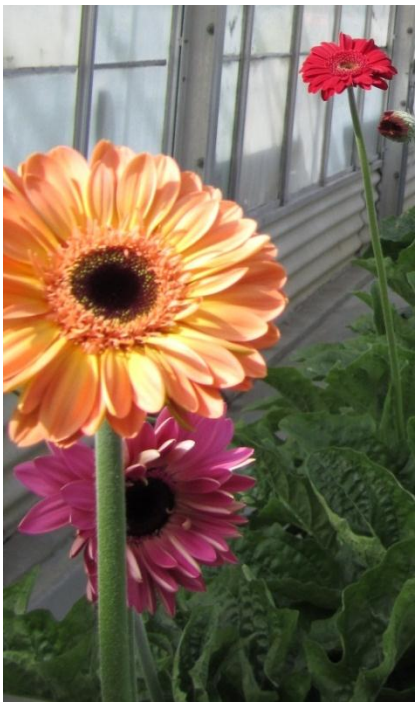


FIGURE 1: GERBERA DASY

- Chrysanthemums

  In house #3, Chrysanthemums (Mums) are grown in three raised concrete beds filled with soil. While the Gerberas produce continuously throughout the year from the same plants, Mums are replanted after every harvest. This means that to maintain a fairly continuous supply of cut flowers, each of the three Mum beds will contain multiple varieties of Mums that were planted at different times to stagger when they are harvested.

  Mums are photoperiodic and require both a lighting and black-cloth system to control day length to ensure they bloom on schedule. (See appendix A for an explanation of photoperiodism as it relates to Mums.)

  Chrysanthemums are good learning plants for students because they have been widely grown in the US for over fifty years. There are hundreds of varieties, and there is a vast wealth of grower experience from which to draw for each variety. They are very hardy, easily scheduled, and a staple in the floral industry.

  Mums are by far the most predictable photoperiodic crop widely grown for cut flowers, making them an ideal crop to introduce students to photoperiodic plants; they provides valuable experience that can be applied to many other crops. Scheduling other varieties of plants becomes more

complicated when temperature and humidity need to be considered, (these factors can play a large role in determining when some plants bloom) but Mums are largely unaffected by these factors.

FIGURE 2: CHRYSANTHEMUM

When students work in house # 3, they learn how to plan and schedule plantings to produce flowers on key dates, such as Mother's Day. Students are also involved in deciding which colors and sizes of flowers would be most likely to sell for various holidays and in selecting appropriate varieties to be planted. The flowers produced are sold in the on-campus plant shop in various student created arrangements.

Both greenhouses and universities strive to create good growing environments. A university greenhouse is where a good growing environment for a plant can mean a good growing environment for a student. House #3 had several areas where improvements made to the systems used in cut flower production would improve a student's learning environment, better preparing him or her to enter into a career in the cut flower industry.

THE FOUR AREAS ADDRESSED IN THE MODERNIZATION OF HOUSE #3

While the Black-Cloth system was the original focus in the modernization of house #3, it quickly became evident that several other areas needed to be addressed: the shade system over the Gerbra bed, the plant support system used for the Mums, and the lighting system.

As the Black-Cloth system was being addressed, it was decided that a similarly designed shade system should be installed over the Gerbras. This system can be used on days of intense sun to protect the flowers from fading before being harvested.

The addition of the new structure for the Black-Cloth system also provided an opportunity to improve the plant support system being used with the mums

Once the design for the Black-Cloth and shade systems was chosen, it was recognized that the old lighting system was not just inefficient; it was also in the way, making it necessary to design and install a new lighting system.

Each of the four areas (Black-Cloth system, shade system, plant support system, and lighting system) improved in the modernization of house #3 will be discussed in detail. The main focus of the modernization centered on the Black-Cloth and Lighting systems; these sections will include a description of the old system, design requirements and considerations for the new system, designs considered, and a description of the chosen design with an evaluation of how the new system fulfills the design requirements.

The addition of a shade system was fairly straightforward and designed to match the black-cloth system, so that section will not include multiple designs considered. The modernization of the plant support system was also very straightforward and will simply provide a description of the old system and an explanation of the new system chosen.

For each area being modernized, design requirements were established early in the process. By choosing a set of design requirements before considering any potential designs, it is more likely that the final design will provide an overall improvement to the system being addressed. It is easy to focus on a few problem areas with an existing design and overlook the many things that are being done well. It is important to look at the entire system and not just one aspect when choosing a new design. Without a complete set of design requirements, it is all too easy to solve one problem while unknowingly creating another.

BLACK-CLOTH SYSTEM

The old Black-cloth system

The old black-cloth system consisted of medium thickness black plastic sheets supported four feet above the growing beds. The plastic sheets on each bed were supported by three plastic wires strung between five frames along the length of the bed. The two end frames were securely fixed to the concrete beds while the three center frames were permanently not attached. To cover the plants each night, the plastic was pulled along the wires from each end of the bed and came together at the center. Having two sheets that met in the middle of the beds kept each piece of plastic sheeting down to a reasonable size and also allowed for the overhead irrigation lines that drop down in the center of the beds.

FIGURE 3: VIEW OF PLASTIC SHEETING PARTLY COVERING MUMS

FIGURE 4: VIEW DOWN THE LENGTH OF THE MUM BEDS SHOWING WIRES AND WIRE SUPPORTS

The black-cloth plastic often snagged on the supports while being opened and closed, damaging the plastic. The rips and tears caused by the support system needed to be repaired regularly, and at least one of the sections was replaced every six months.

Snagging also made covering the plants very time consuming for one person to do alone; it could take 15 minutes for one person but just three minutes for two people working together. The frustrating and time consuming nature of the process often resulted in the plants not getting covered consistently.

Damage to the flowers was also an issue due to the height of the curtains. The Mums often grow taller than the four foot curtain height while still needing to be covered, making it necessary to drag the plastic over the almost mature flower heads. This can break the flower heads off or cause them to discolor from heat and moisture that develops when the plastic is not removed before the sun starts hitting the beds in the morning.

The non-breathable nature of plastic sheeting also increased disease problems such as Powdery Mildew by creating a growing environment that was warm, damp, and lacked air flow. The increase in disease required an increased use of fungicides.

FIGURE 3: MUMS GROWING PAST THE BLACK-CLOTH SUPPORT STRUCTURE

FIGURE 4: DAMAGE TO PLASTIC SHEETING

Black-Cloth Design Requirements and Considerations

The design requirements for the Black-Cloth system were generated by analyzing the main strengths and weaknesses of the current system. While there were many problems with the current system, it served as a good bench mark from which to judge progress. As for design requirements, it was important for the new system to provide

- structure and curtains to shade the growing beds the same as or less than the current design;
- technology for each growing bed to be covered or uncovered independently of the other beds;
- curtains that close without getting stuck;
- technology to cover the entire bed without multiple trips up and down the bed;
- durability to last for a minimum of 5-10 years without any major up keep;
- the ability to work reliably and consistently;
- curtains that require less physical force to open or close than the current design;
- new fabric that is more breathable than the current plastic;
- a structure that doesn't negatively interfere with plant growth;
- minimal mechanical or electrical components; and
- easily operated technology that does not require special training for students.

Black-Cloth system designs considered

The Black-Cloth system had the most room for creativity when considering possible designs. Many of the ideas were quickly ruled out by one or more of the previously listed design requirements. The following design options for the new Black-Cloth system were considered:

- Modify the existing system.

  There were many ways to potentially modify the existing system to make it meet most of the design requirements. These ideas were the first considered because it is often easier to see ways to improve an existing system than to design an entirely new one. Modifying the existing system was appealing because it would be faster and less expensive than designing and installing an entirely new system.

  This idea was rejected because it was decided that a newly designed system would not only improve plant growing conditions but that it would also greatly improve the learning facilities on campus. Before the decision was made to go with an entirely new design, the following two designs to modify the existing system were considered:

  - INSTALL "BRACKETS" WHERE THE WIRES CONNECT TO THE WIRE SUPPORTS SO THAT THE PLASTIC SHEET DOESN'T GET STUCK AT THE SUPPORTS WHEN BEING OPENED AND CLOSED.

    The wires that the curtains slide on were kept in place by wrapping around the pipes of the support system. This junction is where the plastic sheeting gets stuck. By designing some type of small structure that would raise the wire off of the pipe and smooth out the junction, many of the snags could be eliminated. This would make it easier to open and close the plastic sheets but fails to address the many other issues with the existing system

FIGURE 5: VIEW OF SUPORT WIRE WRAPPING AROUND SUPPORTING PIPE

  - CREATE A FRAME ON THE LEADING EDGE OF THE CURTAIN TO MAKE IT EASIER FOR ONE PERSON TO OPEN AND CLOSE.

    A frame on wheels that would raise the leading edge of the plastic sheeting over the wire supports could be used to stop snagging when the sheeting is being closed, but it would be in the way when opening. It could potentially make it easier to operate but could also create more problems than it solved.

- Install a Roll up curtain down the length of the bed.

  The idea behind this design came from the spring loaded window blinds that roll up around a tube when not in use. This idea was appealing because it would provide a very compact, safe way of

storing the curtains when not in use. The tubes could either be spring loaded or crank operated; the spring would make for faster deployment, while the crank would be more reliable and have a longer useable life.

There are several ways that this type of curtain system could be applied; the following are the two options that were more seriously considered:

- USE MULTIPLE CURTAINS COMBINED TO ENCLOSE THE GROWING AREA.

  This design would require eight curtains to fully enclose a single bed. The 52ft length of the beds is too long for a single unsupported tube to span while carrying the weight of the curtain on it and would need to be broken into two 26ft sections. Each short end would require a separate curtain, and the top of each bed would require two curtains that opened horizontally and ran in a track to enclose the top.

  This design was rejected because it would be time and labor intensive to open or close all of the curtains required to completely enclose the beds. This could be avoided by hooking all of the tubes to electric motors so that they could be opened automatically. This would either require 24 separate electric motors to open all of the curtains or fewer motors with more mechanical components to connect a single motor to multiple curtain tubes. Both of these options fail to fulfill the design requirement for the new system to have minimal mechanical or electrical components. The number of large fabric covered tubes that would need to be suspended over each bed also created a large concern for the amount of shade that would be cast on the beds.

- INSTALL A SINGLE TUBE WRAPPED WITH TWO LAYERS OF BLACK-CLOTH DOWN THE CENTER OF THE BED.

  As the curtain is unrolled from the tube, the layers of Black-Cloth separate and go opposite directions to cover the bed. This design would require some type of track to direct the leading edge of the fabric as well as a support system to keep the fabric suspended in more of a Quonset hut type structure. Two small curtains would still be needed to close off each short end of the bed. The idea of two layers of fabric rolled on a single tube is something that has been applied in the venting systems of greenhouses constructed with plastic sheeting; but it has not been used in black cloth systems to my knowledge.

  This design was rejected because of concerns over reliability and consistency. Rolling two sheets of fabric together on a tube works well when both sheets are moderately tensioned (as in venting applications) and where the tube they are being rolled onto can be considerably longer than the fabric being rolled. Having tension and using a tube longer than the fabric helps to ensure that the fabric rolls on the tube straight and square and doesn't "candy cane" to one end of the tube. Neither of these features were options in the designs considered, increasing the likelihood of the curtains miswinding and causing frustration to the operator and potential damage to the system.

- Install curtains on overhead tracks.

One of the problems with the old system was that the plastic sheeting would get stuck on the wire support system. An overhead track makes it so that the supports and the curtain don't interfere with

each other, allowing the curtain to move freely over the entire length of the bed. There were two main ways overhead tracks could be used:

- INSTALL A SINGLE TRACK DOWN THE CENTER OF EACH BED WITH SUPPORT WIRES ON THE SIDES TO SPREAD THE CURTAIN OVER THE BED.

  This design was considered because there was enough old track laying around the greenhouses for one length of track per bed, so it could have been completed without purchasing additional track.

  This design was quickly abandoned because it combined the structural complications of both the overhead track and overhead wire systems while only offering a slight cost savings. There were also issues with where the curtains connected to the wires. The curtains could either go over the wires or be suspended from hangers on the wires. Either of these options require that the wires, which carry most of the weight of the curtain, be unsupported in the range of the curtain's movement.

- INSTALL DOUBLE TRACKS, ONE OVER EACH EDGE OF THE BED, SO THE CURTAINS HANG STRAIGHT DOWN.

  Two tracks over each bed suspended from the existing trusses would create the desired curtain structure over the beds while eliminating the need for any support for tracks to come up from the ground. The tracks would need to be braced apart from each other to keep the curtains from sagging between the tracks or pulling the tracks together.

  This design was considered and developed more than many of the others. Similar designs have been put into practice on a larger scale in commercial greenhouses. It would have been easy to install (as it required minimal structure to be added to the greenhouse) but was rejected because it failed to meet the design requirements of durability and reliability.

  After inspecting the older tracks around the greenhouses, it became clear that the plastic sliders in the tracks were the first thing to break and the hardest part to repair. Each track system is highly customized to the specific manufacturer, making it hard or expensive to replace and nearly impossible to repair. It was decided that a track system, though durable and reliable in the five year range, may not offer the same performance in the 10-15 year range.

  There was also slight concern regarding the shade cast by the structure and the semi-mechanical nature of the track components.

Install a curtain on overhead wires.

An overhead wire system is very similar in concept to the overhead track system. The main important differences are that the curtain could not slide past any supports used to hold up the wires, and the wires would need to be highly tensioned, requiring more overhead structure. Multiple wires would run down the length of the bed, supporting a curtain that either draped over the wires or was suspended below them. The two outermost wires would carry the majority of the curtain weight as they fully support the fabric that hangs down the outside of the beds. Any additional wires would

support the center of the curtain and keep it from sagging, though they would carry little of the actual weight.

It was decided that only two center support wires would be needed to give the desired shape to the curtain, making for a total of four wires running the length of each bed. No matter how highly tensioned, there would be considerable sagging in the support wires if they were to span the 52ft long beds with no intermediate supports. A single support at the center of the beds would be enough to keep the wires from sagging excessively under the weight of the curtain. The wire support at the center of the beds would make it necessary to have two large curtains that connect at the center of the bed. Two small curtains would also be needed to close off the ends of each bed.

This design highly resembles the existing system in the simplicity of the components used while improving on a few of the main problem areas. It would remove all snagging issues by removing intermediate supports that the curtains pass over. The height of the curtain could be raised higher off the beds, minimizing damage to the plants from the curtains. This design would cast very little shadow on the beds, as the shadow from the wires is negligible, and the majority of the structure needed to support the wires wouldn't be located over the beds. It wouldn't require any electrical or mechanical components, and students could use it with little to no special training. The actual components of the system are robust and easily repairable or replaceable if necessary. Various forms of this style of design have been used for both Black-Cloth and shade structures in industrial greenhouses with great success.

The new black-cloth system

After considering the potential designs listed above, it was decided to install an overhead wire system, as it seemed to best meet the design requirements decided upon. The actual system chosen was a modified VRE Systems product designed specifically for our application.

VRE Systems normally works on a much larger scale, covering entire production greenhouses, but it has done several smaller custom applications similar to what was desired for the modernization of house #3. While it would have been possible to design a system completely from scratch, it was decided to work with VRE Systems on this project because of their experience with both industrial and small scale applications.

One of the main reasons for modernizing House # 3 was to provide students with a learning environment where they are exposed to systems similar to what they will encounter in their future careers. This is better

FIGURE 6: NEW BLACK-CLOTH AND SHADE SYSTEM S INSTALLED IN HOUSE #3

achieved by working with a company that sets the industry standard, even if it is in the form of a non-standard custom application. Of all the leading companies looked into, VRE Systems was the only one that had experience in custom applications similar to the one in house #3.

Modifications were made to the design during the instalation process to address design features that didn't end up working as planned or were areas that were not addressed in the orginal design process. (See appendix B for the complete design and installation instructions received from VRE Systems.)

The system installed consists of two large and two small breathable LS fabric curtains per bed. One large curtain is stored at the north end of the bed when not in use, and the other is stored at the center of the bed. The large curtains are suspended from four wires running the length of each bed. The smaller curtain pieces close off the ends of the bed. The small curtain at the north end of the bed remains closed during normal use, as it doesn't shade the bed over the course of the day. The small curtain on the south end of the bed is opened and tied to one of the supports when not in use to minimize the shade cast on the bed.

FIGURE 7: VIEW OF CURTAIN STORED AT NORTH END OF BED ALSO SHOWING UNISTRUT BEAMS ADDED AT THE END OF THE BED

Zippers were added to join the curtains together after abandoning the original aluminum extrusion gasket system that ended up not working for this specific application. This resulted in six seven foot zippers per bed, four of which will need to be used each time a bed is opened or closed.

The four tensioned wires that carry the large curtains are supported by a structure installed in the trusses and gables of the greenhouse. The original design received from VRE Systems had the curtains entirely supported from overhead, making for a very clean looking system. This design was modified during installation to account for the welded-wire plant support system that had not been addressed during the long-distance design process that was necessary while working with the Ontario based company.

The modification consisted of two unistrut beams at the end of each bed, spanning between the concrete growing bed and the overhead support structure installed. The wires that carry the curtains are tensioned between these unisturt beams at each end of the bed. There is an additional support in the center of the bed that keeps the wires from sagging but doesn't carry any of the tension in the wires.

FIGURE 8: TOP VIEW OF STORED CURTAIN

Evaluation of the new Black-Cloth system's fulfillment of design requirements

For the new Black-Cloth system to meet the design requirements decided upon early in the design process, it had to meet the following requirements listed. Under each listed requirement is an evaluation of the new system's ability to fulfill the specific design requirement:

- The structure and curtains shade the growing beds the same or less than current design.

  The lay-out of the new system creates different shade in different spots. Because the old system had a curtain stored at each end of the bed, there was a 3ft section of unplantable bed space at the south end of each bed. This section of bed was constantly shaded by the curtain stored at that end of the bed.

  The new system has a curtain stored in the center of each bed, creating a section that is heavily shaded near the center of each bed. This center area of the bed is now less than ideal to plant in, but it is slightly more plantable than the south end of the bed was with the old system. The shade cast by the new system is also slightly smaller than the old system; it measures about 2ft long instead of the 3ft of the old system.

  The new Black-Cloth design fully meets the requirement of not increasing the shading of the beds.

- Each growing bed can be covered or uncovered independent of the other beds.

  This was an absolutely critical design requirement because of the way the system needed to be used: each bed is planted to bloom on a different schedule. Because the plants in each bed will be on their own schedule, each bed will need to be Black-Clothed at a different time to keep the plants on schedule. The new system allows each bed to be covered and uncovered completely independent of the other beds.

  The new Black-Cloth design fully meets the requirement to cover and uncover each bed independently.

- The curtains will close without getting stuck.

  The highly tensioned overhead support wires removed the need for multiple supports along the length of the beds. The wires on each bed are supported at each end and in the center of the beds. There are no supports that the curtains pass over while being opened or closed, so there is nothing for them to get stuck on.

  The new Black-Cloth system fully meets the requirement to close without getting stuck.

- The entire bed can be covered without multiple trips up and down the bed.

  The curtains are easily closed by one person while only walking 1.5 lengths of the bed. When closing, a person can start at the north end of the bed, pull that curtain closed to the center, zip the leading edge of the north curtain to the back edge of the center curtain, pull the center curtain to the South end of the bed, zip the two zippers on the leading edge of the center curtain to the small curtain that closes the end of the bed, walk half way down the other side of the bed, and close the last zipper between the leading edge of the north curtain and the back edge of the center curtain to fully enclose the bed.

The new system is much more time efficient than the old system that had the potential to get snagged on either of the two supports while being closed. Each snag required walking all the way around the bed to reach the snagged location before it could be closed farther. The addition of zippers to the new system to fully enclose the beds added the additional trip half way down the bed.

The new Black-Cloth design meets the requirement to cover the bed without multiple trips up and down the bed, though not as fully as originally desired because of the extra trip half way down the bed to close the last zipper.

- The system should be durable and last for a minimum of 5-10 years without any major upkeep.

Of all the components of the new system, the only real concern was with the fabric, sewing, and plastic hangers. The LS 100 fabric used in the curtains has a five year warranty, (see Appendix C for LS 100 fabric spec sheet) but the sewing on the curtains is done in a medium weight polyester thread with a chain stich sewing process.

FIGURE 9: HOOKS SEWEN ONTO BLACK-CLOTH CURTAINS

This type of construction was slightly concerning because the life span of such thread in a continuous full sun application is less than five years due to UV degradation. After further research, it was discovered that glass blocks 98% of UV radiation; this explained how the people at VRE Systems could be so confident that the curtains would last for 15- 20 years before needing to be replaced.

The other components of the system are made from galvanized steel and should last indefinitely in an indoor greenhouse application.

The new Black-Cloth design fully meets the requirement to be durable and without major upkeep for 5-10 years.

- The system must be reliable and work consistently.

The simple design and robust components used make for a very reliable system.

The new Black-Cloth system fully meets the requirement to be reliable and work consistently.

- The system must require less physical force to close than the current design.

When first installed, the new system required significantly more effort to open or close than the old system. A significant amount of patch work had been done to the concrete beds, leaving them with a rough finish. The LS 100 fabric has a high snagging propensity that caused it to cling to the rough surface of the beds, making it extremely hard to open or close the curtains.

A quick test (taping aluminum foil to the sides of the bed to create a smooth surface for the curtains to slide over) was done to determine how much of the problem was from clinging and how much was from curtain weight. The aluminum foil greatly reduced the force needed to move the curtains.

A permanent solution was needed to reduce the friction between the bed and the curtains; either the beds could be made smoother, or the curtains could be made less prone to snagging. It was decided to modify the curtains by sewing a ten inch tall strip of a medium weight, woven, coated polyester

fabric along the entire bottom edge of the curtains. The added fabric has a very low snagging propensity and allows the curtains to slide freely over the rough beds.

The new system requires less force to pull the curtains closed as well as less time walking back and forth to unsnag the fabric. Everyone who has used both systems has said the new one is easier and faster to operate.

The new Black-Cloth system fully meets the requirement to take less effort than the old system to close.

FIGURE 10: ALUMINUM FOIL TAPED TO THE SIDE OF THE BED FOR TESTING

- The new fabric must be more breathable than the current plastic.

The new curtains are made of LS 100: this is an uncoated, knit, 100% polyester fabric. While any fabric or plastic black-cloth curtain system will inhibit air flow around the plants, the knit, breathable nature of the new curtains both increases air flow and decreases the amount of moisture trapped under the curtains.

The new Black-Cloth system fully meets the requirement to breathe better than the old plastic.

- The new system must not negatively interfere with plant growth.

This requirement takes into account mechanical damage to the plants caused by any portion of the Black-Cloth system. The height of the new system was raised to 5ft off the growing beds, making it much less likely for the curtain to interfere with the plants. It would have been desirable to raise the curtains even higher off the growing beds, but because of certain features in the greenhouse, it was only reasonable to go as high as 5ft. Some of the Mums will still hit the curtain at times, but raising the curtain from 4ft to 5ft is a huge improvement.

The new Black-Cloth system meets the requirement to minimize interference with plant growth as much as possible, though not completely.

- The new system must have minimal mechanical or electrical components.

Mechanical and electrical components are almost always used in large-scale commercial Black-Cloth applications, allowing the system to be put on a timer or operated from a control panel. For this specific application, we wanted to stay away from an automatically operated system. The increased mechanical and electrical components would make the system more complicated, more expensive, and less operable by the general student population. It would also create more opportunity for system failures. The new system has no true mechanical or electrical components involved.

The new Black-Cloth system fully meets the requirement to have minimal mechanical or electrical components.

- The new system must be easily operated without special training.

  Because the new system is simple and intuitive, with no mechanical or electrical components, it doesn't require any special training to operate. The curtains are connected to the support structure to keep them stored in their appropriate locations when not in use. The connections between curtains are standard zippers. Any student should be able to operate the system with minimal explanation.

  The new Black-Cloth system fully meets the requirement to be easily operated without special training.

SHADE SYSTEM

There was no pre-existing shade system over the Gerberas, and the actual need for one is debatable. The concept behind installing a shade system is that it could be used on particularly harsh days to keep the flowers that are almost ready for harvest from fading in the sun. It would also be useful to protect newly planted plants from extreme conditions. While both of the reasons for installing a shade system are beneficial, neither is necessary. In the end, it was decided to go forward with installing a shade system to match the original design of the black-clothed beds, allowing students to see the various applications of such a system.

FIGURE 11: NEW SHADE SYSTEM OVER GERBERAS

FIGURE 12: NEW SHADE SYSTEM OVER GERBERAS VIEWED FROM SIDE

Shade system design requirements and considerations

The design for the structural portion of the shade system was an extension of the VRE Systems design of the Black-Cloth system. The only change made was the type of curtain being hung from the structure. The two things that needed to be considered when choosing a shade curtain design were what percentage of light transmission was desired and how far the sides of the fabric should hang down. Both of these decisions were made based on common sense and the experience of those who have been involved with projects in House #3 for many years.

The following design requirements were the most important considerations when creating the new shade system:

- The shade system (in use or not in use) must not overly shade plants.
- The shade system must not create air circulation problems.

FIGURE 13: XLS 50 HARMONY REVLOUX SHADE CLOTH

The new shade system

The shade system decided upon and installed is completely suspended from overhead, as the black-cloth system was originally designed to be. The shade curtains are made of XLS 50 Harmony Revolux. (see Appendix C for XLS 50 Harmony Revolux spec sheet) This product provides 50% light transmission and also diffuses the light that it does transmit to stimulate plant growth. It also helps with temperature control. A two foot hang down on the sides was chosen to keep about 2ft between the bottom of the curtain and the Gerberas for adequate air circulation.

Evaluation of the new shade system's fulfillment of design requirements

The overall design of the system came out very well. It is nice to have an example of the system as originally designed by VRE Systems. It is a very clean looking system because it doesn't require any supports going to the ground. Students can get a better idea of potential ways of dealing with an overhead suspended curtain situation, whether it be for shade, black-cloth, insect protection, heat retention, etc.

For the shade system to meet the design requirements, it had to meet the following requirements listed. Under each listed requirement is an evaluation of the new system's ability to fulfill the specific design requirement:

- The shade system (in use or not in use) must not overly shade plants.

  This is a slightly vague requirement, and it is harder to gauge than some others. Because there was no existing shade system, there is no bench mark by which to judge progress. The evaluation of the new shade system's fulfillment of this requirement was based on the opinion of those involved with House #3 for many years; they were happy with the results achieved.

  The new shade system fulfills the requirement of not overly shading plants.

FIGURE 14: SHADE SYSTEM WITH CURTAINS STORED

- The shade system must not create air circulation problems.

  Holding the bottom edge of the curtain 2ft above the plants left enough space for free air circulation; though any large shade structure will decrease air flow to some extent. A fan can be installed for increased circulation if it turns out to be a problem. At this point, air circulation does not seem to be an issue.

  The new shade system fulfills the requirement of not creating air circulation problems.

PLANT SUPPORT SYSTEM

FIGURE 15: TOP VIEW OF WIRE SUPPORT WITH NEWLY PLANTED MUMS

There are three layers of welded wire panels over each of the 52 foot long Mum beds. As the Mums grow, the panels are raised with them to keep them growing straight and out of the aisles. All three layers are moved together until the plants are about a foot tall; the bottom layer remains at this height, while the top two layers continue to be raised. When the plants are fully grown, there will be about a foot between each of the layers, providing support for the lower three feet of plant growth. This will leave only one to two feet of growth above the wire support system.

The old plant support system was supported by the same structure as the wires that carried the old Black-Cloth system. The welded wire panels were tensioned as much as possible between the supports at the end of each bed. The intermediate supports had chains at various heights to hold up the wires because the end supports couldn't carry enough tension to keep the wire panels suspended over the 52 foot long beds.

New plant support system

The original Black-Cloth system design was altered from being completely suspended from the overhead structure installed, to having two unistrut beams that spanned from the overhead structure to the ground at the end of each bed. Theses beams were bolted into the beds using concrete inserts. The beams created a very stable structure from which to tension the plant support wire panels. A second piece of unistrut was attached to the beams with a spacer in between the two; this created a slot in which a pipe could slide up and down. Each panel was attached to a pipe on each end and highly tensioned between the supports on each end of the bed.

FIGURE 16: NEW UNISTRUT SUPORT STRUCTURE AT END OF BED

With the new support structure, it is possible to get enough tension in the panels to remove the need for any intermediate supports. The pipes can be adjusted up and down freely in the slot and are held in place solely by friction, making the heights at which the panels are held completely adjustable.

The wire panels themselves also need to be replaced as they are broken in many places. Upon looking to purchase new wire, it was discovered that the specific configuration desired for this application is no longer standardly manufactured, and it would be necessary to get a mill to do a custom manufacturing run. The specific configuration desired is panels that are at least 50'x4' with 6"x8" box sizes made from a 12 gauge galvanized steel. This specific configuration is desired because it completely covers the bed with one panel of wire; the box size provides an easy way to determine plant spacing when planting by putting two plugs per box, and the wire size and finish makes it very sturdy and durable. The new welded wire panels have not been purchased at this time but will be very easy to install in the new support system when they are purchased in the future.

LIGHTING SYSTEM

The old lighting system

The old lighting system consisted of two rows of fluorescent lights running the length of the house. Each row contained twenty-two, three foot long bulbs. The original design called for only nine fluorescent lights per row, for a total of eighteen lights, but due to a misreading of the original blueprints, forty-four lights were installed. Each of the forty-four bulbs consumes 23W; that is a total of 1408W for the entire house. The lights come on at 10pm and go off at 2am each night.

All of the extra lights in the system create a large shaded area that moves across the greenhouse during the day and uses excessive amounts of electricity at night. A more appropriately sized lighting instillation will not only lower operation costs, but it will give students a better feel for how much lighting is actually required in photoperiodic control applications.

FIGURE 17: OLD LIGHTING SYSTEM

The location of the fluorescent lights also interfered with the new black-cloth system being designed. The fluorescent lights were located over both of the center aisles and the edges of the growing beds at a height that interfered with the overhead wires to be installed. It would have been possible to raise all of the lighting fixtures above the new black-cloth system, but it would have been a very time and labor intensive modification to save an inefficient system.

Lighting system design requirements and considerations

The lighting system allows less room for creativity than the Black-Cloth system; therefore, fewer design requirements were needed to keep the project on track. In the end, there were only three design requirements taken into consideration:

- The new lighting system must provide enough light to meet photoperiodic requirements of Mums.
- The new lighting system must use less energy than the old system.
- The new lighting system must shade the beds less than the existing system.

Lighting system designs considered

There were only a few viable options to consider when choosing a new lighting system that would meet the outlined requirements. The following were the design options considered:

- Modify the current fluorescent bulb system.

  The old system could have been modified to meet the original system design and raised to avoid the new black-cloth system. This would have removed all but 18 of the fluorescent fixtures from the house, dropping it down to a 414W system. This would reduce both the shade created and the energy used while still meeting the minimum lighting requirements. The only cost of this option would be the expense of paying campus electricians for the time intensive job of modifying the system.

- Replace fluorescents with Incandescent bulbs.

  This would require removing the old system completely and installing new drop down incandescent bulb fixtures every 8-10ft to ensure proper lighting. This option created several problems. The house lacked support systems in the proper locations, and the incandescent lights would require a lot of additional wiring to be run.

  This design was not considered in great detail as fluorescent systems are already more energy efficient than incandescent. It was not necessary to fully design the system to see that it wouldn't be a very energy efficient option.

- Replace fluorescents with LEDs.

  While LEDs are starting to be used in greenhouse applications, they are still very expensive and have no guarantees on life span. There is research being done by various people on using specific wavelength LEDs specifically for photoperiodic uses, though it is still very experimental, and there are no commercially available systems.

  This option, though looked into, is more of a research topic than something to be installed in a working production house.

- Replace fluorescents with BEAMflicker.

  A BEAMflicker is an oscillating parabolic reflector with a high-intensity sodium lamp that flicks beams of light from one end of the greenhouse to the other, providing intermittent light across the entire crop. This would allow all of the current lighting to be replaced by one small unit located high in the

center of the house. BEAMflicker is specifically designed for photoperiodic control and can easily meet the light requirements of Mums in a house the size of house #3. There is both a 400Watt and a 600Watt model. (see Appendix C for BEAMflicker info sheet)

The new lighting system

After evaluating each of the above options, it was determined that a BEAMflicker was the best option for the application. All of the old lighting and the lighting support system were removed from the house, and a new 600Watt BEAMflicker was installed in the center of the house at the peak of the gable. The unit was secured as best as possible because a similar unit was recently stolen from a different house.

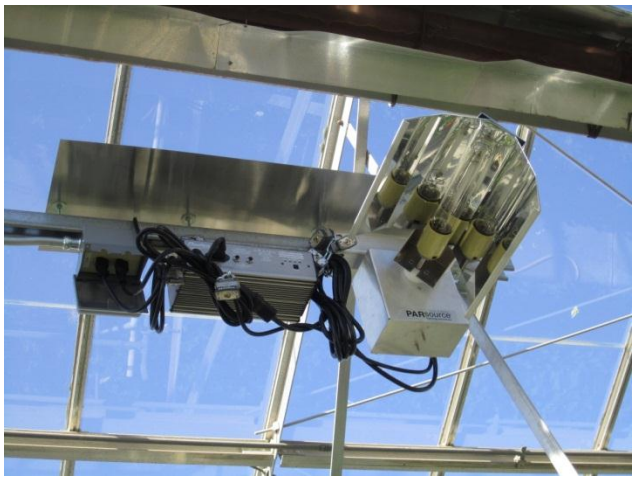


FIGURE 18: NEW BEAMFLICKER INSTALLED

Evaluation of new lighting system's fulfillment of design requirements

For the new lighting system to meet the design requirements decided upon early in the design process, it had to meet the following requirements listed. Under each listed requirement is an evaluation of the new system's ability to fulfill the specific design requirement:

- New lighting must provide enough light to meet the photoperiodic requirements of Mums.

  The BEAMflicker easily meets this requirement by providing more than the required 10Lumens over the entire house.

- New lighting must use less energy than the old system.

  The old Fluorescent system required 1408Watts, while the new BEAMflicker only requires 600Watts. This represents a savings of 808Watts.

- New lighting must shade the beds less than existing lights.

  The BEAMflicker measures less than 1ftx2ft and is located under an existing IR heating duct. This removes all shading created by the lighting system.

CONCLUSION: FINAL THOUGHTS ON THE MODERNIZATION OF HOUSE # 3

The goal of modernizing House # 3 was to provide a better growing environment for Gerberas and Chrysanthemums and a better learning experience for Cal Poly students studying horticulture. The systems installed to modernize the Black-Cloth system, shading system, plant support system, and lighting system were each carefully chosen using sets of design requirements to guide the design process, ensuring the final results met those goals.

The design requirements were determined by analyzing the existing systems, determining what they did well, what needed to be changed, and establishing bench marks by which to evaluate change. These design requirements and bench marks were referred to throughout the design and installation process to ensure the project was moving in the right direction. Modifications to the designs were made as necessary during the installation process to ensure that all of the design requirements were met and the systems made the improvements intended without creating problems in other areas.

Since careful analysis was used to select the designs chosen to modernize house# 3, the building should provide an enhanced growing environment for Gerberas and Chrysanthemums and an exceptional learning experience for many generations of students to come.

Appendix A

PHOTOPERIODISM IN CHYSANTHEMUMS

PHOTOPERIODISM

Photoperiodism refers to how day length affects when plants bloom. To override this effect requires several control systems in a greenhouse, but few people ever think about this. Chrysanthemums are both highly photoperiodic and widely grown as cut flower and potted plants.

PHOTOPERIODISM IN CHRYSANTHEMUMS

It used to be that the only time one saw blooming Chrysanthemums was in the fall when they bloom naturally. However, it was discovered in the1940s and 50s that Chrysanthemums could be forced to bloom at any time of the year simply by controlling the length of the days the plants were exposed to. Later, it was discovered that it is actually the length of the dark periods and a slight temperature dependency that initiates flowering in Mums.

Long-days

Long-days cause vegetative plant growth in Chrysanthemums. In scheduled production, newly planted cuttings will receive supplemental lighting during the night to ensure that the plants are always exposed to long-days. This is commonly done in the following ways:

- Night interruption

  Lights come on during the night for between 2-4 hours. This can be done in one long segment or in 20 minute intervals throughout the night.

- Light extension

  Lights come on at dusk and remain on for 2-4 hours depending on the month and how much additional lighting is required to ensure vegetative growth.

Short-days

Chrysanthemums need to have short-days in order to bloom. To a Chrysanthemum, a short-day means that it has 12-15 hours of dark period each night, depending on the variety of Chrysanthemum. They will naturally be exposed to short-days from September 21 through March 21. For the rest of the year, it is necessary to use black-out curtains to ensure flower initiation. Plants are normally covered before dusk and uncovered between 7am and 9am. It is important to uncover the plants early in the day to avoid overheating, as a sharp rise in temperature can also cause a delay in flower initiation and partly negate the effect of the short-days.

Resources

http://www.ag.auburn.edu/hort/landscape/Potmum.htm

Appendix B

VRE SYSTEMS DESIGN

This appendix contains the original documents received from VRE Systems. This includes both the installation instruction as well as technical drawings of the components.

September 2011

VRE Manual Bench Covers for Cal Poly, San Luis Obispo, CA
Installation Instruction Sequence for Job # 10391
to be used in conjunction with Part Drawings # 10391-1 to 10
and installation Drawings # 10391-11 to 16

1 Mount 4 - 2x2 angle irons of 13' length with bolts on both gable ends to match the slope and elevation of the bottom chord of the interior trusses. Using the 2x3 BR-ENDFRAME brackets at the 4 cornor posts.

2 Start installation doing only the shade bench first on the West side of greenhouse

3 Set a typical set of the 2x2 square tubes, 11' lengths, on top of the angle installed at the gable, and the first truss line. Place them +/- 3' apart, centered on the width of the shade bench. Determine the required cut length to fit between two of the 2x3 BR- ENDFRAME brackets. Note these should be level, from gable to first truss, if the end frames were mounted at the correct elevation on the gables. Because of the bottom chord of truss is sloped, these pieces will be at a slight angle, tipped to the side wall

4 After cutting the 2x2 square to proper length use 2 of the 2x3 BR-ENDFRAME brackets to secure each 2x2 square tube to be in line with bench direction, perpendicular to the gable walls and level in the house width direction.

5 Repeat the above at the opposite gable and ensure all 4 horizontal square tubes are fastened securely

6 Install 2 vertical 2x2 square tubes 36" lengths (drawing -5) to hang vertically with the U bracket welded to the top end. Inside face of vertical square tubes should be flush with the end of the bench concrete. Mark the inside face of these at 60" from top of concrete beds.

7 Now install the 53" wide horizontal 2x2 end frames (drawing -7) with welded tabs mounted on the gable side, at the 60" elevation mark, using brackets (drawing -6). Both 53" ends should be aligned to match arrow straight from gable to gable and be mounted 60" above top of concrete bench level, and be directly above the concrete.

8 Loosely assemble the 4 - 39" round brace tubes with a set of U brackets with tabs (drawing -8). Once you are confident both end frames are in the correct elevation tighten these braces, as they will carry the tension of the suspension wires spanning the length of the greenhouse, plus the weight of the curtains.

9 Install 2 of the 2x2 x 1/8" angle irons vertically from the south side of middle truss in the greenhouse to carry the centre support frames. Use 20-6 'U' bolts and clamp plates and 2x2 square 'spacer' cutoff pieces as required to make these connections. Make sure these are long enough to mount a matching 2x2 square tube at the same elevation 60" above the concrete bed as the existing gable end 53" long frames which are also 60" above the concrete bed.

10 Now install the 53" lengths of 2x2 square tube horizontal (without tabs) directly below the truss, on north side of verticals, with bolts and add the middle aluminum extrusion 53" length (drawing -3) on the north side of this square tube.

11 Also mount the last 53" length aluminum (drawing -3) extrusion at the South end horizontal frame of bench.

12 On North end frame tabs only, bolt on wire tighteners, this should be end without aluminum.

13 Install spring steel suspension wires on length of system, start at South end through the extrusion and secure wire to the tab then thread wire through middle aluminum holes and connect into wire tightener at North end. Install all 4 wires the same and tighten as tight as possible with wire tightener at the north end.

14 The shade fabric curtain (drawing 4) should now be hooked to the wires, with the double hook side at the south edge of both curtains.

15 Cut 2 - 53" lengths of 3/4" leading edge material to install for the front edge of both shade curtains and assemble with the 39" long tube carrier support (drawing -9) at the leading/moving south edge of both curtains. Black PVC clips will be used to secure the fabric to this 3/4" tube.

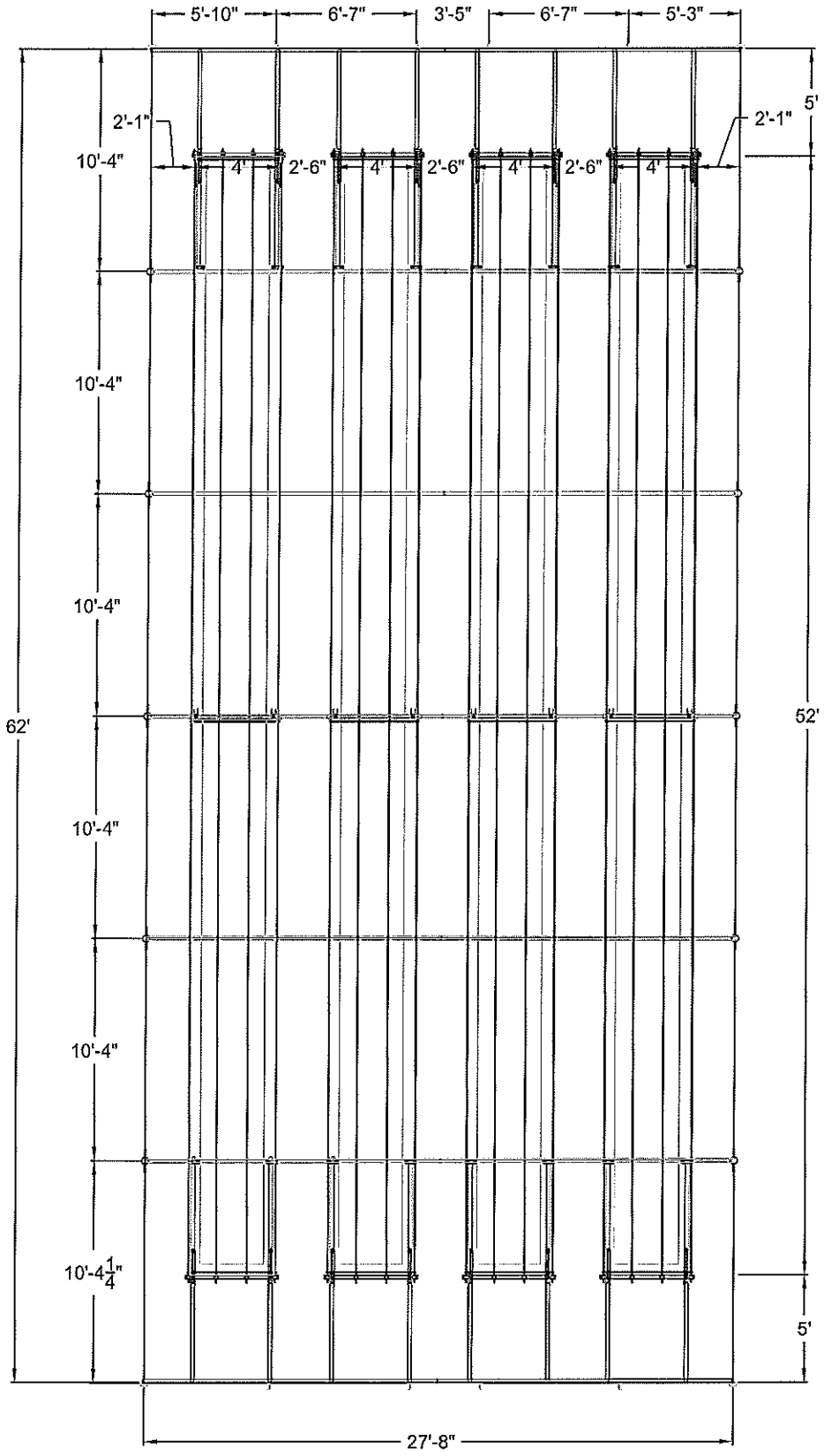
16 Insert a 48" length of 1" pre-galvanized round tube into the end of these tube carrier supports. These tubes will slide in and out to pull along and manually close the curtain from either aisle.

17 This should complete the installation for the shade bench cover.

18 Now repeat for each black out bench. Please refer to drawings -1 for 3 piece aluminum extrusions which will also connect to concrete beds at the bottom. Drawing -2 are the black out curtains. The fabric will need to be slit at the middle frame to seal around the vertical framing. These black out sections will also include 3/4" tubes with PVC elbows for the vertical side drapes on these black out benches.

19 The black out curtains also include enough fabric for stationary end covers. A shower curtain could also be used on the south end to make them retractable. An additional horizontal wire will be required to open and close these south curtains at a suitable height. Be sure to allow for enough stationary coverage on edges to ensure full black out is still obtained. Triangular pieces of fabric have also been supplied to ensure manually drawn curtains will seal properly at the closure points as well. Please refer to drawing -13 for end and triangle edge coverage.

Questions please contact George Dekker at VRE
office # 905-945-8863 ext 232
or by cell at 905-975-1640



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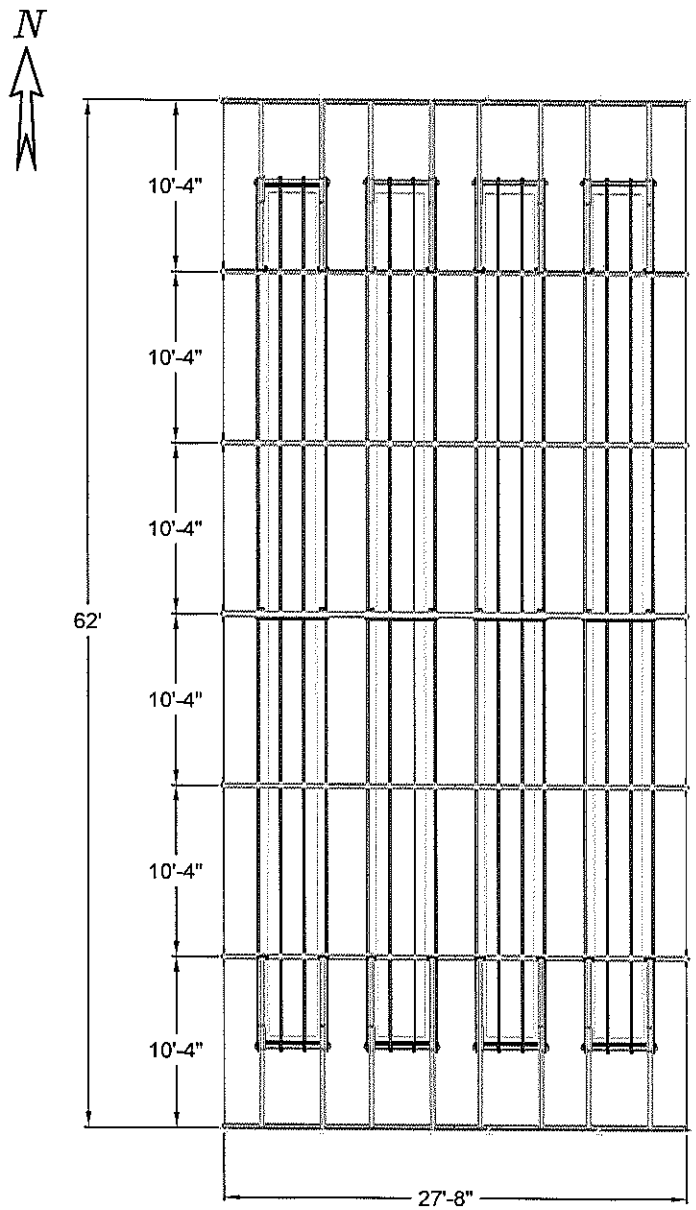

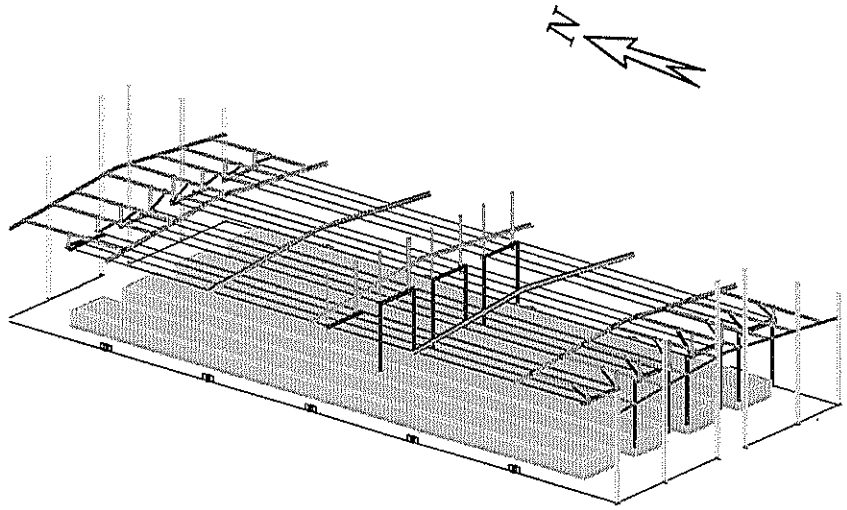

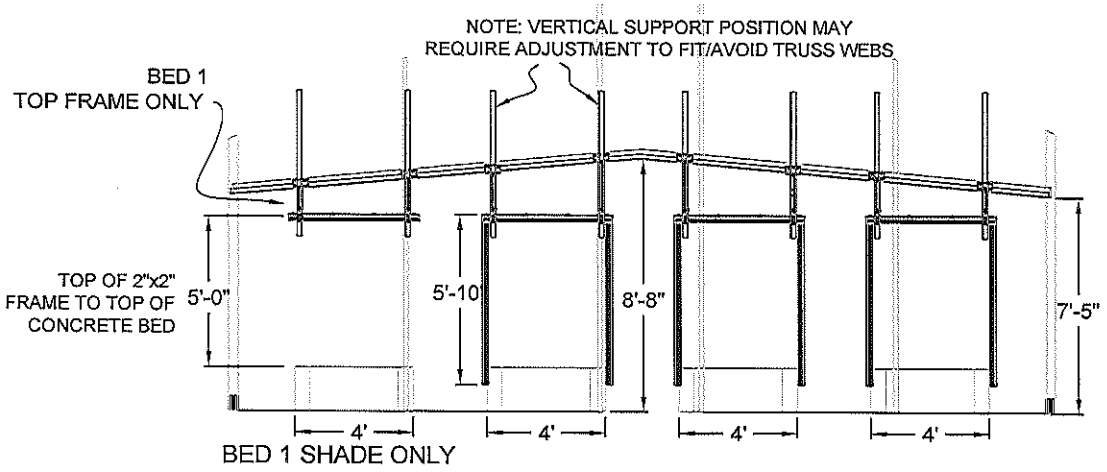

VIEW FROM SOUTH ELEVATION

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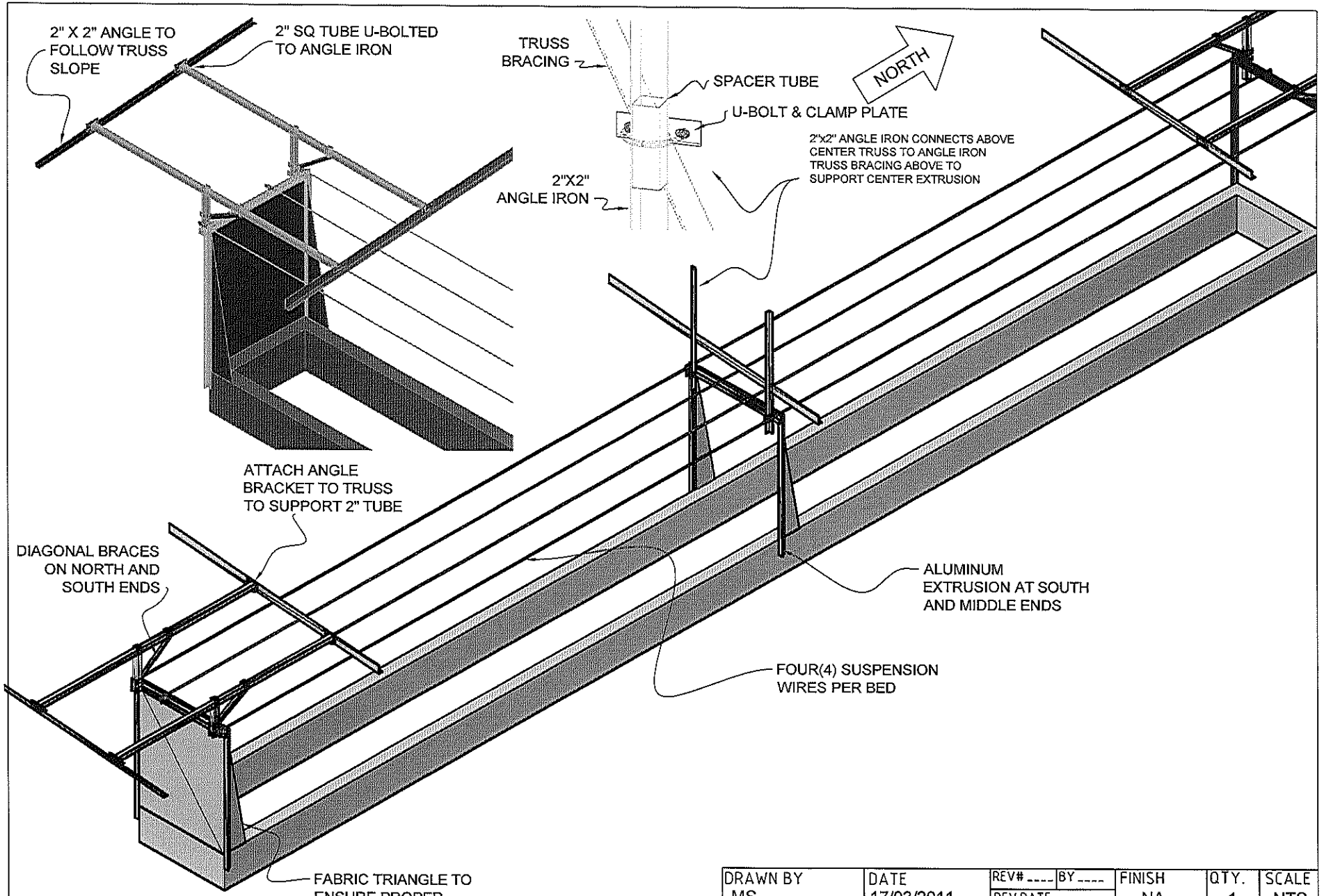

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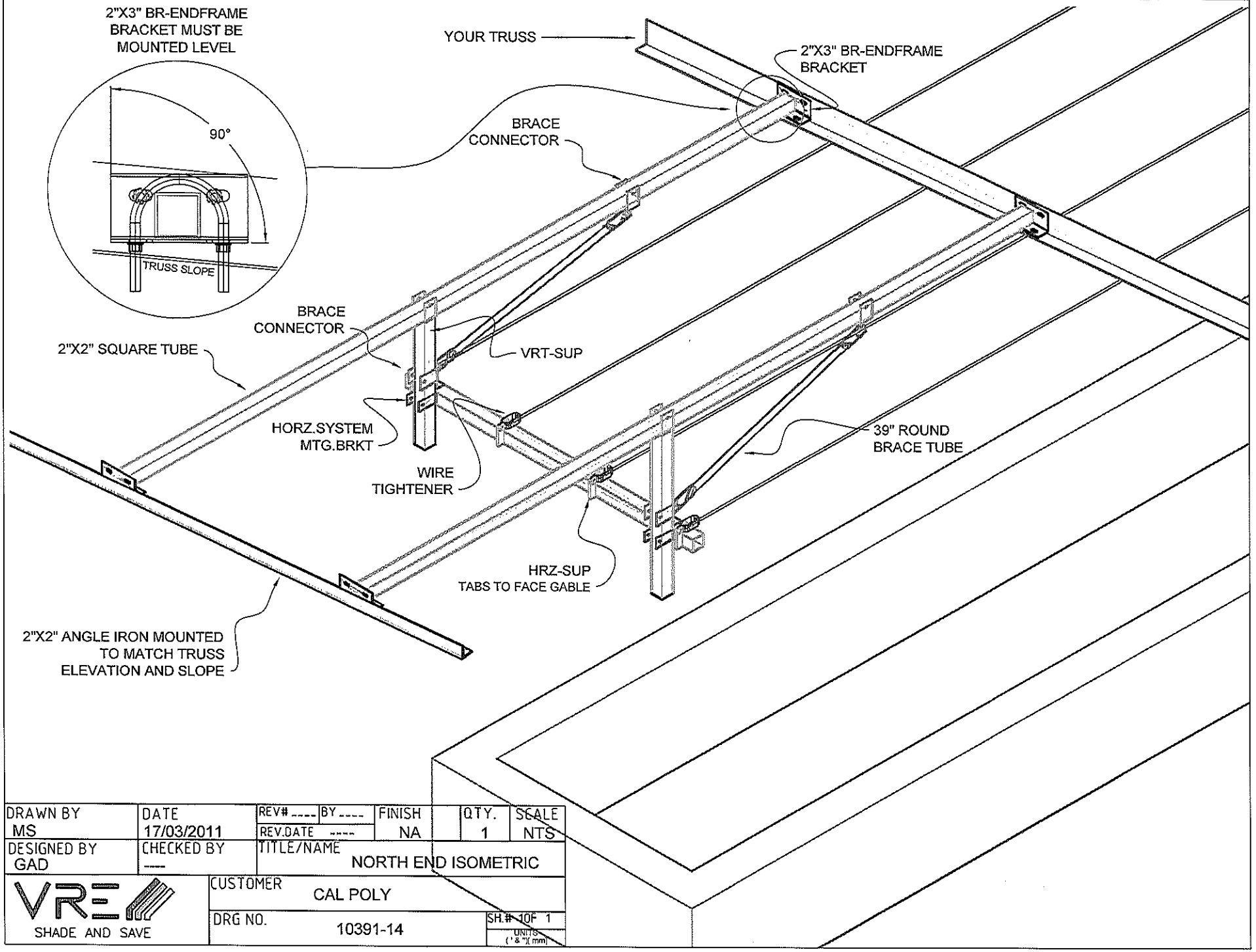

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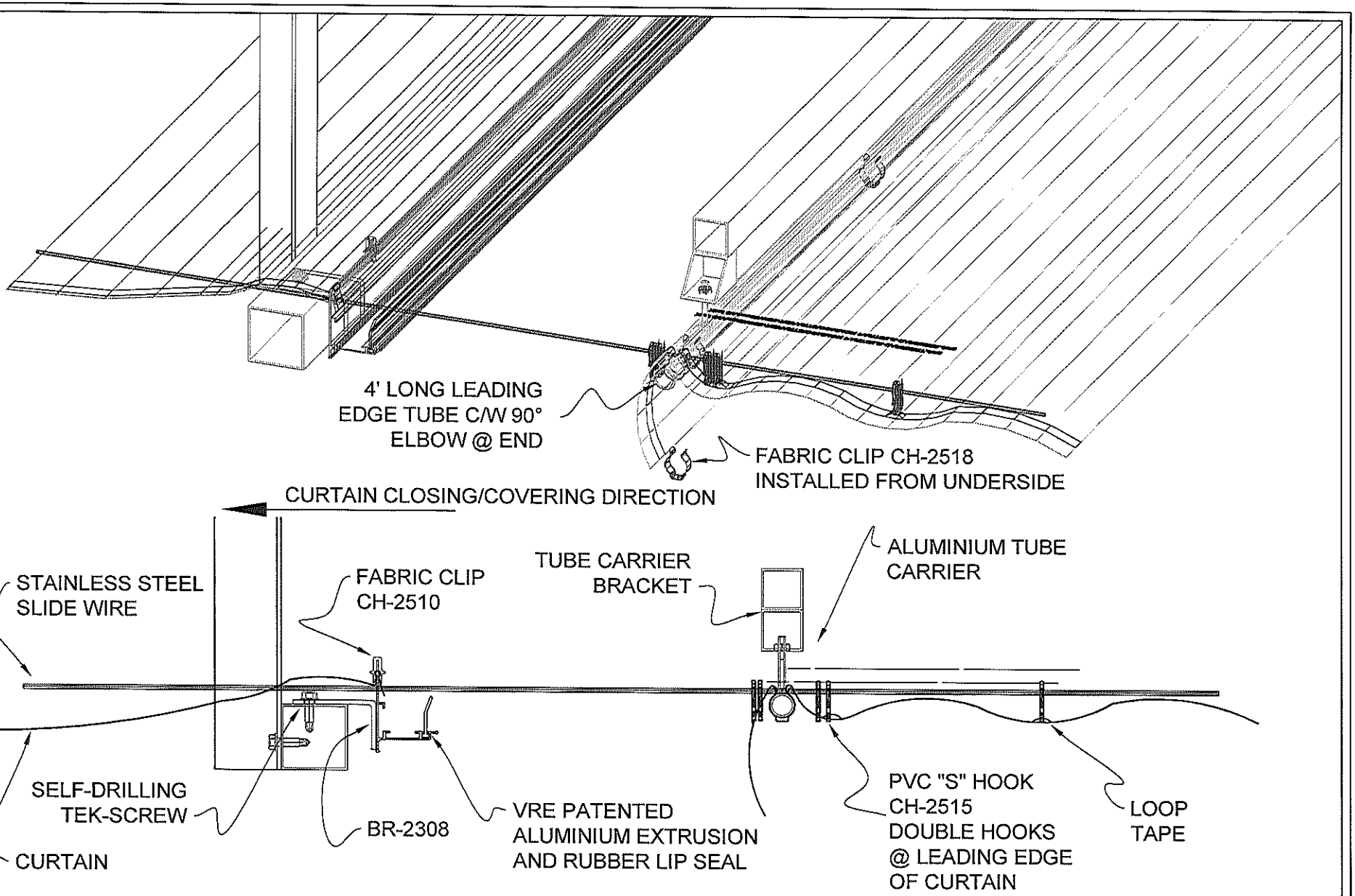

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PWE	---	SUSPENDED SYSTEM				
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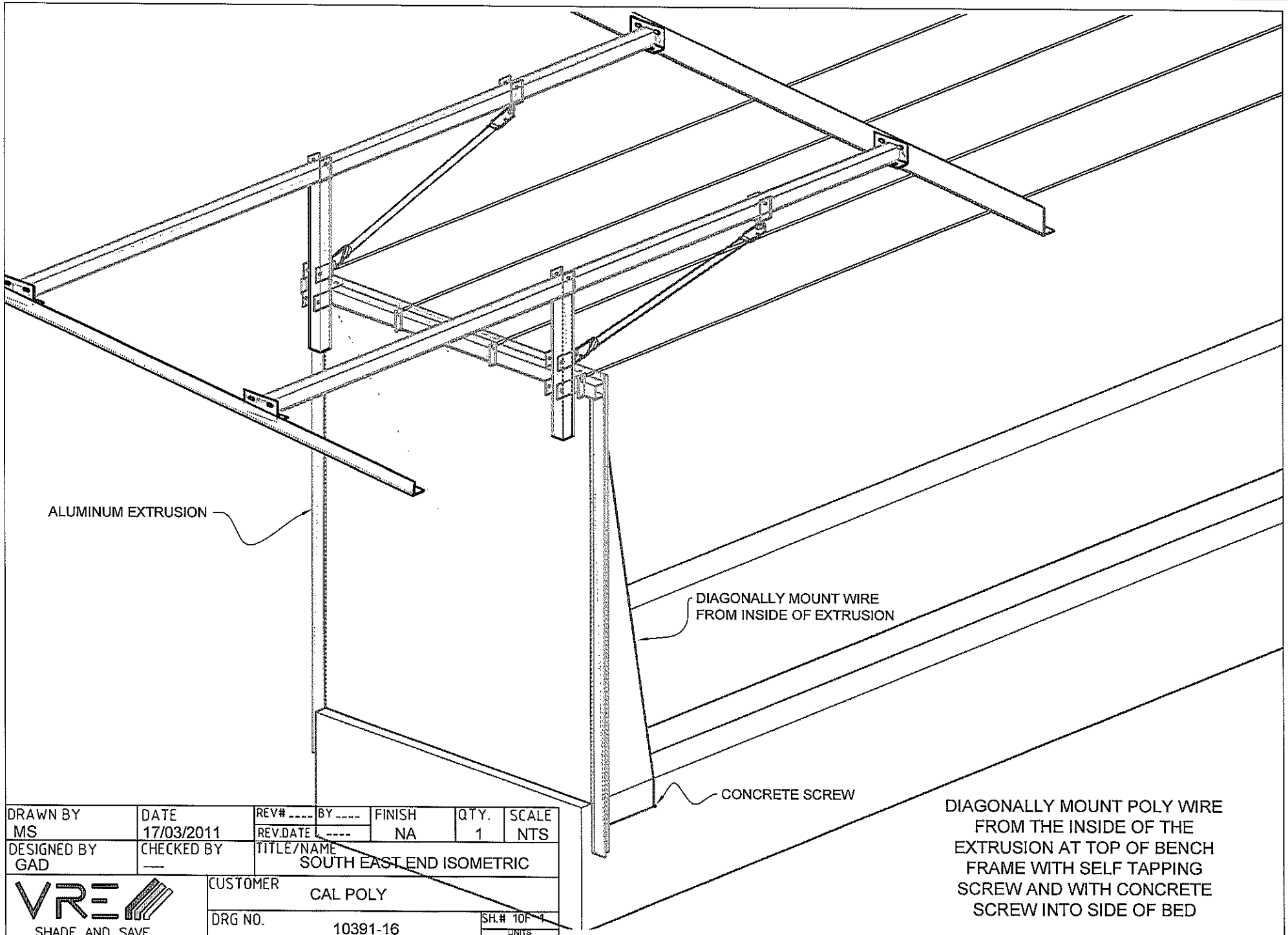


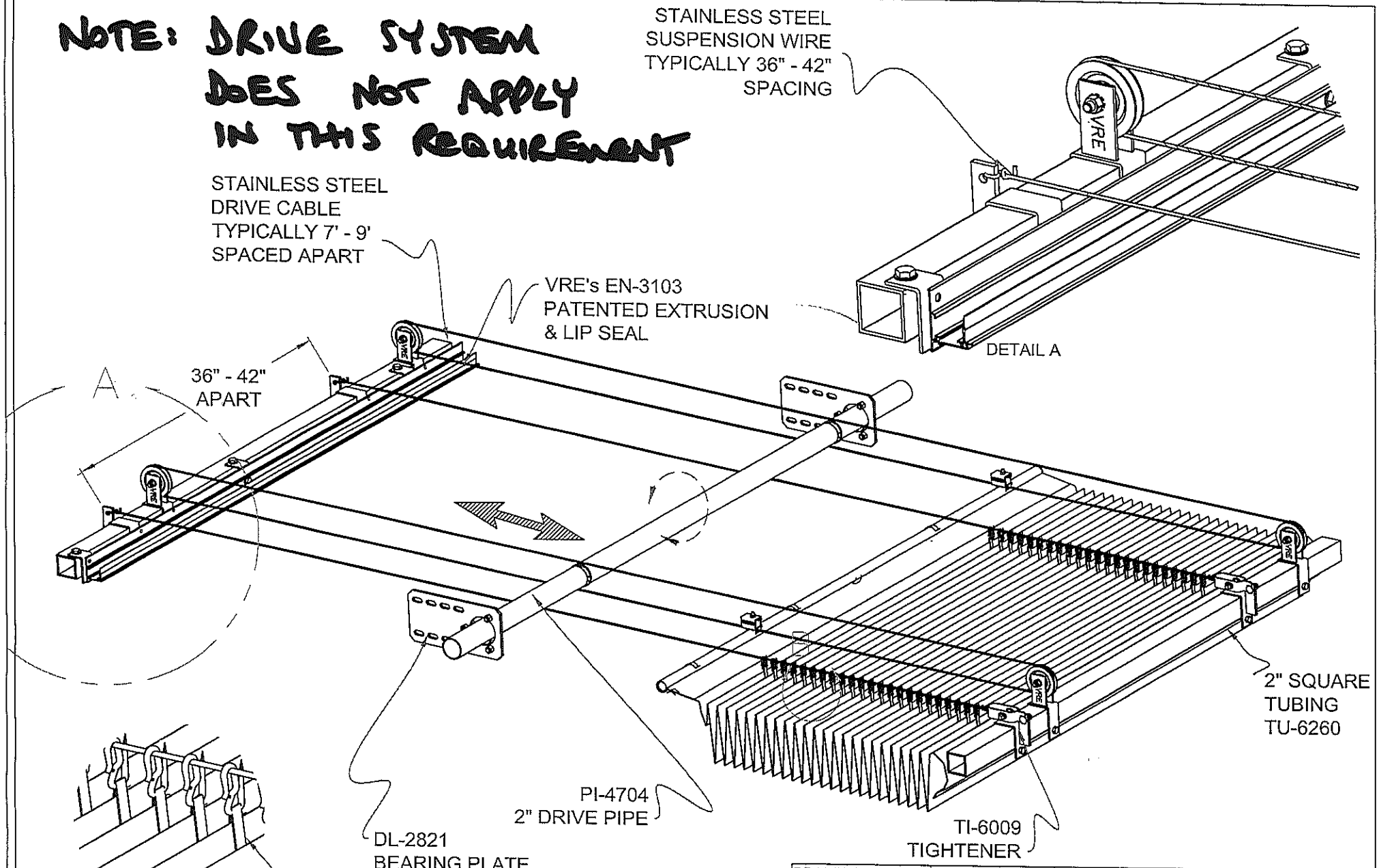
DIAGONALLY MOUNT POLY WIRE FROM THE INSIDE OF THE EXTRUSION AT TOP OF BENCH FRAME WITH SELF TAPPING SCREW AND WITH CONCRETE SCREW INTO SIDE OF BED

DRAWN BY	DATE	REV# ----	BY ----	FINISH	QTY.	SCALE
MS	17/03/2011	REV.DATE ----		NA	1	NTS
DESIGNED BY	CHECKED BY	TITLE/NAME				
GAD	---	SOUTH EAST END ISOMETRIC				

VRE
SHADE AND SAVE

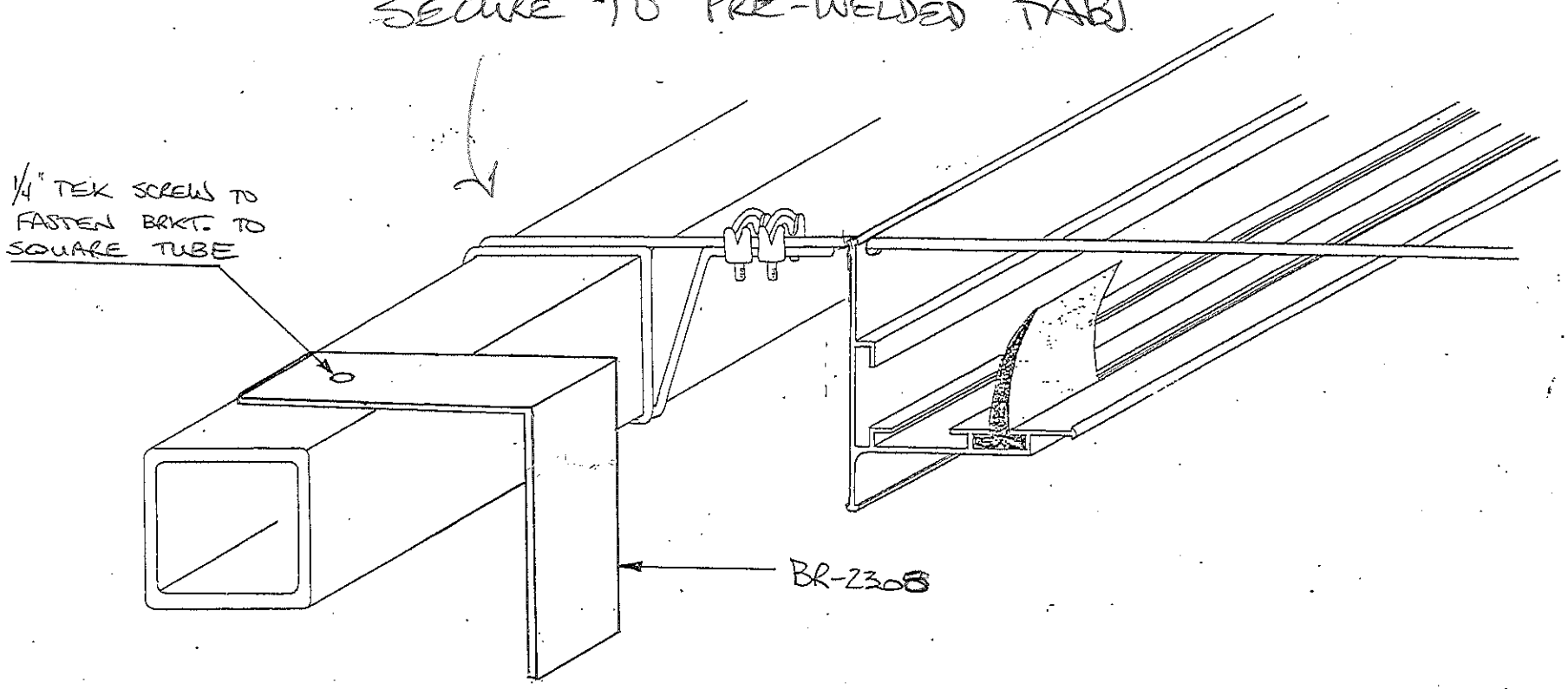
CUSTOMER	CAL POLY	
DRG NO.	10391-16	SH.# 10F 4
		UNITS (' & "/mm)

NOTE: DRIVE SYSTEM DOES NOT APPLY IN THIS REQUIREMENT



DRAWN BY PWE	DATE 04.27.06	REV# ---- BY ---- REV.DATE ----	FINISH NA	QTY. 1	SCALE NTS
DESIGNED BY GAD	CHECKED BY ---	TITLE/NAME SUSPENDED CURTAIN SYSTEM - SHAFT ABOVE			
VRE SHADE AND SAVE	CUSTOMER -				
	DRG NO. SUSP_SYSTEM_A			SH.# 1 OF 1 UNITS (' & ")[mm]	

SECURE TO PRE-WELDED TABS



USE BR-2308 2"×4" BRKT. FOR MOUNTING ALUM. EXTRUSION TO SQ. TUBE ON 5'-6' SPACING

USE BR-2308 ALUM. ANGLE BRKT. SPACERS FOR TRUSS MOUNTING WHEN REQUIRED FOR ALUM. ALIGNMENT

VRE GREENHOUSE SYSTEMS

U.S.A. PATENTED 1986 # 4,585,220
CANADA PATENTED 1984 # 1,179,844

REVISIONS			VRE GREENHOUSE SYSTEMS		
NO.	DATE	BY			
1			CUSTOMER SUSPENDED SYSTEM		
2					
3			DRAWN BY KEVIN	SCALE N.T.S.	MATERIAL
4			CHK'D	DATE	DRAWING NO.
5			TRACED UPDATED SJR	APP'D	

332-9120

LEADING EDGE

Once the design and shape of your system has been determined, it is necessary to calculate the number of joints (maximum 5) and the length of the leading edge between the joints. A nylon elbow is provided to a) connect two (2) pieces of leading edge and b) obtain the various angles of your design.

ASSEMBLY OF LEADING EDGE

Measure distance between joints. See note below.

Transfer markings to leading edge. Cut leading edge.

Take side piece of leading edge. Insert one section of nylon elbow. Push into leading edge until the leading edge rests against the ridge of nylon elbow.

NOTE: It is necessary when calculating the leading edge, to take into account the distance AB of nylon elbow (see drawing).

The side pieces of leading edge (on drawing referred to as L.E. PIPE Z) require one nylon elbow since there is one joint, so a deduction of 1/4" is required.

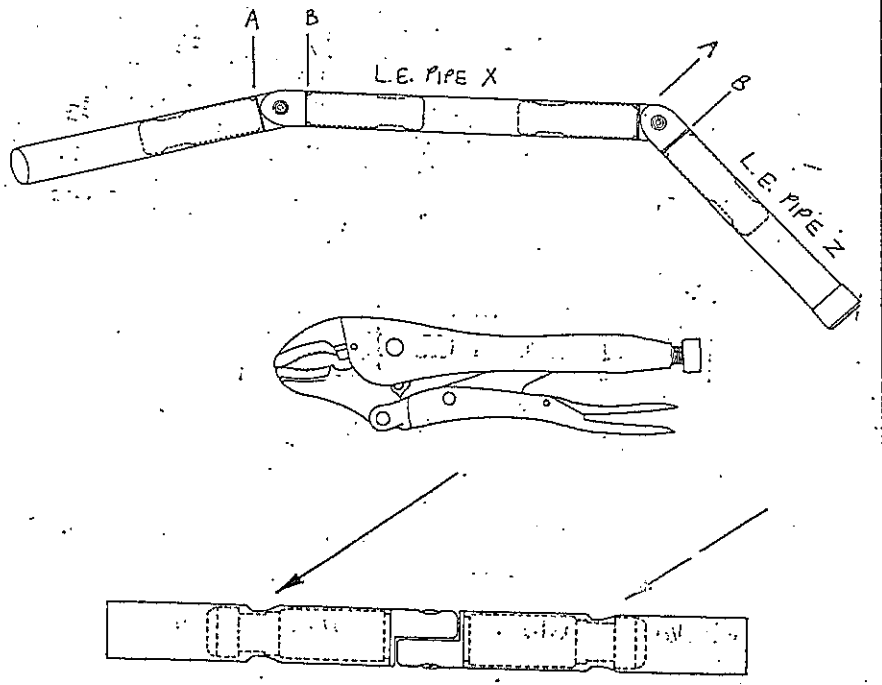
The top pieces of leading edge (on drawing referred to as L.E. PIPE X) require two nylon elbows since there is a joint at each end. A deduction of 1/2" (1/4" x 2") is required.

Using vice-grips, squeeze leading edge pipe in area around nylon elbow as indicated in drawing. This will ensure that nylon elbow will not slip out of leading edge pipe.

Insert adjoining section of nylon elbow into next section of leading edge. Secure in same manner as done previously.

Continue to add nylon elbows and leading edge as required.

Slide plastic caps onto bottom of side extensions of leading edge. These plastic caps will eliminate any sharp edges and will aid in the smooth operation of your system.

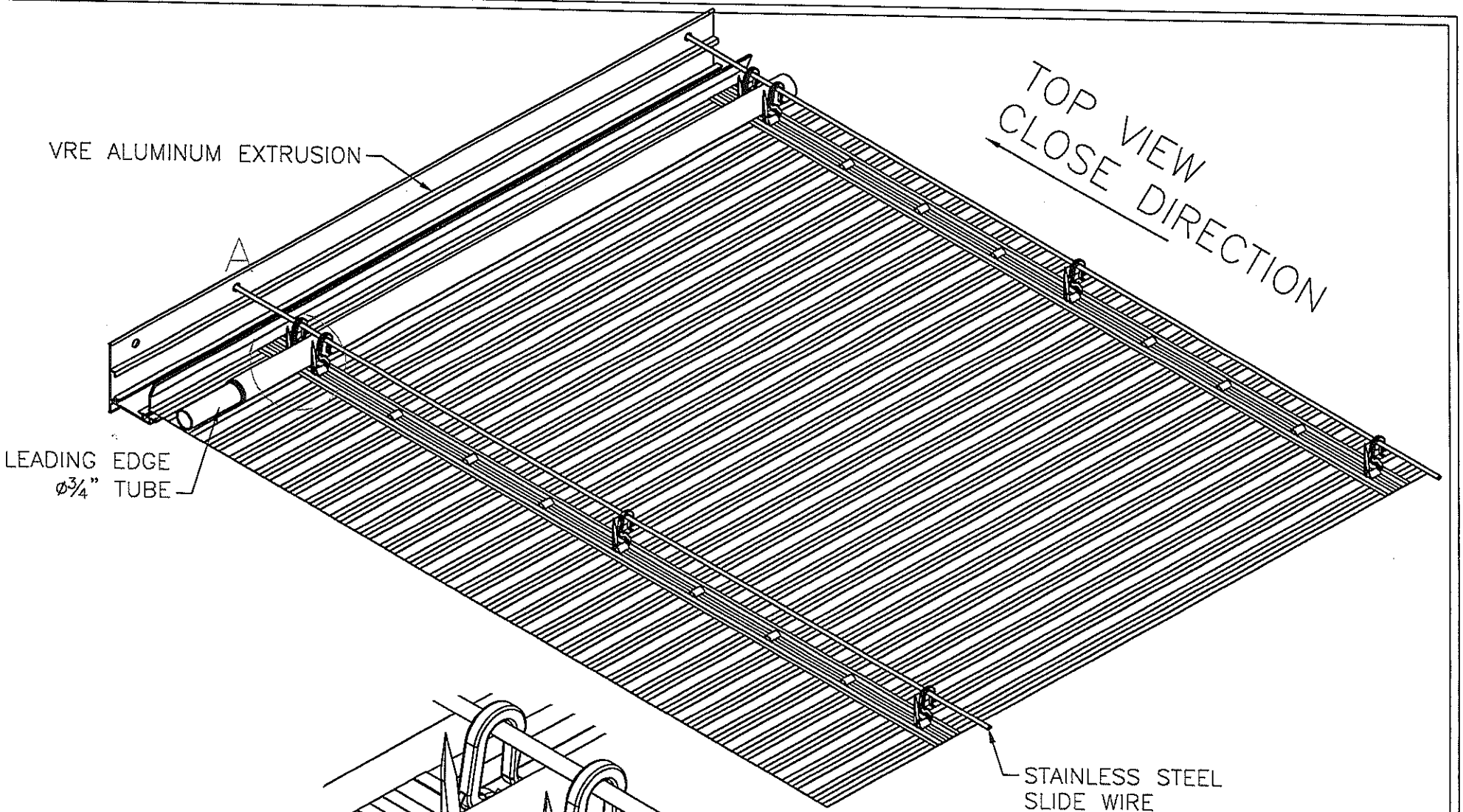


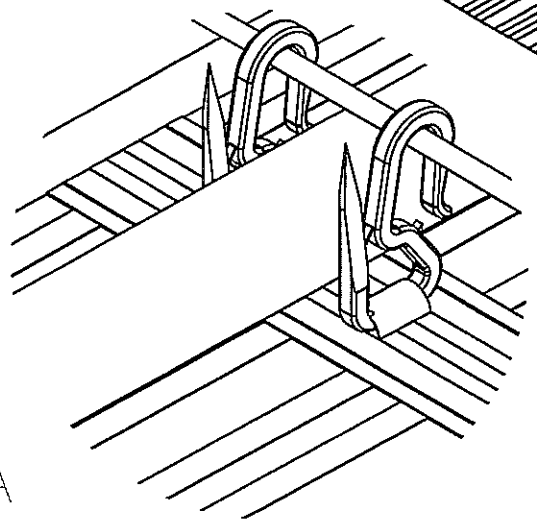
NOTE: ROBERTSON SCREWS CAN ALSO BE USED ON THESE CONNECTIONS

VRE GREENHOUSE SYSTEMS

TITLE: LEADING EDGE DETAILS		
DRAWN BY	SCALE N.T.S	MATERIAL
CHK'D	DATE 7/9/91	DRAWING NO.
TRACED	APP'D	

33Z-9120





DETAIL A

DRAWN BY MATT ZWIEP	DATE 07/08/03	REVISION NO.1 07/18/03	FINISH HDG	QTY. –	SCALE 1/4
DESIGNED BY G.A.DEKKER	CHECKED BY --	TITLE/NAME SUSPENDED CURTAIN HOOK TAPE			
VRE SHADE & SAVE	CUSTOMER --				
	DRG NO. CURTAIN SUSP SYS (1-2)				

FILE ❑ **INSTALLATION ❑** **SHIPPING ❑**

REQUIRED DATE: OCT 13/11

VRE SHADE & SAVE SYSTEMS

PARTS LISTING

DEALER SALE NO U.S. SALE YES

JOB NUMBER: # 10391 DATE: SEPT 2011

PROJECT: CAL POLY

LOCATION: SAN LUIS OBISPO, CA PHONE #

OF GREENHOUSES: ONE - 4 BENCHES MAKE:

1 SHADE 4 FT. WIDE x 52 FT. LONG MONO WIRES BOTTOM TOP

3 B/O 4 FT. WIDE x 52 FT. LONG ST/ST WIRES HOOK 4/BENCH BOOT

TOTAL AREA: 208/BENCH SQ. FT. TOTAL WIRES: 16

GLASS / POLY / COVERING POST SPACING 10 FT. 4 INCHES

GUTTER CONNECTED / FREESTANDING NO. OF SECTIONS PER HOUSE: 6

TOP FABRIC REQUIRED: XLS/60 HARMONY REV LS/100 POLYESTER TOTAL NO. OF SECTIONS: 2/BENCH

FABRIC DIMENSIONS: x # OF DRIVE CABLES:

COVERING TO MOVE: TRUSS TO TRUSS TOTAL CABLES:

CABLE TYPE: MANUAL

FLAT / ~~PEAK, SLIDING~~ / SUSPENDED ELECTRICAL POWER: PULL

WALL FABRIC REQUIRED: EXTENSION OF TOP POST HEIGHT FT. INCHES

SIDE WALLS ~~YES~~ / NO

MOTORIZED ~~YES~~ / NO # OF BOOT WIRES =

GABLE ENDS ~~YES~~ / NO

PERMANENT ? MOTORIZED ?

INSTALLATION INSTRUCTIONS:

TOP LINES CALCULATED AT x # OF BOTTOM LINES

DRIVE SHAFT U-JOINTS OR STRAIGHT

INSTALLED BY: VRE ❑ LDG ❑ LGS ❑ CUSTOMER ☑ SELF INSTALL

NOTES:

REVISED FEBRUARY 2009

VRE SHADE & SAVE SPECIFICATION LIST

JOB # 10391

ITEM #	REQ'D	DESCRIPTION	SHIPPED	FORMULA	B/O	DWG.#
AI-2x2x1/8G	60'	PLATED 2" x 2" x 1/8" (6 x 10')		FOR SUSPENSION OF ROOF FRAMES		
AI-2 x 2 x 1/4"	52'	PLATED 2" x 2 x 1/4" (4 x 13')		SYSTEM MOUNTING FRAME @ GABLES		
BN ½ x 1.5		½ " x 1 ½ " BOLTS				
BN-LN ½		½ " NYLOCK NUTS				
	30	CONCRETE SCREWS		SHORT - FOR ALUM ON B/O # TRIANGLES		
BN-HB1/4x2		1/4" x HEX BOLT				
BN-HB5/16x1	150	5/16" x 1" HEX BOLT				
BN-HB3/8x1.25		3/8" x 1¼" HEX BOLT		(5 PER DRIVE UNIT) + (2 BEARING PLATE)		
BN-HB3/8x1.5		3/8" x 1 ½" HEX BOLT		*1 PER RETURN PULLEY & BRACE & SLIDE WIRE BRACKET*		
BN-LN1/4		1/4" NY-LOCK NUT				
BN-KN5/16	150	5/16" LOCK NUT		2 PER 20-6 OR 20-8 OR ANY SQ.U-BOLT		
BN-KN3/8	80	3/8" LOCK NUT		2 PER THREADED ROD		
BN-LN3/8		3/8" NY-LOCK NUT		RETURN PULLEY / PULLEY HOUSING / U-JOINT SLEEVE - 2 x PIPE SLEEVE		
BN-SN7/16		7/16" SPACER NUT		2 PER RETURN PULLEY		
BN-FW1/4		1/4" FLAT WASHER				
BN-FW5/16USS	150	5/16" FLAT WASHER		2 PER THR.. ROD / OR "U" BOLT OR CLAMP PLATE		
BN-FW3/8	80	3/8" FLAT WASHER				
BN-HB3/8x3	80	3/8" x 3" HEX BOLT		1 PER PH-4638 OR 4641 PULLEY HOUSINGS 2/TU-6270 PIPE SLEEVE & 1/UJ-6515 'U' JOINT SLEEVE		
BN-THDROD3/8	10	3/8" x 9" THREADED ROD		1 PER CL-2610 CLAMP PLATE c/w BNKN 3/8 & BNKFW 3/8		
BN-TS5/8	100	TEK SCR 10-16 x 5/8		4x4 BRKT., SPACER BRKT., +1/100 SQ. FT., 3/4" TUBING, CONN. PLATES, BOOT WIRE		
BN-TS1/4X1	100	TEK SCR 1/4 - 20 x 1		4x4 BRKT., SPACER BRKT., +1/100 SQ. FT. + 2x SQUARE SLEEVE / ELBOW		
BN-TS5/8 ROB	50	TEK SCR 1/4 - ROB		ROBERTSON TEK SCREW 1 per 12' of 3/4" TUBE		
BN-		*SQUARE U-BOLT _____"*		*c/w 5/16 KN & 5/16 FW*		
BN-		SQUARE U-BOLT _____"		c/w 5/16 KN & 5/16 FW		
BN-		SQUARE U-BOLT _____"		c/w 5/16 KN & 5/16 FW		
BN-UB20-3		*U-BOLT 20-3 - 1 3/4" ID*		*c/w 5/16 KN & 5/16 FW*		
BN-UB20-4		U-BOLT 20-4 - 2" ID		c/w 5/16 KN & 5/16 FW		
BN-UB20-5	36+20	U-BOLT 20-5 - 2 1/2" ID		c/w 5/16 KN & 5/16 FW		
BN-UB20-6	20	*U-BOLT 20-6 - 3" ID*		*c/w 5/16 KN & 5/16 FW*		
BN-UB20-8		U-BOLT 20-8 - 4 1/2" ID		c/w 5/16 KN & 5/16 FW		
BR-2305		BRACKET 2.25x4 FOR GABLE ENDS		1BN-TS5/8&BN-TS1/4 FOR EA.= 1 PER 5' ON GABLE		
BR-2308	+ 30	*SPACERS FOR # EN- 3103*		*+ BN-TS5/8 + BN-TS1/4 - 1 PER 10' ALUM EXTRUSION*		
BR-CONECPLT	14	1" CONNECTION PLATES		1 PER JOINT IN VRE ALUM. EXTRUSION + BN-TS5/8		
BR-2331		SLIDE WIRE BRACKET - NO TIGHTENER		☐ SQUARE TUBE TYPE ☐ CLIP ON TYPE		
BR-2331T		*SLIDE WIRE BRKT. C/W # 3 TIGHTENER*		☐ SQUARE TUBE TYPE ☐ CLIP ON TYPE		
BR-2333		BOOT WIRE MTG. BRACKET (PAIR)		C/W S-HOOKS & WIRE TIGHTENER		
BR-2335		BRACKET FOR BRACE CONNECT		ON 2" x 2" SQUARE TUBE		
BR-2336		1 x 2 TRUSS BRACKET		ON 2" x 2" SQUARE TUBE		
BR-2340		BOOT WIRE BRACKET		ADD 1 BN-TS5/8 FOR EACH 1/11 FT. OF SIDEWALL		
BR-2341		B/O WALL BOOT WIRE BRKT.				
BR-2345		1 x 2 TRUSS BRACE BRACKET		AND 2 x 2 END FRAME MOUNTING COMBINATION		

VRE SHADE & SAVE SPECIFICATION LIST JOB # 10391

ITEM #	REQ'D	DESCRIPTION	SHIPPED	FORMULA	B/O	DWG.#
BR-2350		VERTICAL BAR MOUNT FOR		ROLL UP WALLS (IN GRADE INST'N)		
BR- END FRAME	4+32	2 x 3 ANGLE FOR SQ. TUBE MOUNTING		& MTG ANGLES ON 4 CORNER POSTS		
BR-SPEC	16	BRACKET TO MOUNT HRZ. TO		VRT 2" SQ. TUBES @ C		-6
BR-SPEC	32	BRACKET TO MOUNT BRACE		CONNECTIONS =C		-8
BR-SPEC	8	BRACKET TO PULL CURTAINS		1¼" × 39" TUBING		-9
BR-SPEC						
CH-2507		STAINLESS STEEL FABRIC CLIPS		2x # OF FT. OF VRE ALUM. EXTR. EN-3103		
CH-2510	300	PVC FABRIC CLIPS		FOR STATIONARY SEALS & CURTAIN END		
CH-2509	100	PVC " "		FOR REMOVABLE ENDS		
CH-2515	400	PVC "S" HOOK (in curtains)		MATCH TO LOOP TAPE - 1 PER FOOT		-24
CH-2515	40	PVC "S" HOOK "EXTRAS"		½ % EXTRA TO ABOVE FOR CHANGES		
CH-2518		TERRY CLIP 3/4" PLATED STEEL				
CH-2519	150	TERRY CLIP 3/4" BLK .PLASTIC				
CH-2522		DUTCH TYPE TOP WIRE CLIP				
CL-2603	50	CABLE CLAMP 1/8"				
CL-2605		2 PIECE OVAL CABLE CLAMP		2 PER SL- SLIDER		
CL-2610-6	20	6" CLAMP PLATE		2 PER FASTENING POINT - less than 3 ½" Post		
CL-2610-7		7" CLAMP PLATE		2 PER FASTENING POINT - greater than 3 ½" Post		
CL-2610-8		8" CLAMP PLATE		2 PER FASTENING POINT - greater than 5" Post		
CL-2611-7		7" CLAMP PLATE FRONT		FOR 2 x 3 ANGLE @ POSTS		
CL-2612		7" CLAMP PLATE BACK (FLAT)		FOR 2 x 3 ANGLE @ POSTS		
CL-2613-4		4" CLAMP PLATE FRONT		FOR 2 x 3 ANGLE & PH		
CL-2614		4" CLAMP PLATE BACK (FLAT)		FOR 2 x 3 ANGLE & PH		
CN-2702		JACK CHAIN		1 FT. PER AWNING PULLEY - PH-4603		
	528	LS LOCKING HOOKS		IN CURTAINS		-24
	50	" " " "EXTRA"				
DL-2809		CABLE ST/ST 7×7-3/32"		LENGTH × 2 + BRACING DIAGONALS		
DL-2808		CABLE ST/ST 7×19 1/8" 316		LENGTH × 2 + BRACING DIAGONALS		
DL-2811		PREMADES ____ FT. LONG		3 FT. LONGER THAN CURTAIN TRAVEL DIST.		
DL-2821		BEAR PLATE 2" VRE 3 BRGS.		1 PER 10 or 12 FT. DRIVE SHAFT PIPE		
DL-2823		SKID PLATES		SUSP. SYSTEM ONLY - 1 PER TUBE CARRIER - LE-CARRIER		
DL-28___		CABLE DRUM _____" STEEL		1 PER DRIVE CABLE		
DL-HAS32		HOSE CLAMP # 32 ST/ST		2 × # OF DRIVE CABLES		
DU-RW243		RW 243-_____D/UNIT _____V		SERIAL# _____ MODEL #		
DU-RW403		RW 403-_____D/UNIT_____V		SERIAL# _____ MODEL #		
DL-2830T		SHAFT BRACE BRACKET		BEARING PLATES C/W 2 or 4 - #3 TIGHTENERS		
DU-2921		RB50 MOUNTING BRKT FOR		DRIVE UNIT PLATE C/W SQ. SLOT		
DU-2932		MOUNTING BRACKETS FOR MC21		TO MOUNT MC-21 CONTROL BOX		

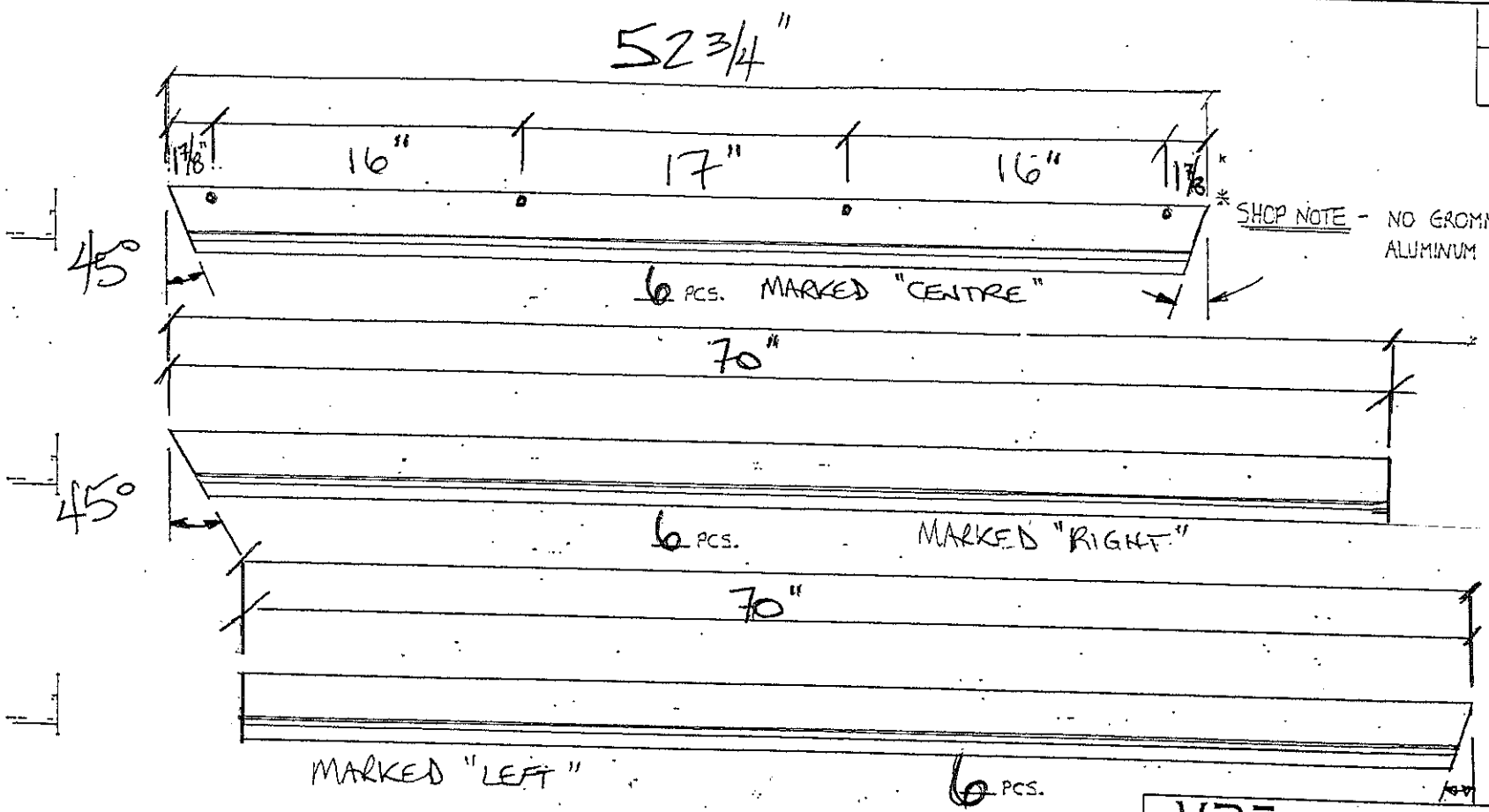
ITEM #	REQ'D	DESCRIPTION	SHIPPED	FORMULA	B/O	DWG.#
DU-BRACE		DRIVE UNIT DIAGONAL BRACE				
DU-2920		DR/UNIT FLAT MOUNTING PLATE		1 PER RIDDER 240/400 and 600 SERIES DU'S		
DU-2926		SELF ROLLUP MTR BRT/BRGS		1 PER WALL		
DU-2927		RIDDER ALUM GUIDE 3M				
DU-2928 or 30		RIDDER ROLL UP BRACKET		#28 = SHORT 6.75cm for TUBE MOTOR OR #30 = LONG 17cm for RW45		
DU-RMA115V		LOCK TUBE MOTOR 115V		C/W SWITCH, TUBING & DIA.		
DU.TWDUI:15		MANUAL HAND CRANK		1:15 RATIO DRIVE		
EL-3044		.4 HP LAFERT 220V 1 PHASE				
EL-3045		.5 HP LAFERT 208V 3 PHASE				
EL-3046		.12 HP LAFERT 208V 3 PHASE				
EL-3047		.12 HP LAFERT 220V 1 PHASE				
EL-4412		ROLL UP RELAY BOX				
EL-3084		VRE REMOTE CONTROL		c/w 40 ft. LVT WIRE		
EL-MC21		MC21 REVERSING MOTOR CONTROL BOX		1 PER MOTOR		
EN-3103	108	FT. VRE ALUM. EXTRUSION		STANDARD/REGULAR PROFILE		1,3
EN-3107	108	FT/GREY RUBBER - IN EXTR.		= to VRE. EXTRUSION # EN-3103 or 7000		1,3
EN-3107	FT	_____ x 3" PIECES OF RUBBER-GREY		1 PER LENGTH OF VRE EXTRUSION		
EN-7000		FT. VRE ALUM. EXTRUSION		HIGH PROFILE FOR GUTTER TO GUTTER		
FA-POLYBLK3MIL		3 MIL BLACK POLY 13'1/2"×328'				
FA-POLYBLK3MIL-2		3 MIL BLACK POLY 22' 11 ½" X328'				
FA-VRE55		SQ FT VRE/55		12 PCS.		
FA-SILVBLK	264	SQ FT SILVER/BLACK		54" TRIANGLES. +210" = 6 PCS.		
FA-OBAABBFB		SQ FT OBSCURA AA + BB Firebreak				
FA-LS100	2640	SQ FT LS/100		6 CURTAINS + 3 SHOWER CURTAINS		-2
~~FA-IL SHORTWW~~	90	~~WHITE/WHITE ROLL UP FABRIC~~				
FA-		SQ FT VRE/40FR				
FA-		SQ FT VRE/60FR				
	460	" " XLS/50 HARMONY		REVOLUX - 2 CURTAINS		-4
FA-XLSR10		SQ FT XLS 10 Revolux				
FA-XLS14FB		SQ FT XLS 14 Firebreak				
FA-XLS15FB		SQ FT XLS 15 Firebreak				
FA-XLS16FB		SQ FT XLS 16 Firebreak				
FA-XLS17FB		SQ FT XLS 17 Firebreak				
FA-XLSAAFB		SQ FT XLS A/A Firebreak				
FA-XLSR___		SQ FT XLS ____ REVOLUX				
FA-PH1		SQ FT PH 1 DOUBLE LAYER				
FA-PH55		SQ FT PH 55				
FA-PH66		SQ FT PH 66				
FA-PH77		SQ FT PH 77				
FA-PH98&1		SQ FT PH 98 & PH 1				
FA-SESTRIP	440	SUSPENSION TAPE		SEWN INTO CURTAINS		2,4
FB-1/8x1AL		FLAT BAR ALUM. 1/8 x 1"				

ITEM #	REQ'D	DESCRIPTION	SHIPPED	FORMULA	B/O	DWG.#
FS-3503		DOUBLE SIDED TAPE		FULL ROLL IS 75'		
FS-3509		RIVETS FOR 2" TUBES		4 PER TU-6201 CONNECTION FOR ROLL UP TUBE		
GR-3702		VRE GROMMETS		INSTALLED IN VRE ALUM. EXTRUSION		
LE WIREGD - LG		LONG WIRE GUIDE		TOP NYLONS x # SECTIONS		
LE WIREGD - ST		SHORT WIRE GUIDE		BOTTOM NYLONS x # SECTIONS		
LE-GATHER		COVER GATH STAINLESS		# =TUBE CARRIERS - (GTRGTR X 2)		
LE-ELBOW	15	NYLON ELBOW 3/4" TUBING		PEAK SYSTEMS ONLY WITH 20GA. TUBE*		
LE-CAP3/4	20	PLASTIC CAP 3/4"		1 PER END OF 3/4" SWAGGED TUBE		
LE-CARRIER	18	TUBE CARRIER ALUMINUM		SEE # OF DRIVE CABLES AND SECTIONS		
		16 Read				
MO-4410		2" STUB BRACKET				
PH-4603		AWNING PULLEY 1- 1/4" ALUM.		? # PER DRIVE 1 PER 30' HOUSE		
PH-4609		IDLER PULLEY ASSEMBLY 2"		2 PER DRIVE LINE IF REQUIRED		
PH-4617		NYLON PULLEY 2" W/BEARING		SUSPENDED SYSTEMS 4 PER DRIVE CABLE		
PH-4621		PULLEY HOUSING WITH 3" PULLEY		ASSEMBLED FOR 2" SQ. 2 PER DRIVE CABLE		
PH-4622		PULLEY 3" BLACK				
PH-4630		PULLEY HOUSING-2" SQUARE		c/w 3/8" BOLTS SEE BN SECTION		
PH-4637		3" PULLEY HOUSING CLIP ON		ASSEMBLED FOR 2" X 3" ANGLE		
PH-4641		PULLEY HOUSING DOUBLE 3"FITS ON 2" SQUARE		USE 2 3"PULLEYS - PH-4622 ON SUSPENDED SYSTEM - 2 PER DRIVE CABLE		
PH-4643		PULLEY HOUSING DOUBLE 3"FITS ON 2 x 3 ANGLE		USE 2 3"PULLEYS - PH-4622 ON SUSPENDED SYSTEM - 2 PER DRIVE CABLE		
PH-4647		SWIVEL PULLEY 2" BLACK				
PH-4650		SWIVEL PULLEY 2" REGULAR				
PH-4700		SPEED ATTACH AWNING PULLEY		SERVICE REPLACEMENT FOR PH4603		
PH-COVER		DBLE PULLEY HOUSING COVER				
PI-2G		STD. GALV. PIPE 2"		21 FT. PER LENGTH		
RO-5004		SASH CORD NO. 4				
RO-5005		SASH CORD NO.5				
RO-5008		BUNGEE CORD 5/16"		= # ' OF TU-6200 ROLL UP WALL TUBE		
SL-5501 MOD		MODIFIED ADJUSTABLE DELAY		MODIFIED WITH ALUM. CARRIER BLOCK		
SL-5506		SLIDERS 6"		SLIDER CUT AND LE CARRIER ATTACHED		
SL-5512		SLIDERS 12"		2 PER DRIVE LINE		
SL-5518		SLIDERS 18"		SLIDER CUT AND LE CARRIER ATTACHED		
SL-5524		SLIDERS 24"		SLIDER CUT AND LE CARRIER ATTACHED		
SL-5536		SLIDERS 36"		SLIDER CUT AND LE CARRIER ATTACHED		
SL-5548		SLIDERS 48"		SLIDER CUT AND LE CARRIER ATTACHED		
SL-5560		SLIDERS OVER 48"		SLIDER CUT AND LE CARRIER ATTACHED		

ITEM #	REQ'D	DESCRIPTION	SHIPPED	FORMULA	B/O	DWG.#
ST-5807	1	ST/ST STAPLES FOR RAPID 31				
ST-5804	1	STAPLER-RAPID 31		1 PER ORDER		
TI-6009	16+4	WIRE TIGHTENER #3		FOR SUSPENSION STIFFENER WIRES		
TU-6200		ALUM. TUBE FOR SELF ROLL WALLS		PIECES OF 21' OR 24' C/W TU-6201 INSTALLED		
TU-6201		ALUM. TUBE 9" CONNECTORS		1 PER # TU-6200		
TU-6204	120'	TUBING 3/4 OD x 20 GA 10 12' ers		TOTAL TO EQUAL VRE ALUM. EXTRUSION EN-3103 PLUS AS REQUIRED FOR B/O CORNER BOOTS		
TU-62	32'	TUBING 27mm (1" DIA)		8 PCS - 4' LONG		
TU-62		TUBING				
TU-BRSQINS		SQ. INSERT FOR 1.5" BRACE TUBE		1 PER BRACE TUBE BELOW		
TU-1.514SG		TUBING 1½ SQ. x 14 GA		BRACING (____ x 12')		
TU-BRRNDINS		RND. INSERT FOR 1.25" BRACE TUBE		1 PER BRACE TUBE BELOW		
TU-1.2514SG		TUBING 1 1/4 SQ. x 14 GA		BRACING (____ x 5')		
TU-6220	16	TUBING 1 5/16 x 14 GA x ~~39"~~		~~ROLL UP WALL GUIDE TUBE~~ BRACE C/W FLAT ENDS		
TU-6250		U CONNECTOR FOR 2x2 SQ. GALV.		SQUARE TUBE CONNECTORS 1 PER 20'		
TU-6260G	176'	2" SQ. TUBING PLATED, 16 x 11' PCS.		LENGTH OF GABLE END/SIDE VRE EXTRUSION x 2		
TU-626~~0~~G	48'	" VRT. SUPPRT C/W U		BRKT. 35 3/4" LONG x 16 PCS		-5
TU-6260G	36'	" HRZ " C/W TABS		53" LONG C/W 4 TABS x 8 PCS		-7
· ttt	18'	PLAIN HORIZONTAL		4 x 53" LONG FOR CENTRE MOUNTS		
UJ-6519		PIPE INSERT W/ UNIVERSAL JOINT		ASSEMBLED UJ-6515 AND UJ-6517		
UJ-6550		2" SQ. ELBOW FOR 2" SQ.		PEAK SYSTEM C/W 2" x 3/8" BOLT & NUT		
UJ-						
WI-6705	250'	MONO WIRE 2.5mm ROLL		(5900 FT. PER SPOOL) REQUIRED @ 18" SPACING		
WI-6710SS	1000'	STN/STL SLIDE WIRE .078 (65'/lb)		@ 65 FEET PER POUND = 16 LBS.		
PARTS LIST	1	SHADE & SAVE PARTS LIST				
TOOL KIT						
	1	ROBERTSON HEAD SCREW GUN TIP		FOR LE CONNECTIONS IN **USA ONLY**		

DRAWING #	FABRICATION DRAWINGS	DRAWING #	INSTALLATION DRAWINGS
10391 -1	ALUM. EXTR. FOR B/O	10391 -11	POST LAYOUT
" -2	CURTAINS FOR B/O	" -12	OVERVIEW + SOUTH ELEVATION
" -3	ALUM. EXTR. FOR SHADE	" -13	ISO METRIC VIEW
" -4	CURTAINS FOR SHADE	" -14	NORTH END ISO VIEW W/O TIGHTENER
" -5	VRT. SUPPORTS FOR END FRAMES	" -15	MIDDLE CLOSURE DETAIL
" -6	HORZ. MTG. BRKT FOR SQ. TUBE	" -16	
" -7	HRZ SUP - 2" SQ C/W TABS (4)	" -17	
" -8	BRACE CONNECTOR	" -18	
" -9	TUBE CARRIER SUPPORT	" -19	
" -10	ENDS & CLOSURE FABRIC	" -20	

EN-3103
SUSPENDED SYSTEM



* SHOP NOTE - NO GROMMETS ALUMINUM IS PUNCHED

108' EXTRUSION

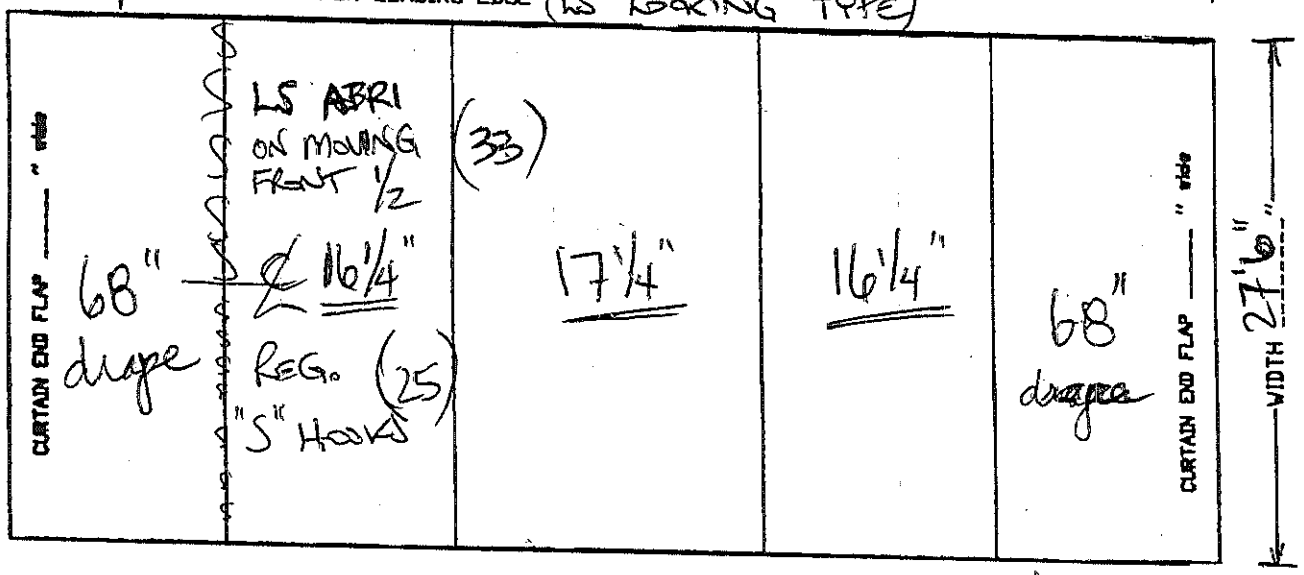
VRE GREENHOUSE SYSTEMS

TITLE: CAL POLY B/O BENCH		
DRAWN BY	SCALE NTS.	MATERIAL
CHK'D	DATE	DRAWING NO 10391-1
TRACED	APP'D	

VIRE SPACING .16. .17. .16. = ____'TOTAL

LENGTH 185 3/4" (15' 5 3/4")

DOUBLE HOOK FOR LEADING EDGE (LS LOCKING TYPE)



NOTE: 9/w 6" Hook SPACING

FINISHED SIZE

POST SPACING 312" + 2% shrinkage = 318"
+ 45" TO CLIP FABRIC TO EXTRUSION = 324"
+ 15" FOR FRONT FABRIC SEALING FLAP = 330"
THEN CALCULATE ANY SEAMS REQUIRED

27'6" WIDE x 16' LONG = 440 SQ.FT. x 6 PCS. = 2640 SQ.FT.
___' WIDE x ___' LONG = _____ SQ.FT. x ___ PCS. = _____ SQ.FT.
___' WIDE x ___' LONG = _____ SQ.FT. x ___ PCS. = _____ SQ.FT.

TOTAL SQ.FT.FABRIC. = _____ SQ.FT.

CURTAIN FABRIC REQUIRED LS/100 CLOTH

No. OF PCS. FABRIC REQUIRED 6 = No. OF SECTIONS

LENGTH OF VRE EXTRUSION _____' - (bootwire from ends 2x ___ = ____) = _____' + (2% shrinkage____) = _____

+ (end flaps 2x___=____) =_____' = LENGTH ___'___".

BOOT FABRIC REQUIRED LS/100

		SQ.FT.FABRIC
GABLE ENDS	___ Pcs. ___ " Wide x ___'___" Long	_____ SQ.FT
SIDE BOOTS	___ Pcs. ___ " Wide x ___'___" Long	_____ SQ.FT
UNDER GUTTER BOOTS	___ Pcs. ___" Wide x ___'___" Long	_____ SQ.FT
TOTAL BOOT FABRIC :		_____ SQ.FT

	PER CURTAIN	# OF CURTAINS	TOTAL
LOOP TAPE	55' x	6 =	330'
ABRI LOCKING HOOK (33x2)	x	6 =	396
REG. "S" HOOKS	50' x	6 =	300

☐ LINES ONLY

☑ SUSPENSION TAPES WITH S HOOKS

VRE CARTS & MERCHANDISING

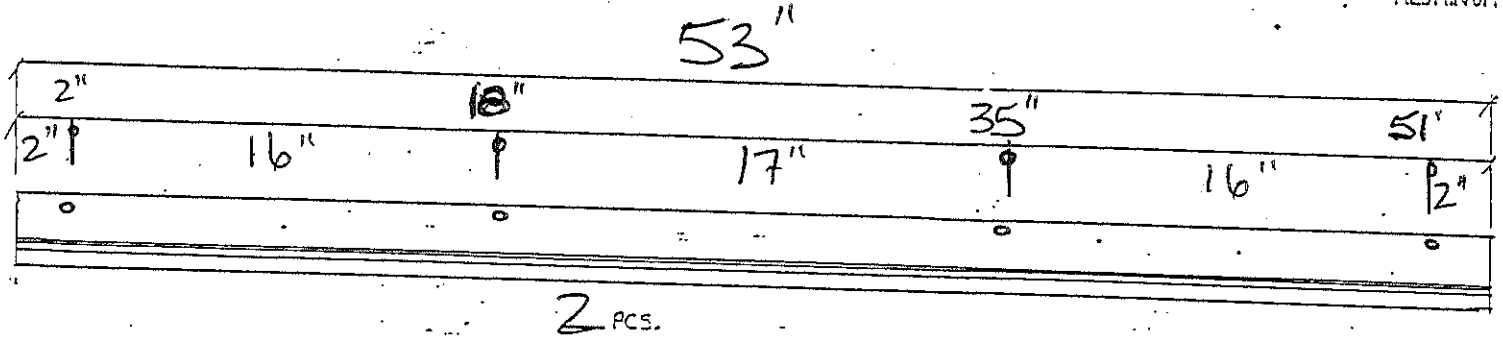
CUSTOMER: CAL POLY - SLO

TITLE: SUSPENDED CURTAIN DRAWING

DRAWN BY:	SCALE: NTS	MATERIAL:
CANADA ☐ U.S.A. ☑	GIVEN TO SHOP: ___/___/___ DATE REQ'D ___/___/___	DRAWING NO. 10391-Z

EN-3103
SUSPENDED SYSTEM

*SHOP NOTE - NO GROMMETS
ALUMINUM IS PUNCHED



FOLD OVER & STAPLE RUBBER @ BOTH ENDS

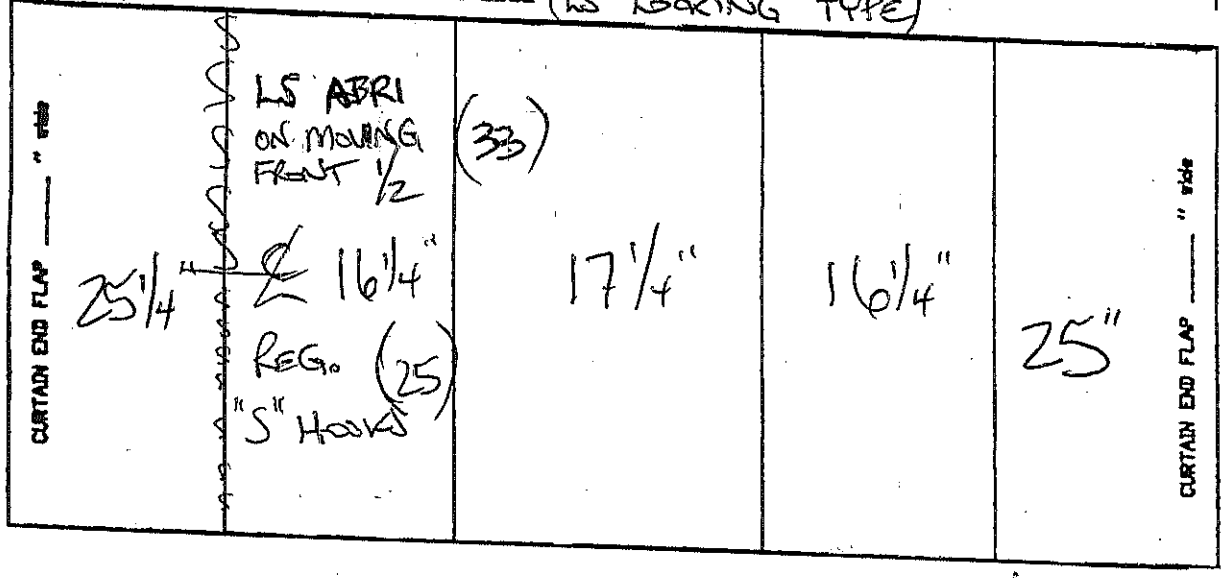
9'

VRE GREENHOUSE SYSTEMS		
TITLE: CAL POLY - SHADE BENCH		
DRAWN BY	SCALE NTS	MATERIAL
CHK'D	DATE	DRAWING NO 10391-3
TRACED	APP'D	

VIRE SPACING 16. 17. 16. = ____"TOTAL

LENGTH 8'4" (100")

DOUBLE HOOK FOR LEADING EDGE (LS LOCKING TYPE)



NOTE: 6" HOOK SPACING

FINISHED SIZE

POST SPACING 312" + 2% shrinkage = 318"
+ 4.5" TO CLIP FABRIC TO EXTRUSION = 324"
+ 7.5" FOR FRONT FABRIC SEALING FLAP = 330
THEN CALCULATE ANY SEAMS REQUIRED

27'6" WIDE x 8'4" LONG = 230 SQ.FT. x 2 PCS. = 460 SQ.FT.
___'___" WIDE x ___'___" LONG = _____ SQ.FT. x ___ PCS. = _____ SQ.FT.
___'___" WIDE x ___'___" LONG = _____ SQ.FT. x ___ PCS. = _____ SQ.FT.

TOTAL SQ.FT.FABRIC = _____ SQ.FT.

CURTAIN FABRIC REQUIRED XLS/50 HARMONY REVOLUX

No. OF PCS. FABRIC REQUIRED 2 = No. OF SECTIONS

LENGTH OF VRE EXTRUSION _____' - (bootwire from ends 2x ___ = ____) = _____' + (2% shrinkage____) = _____.

+ (end flaps 2x___=____) =_____' = LENGTH ____'___".

BOOT FABRIC REQUIRED _____

		SQ.FT.FABRIC
GABLE ENDS	___ Pcs. ___ " Wide x ____'____" Long	_____ SQ.FT
SIDE BOOTS	___ Pcs. ___ " Wide x ____'____" Long	_____ SQ.FT
UNDER GUTTER BOOTS	___ Pcs. ___" Wide x ____'____" Long	_____ SQ.FT
TOTAL BOOT FABRIC:		_____ SQ.FT

- - - - - ☐ LINES ONLY

_____ ☐ SUSPENSION TAPES WITH S HOOKS

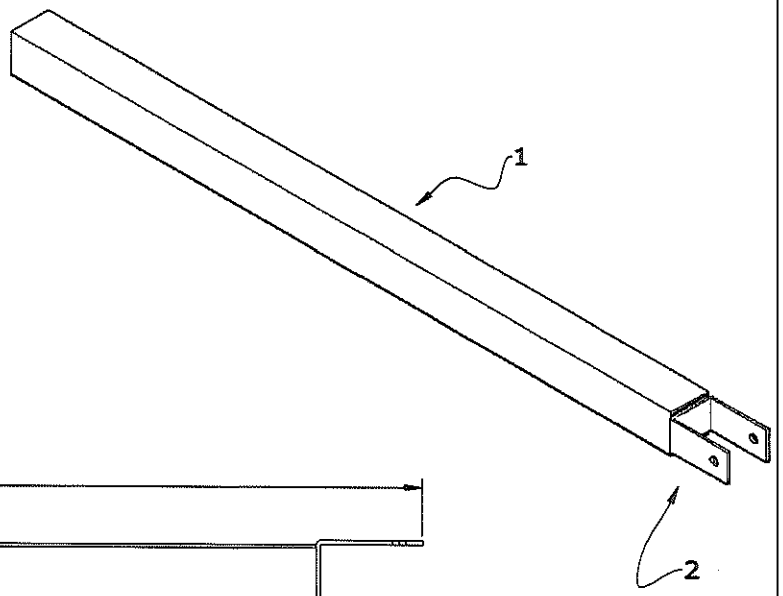
	PER CURTAIN	# OF CURTAINS	TOTAL
LOOP TAPE	55	2	110
ABRI Locking Hook (33x2)	66	2	132
REG. "S" HOOKS	50	2	100

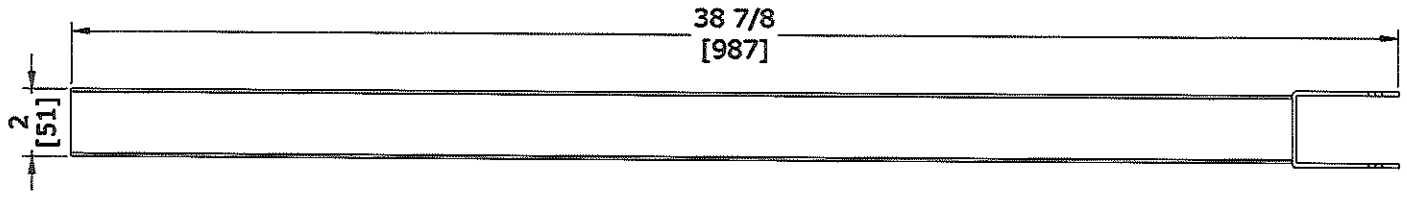
VRE CARTS & MERCHANDISING

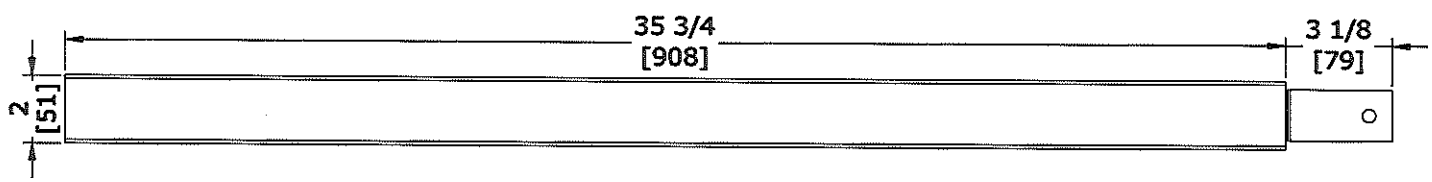
CUSTOMER: CAL POLY - SHADE

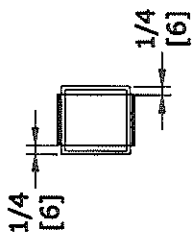
TITLE: SUSPENDED CURTAIN DRAWING

DRAWN BY:	SCALE: NTS	MATERIAL:
CANADA ☐ U.S.A. ☑	GIVEN TO SHOP: ___/___/___ DATE REQ'D: ___/___/___	DRAWING NO. 10891-4







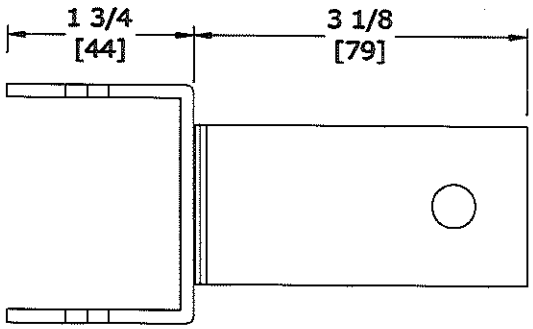


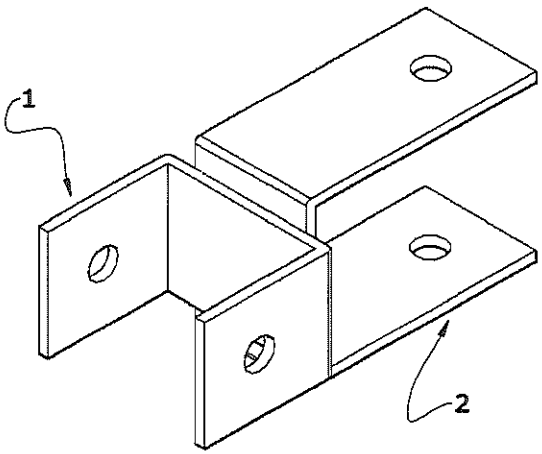
10391-5

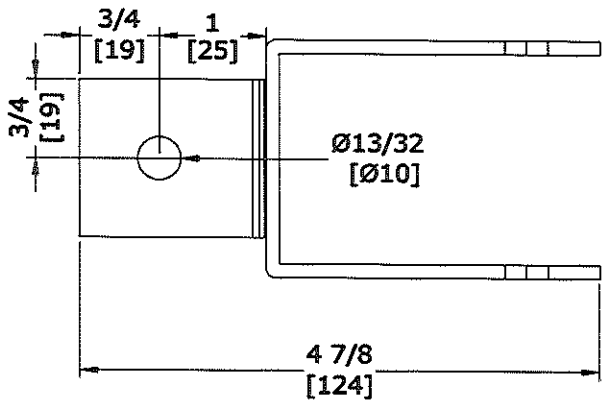
ITEM	QTY	NAME	MATERIAL	DIM
2	2	BR-2331	2" U-BRACKET	STK
1	1	VRT_TU	SQ.TU_2 X 2 X .100	908

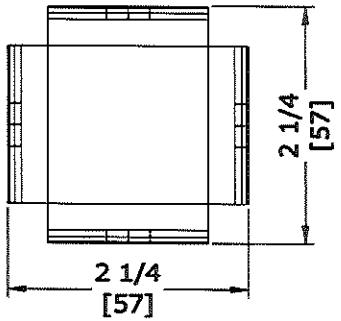
Parts List

DRAWN BY: MS	DATE: 29/07/2011	REV#	BY -	FINISH: HDG	QTY.: 16	SCALE: NTS
		REV.DATE -				
DESIGNED BY: GAD	CHECKED BY: ---	TITLE/NAME: VRT-SUP				
VRE SHADE & SAVE	CUSTOMER: CAL-POLY					
	DRG NO.: 10391-PARTS			SH.# 1 OF 1	UNITS: [ ] (mm)	







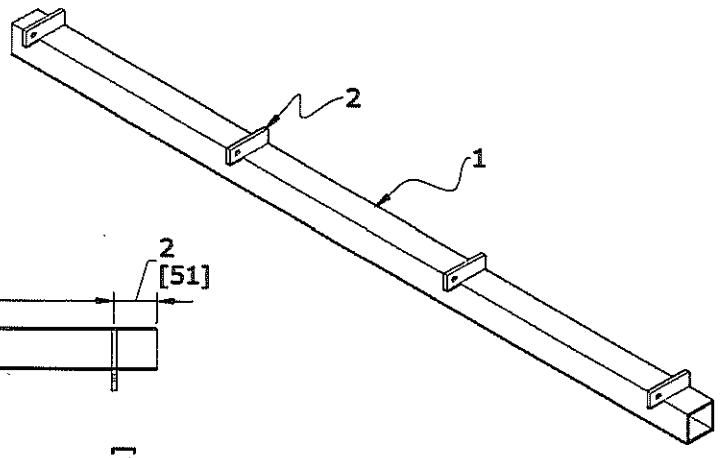


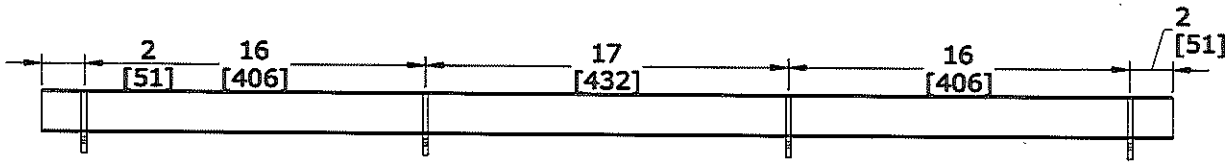
10391-6

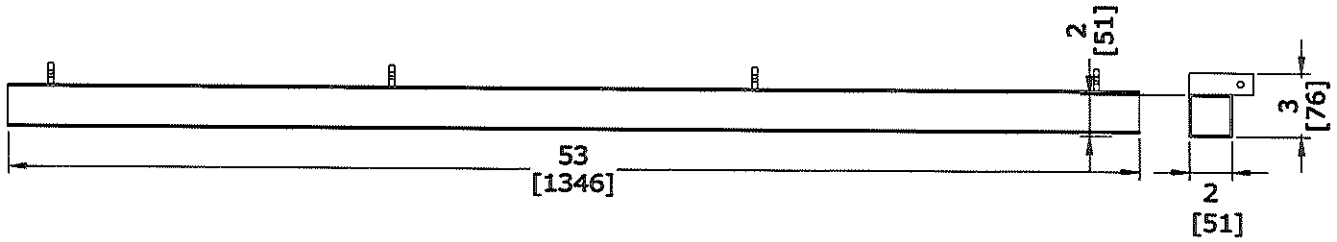
ITEM	QTY	NAME	MATERIAL	DIM
2	2	BR-2331	2" U-BRACKET	STK
1	1	CUT-BR-2331	2" U-BRACKET	133

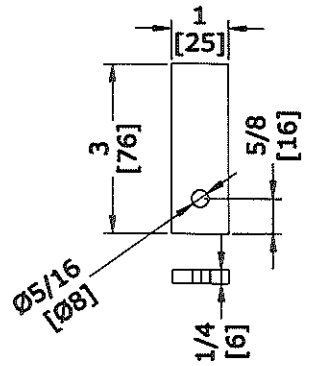
Parts List

DRAWN BY MS	DATE 29/07/2011	REV# BY. REV.DATE -	FINISH HDG	QTY. 16	SCALE NTS	
DESIGNED BY GAD	CHECKED BY ---	TITLE/NAME HORZ.SYSTEM MTG.BRKT				
VRE SHADE & SAVE	CUSTOMER CAL-POLY					
	DRG NO. 10391-PARTS	SH.# 1 OF 1 UNITS (mm)				







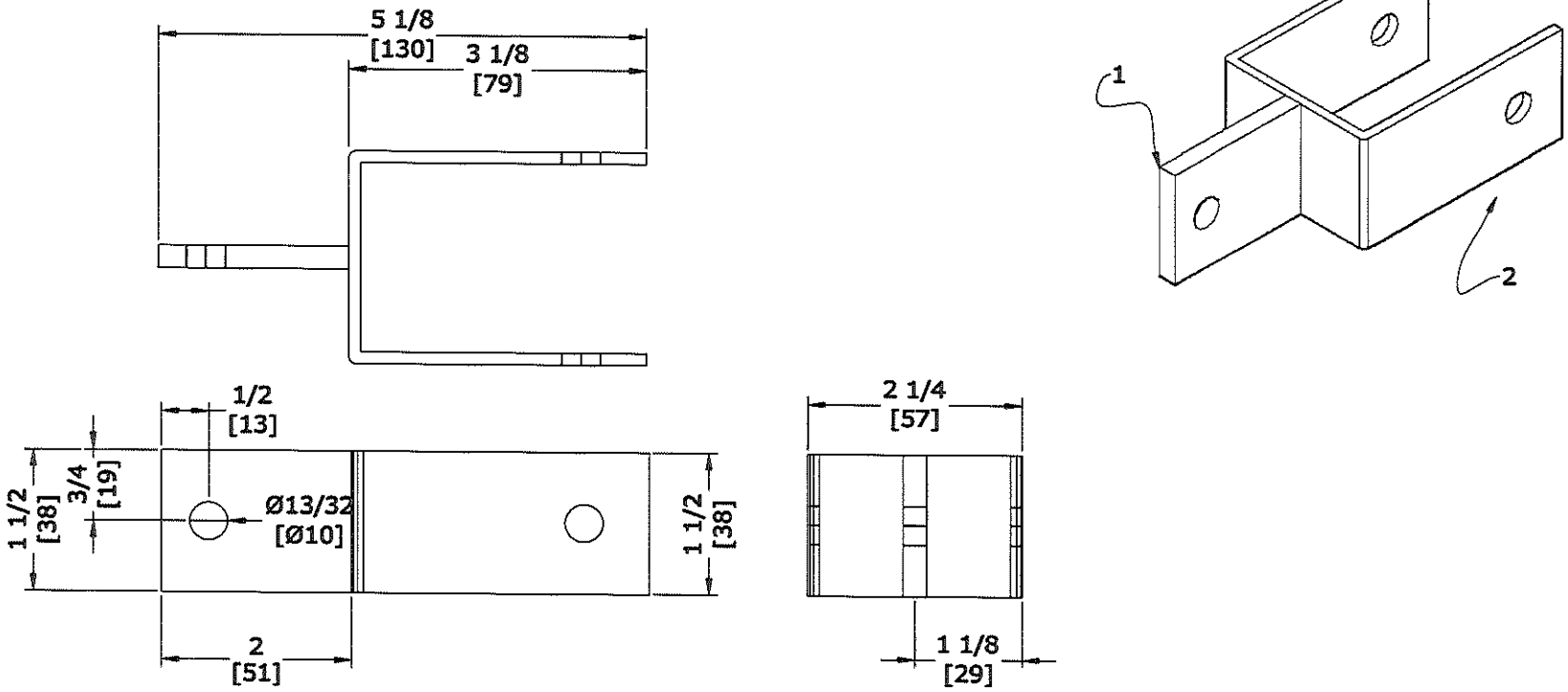


10391-7

ITEM	QTY	NAME	MATERIAL	DIM
2	1	W-TAB	FB - 1 X 3 X 1/4	76
1	1	HRZ_TU	SQ.TU 2 X 2 X .100	457

Parts List

DRAWN BY: MS	DATE: 29/07/2011	REV#	BY.	FINISH: HDG	QTY.: 8	SCALE: NTS
		REV.DATE --				
DESIGNED BY: GAD	CHECKED BY: ---	TITLE/NAME: HRZ-SUP				
VRE SHADE & SAVE	CUSTOMER: CAL-POLY					
	DRG NO.: 10391-PARTS				SH.# 1 OF 1	UNITS: [mm]

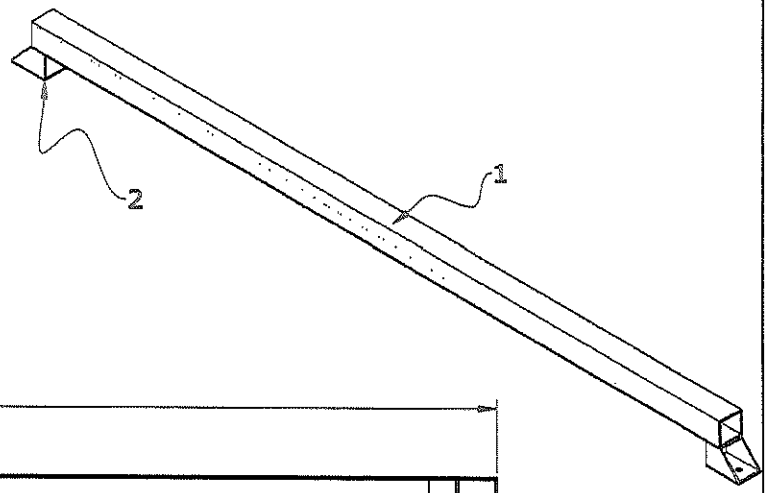


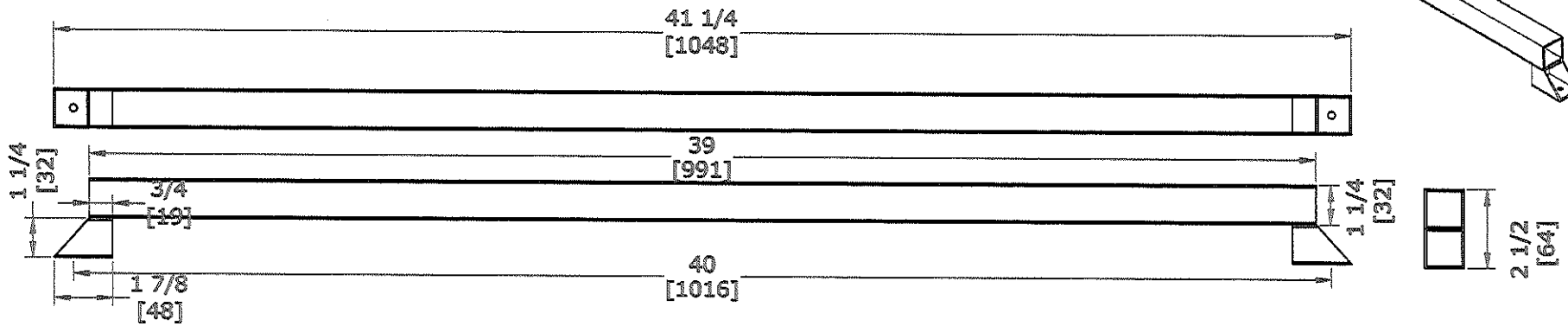
ITEM	QTY	NAME	MATERIAL	DIM
2	2	BR-2331	2" U-BRACKET	STK
1	1	TAB	FB_1½ X 1/8	51

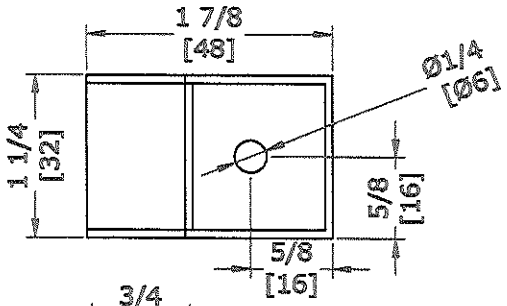
Parts List

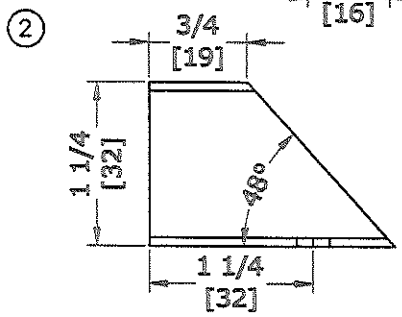
10391-8

DRAWN BY MS	DATE 29/07/2011	REV# BY -	FINISH HDG	QTY. 32	SCALE NTS	
DESIGNED BY GAD	CHECKED BY ---	REV.DATE -	TITLE/NAME BRACE CONNECTOR			
VRE SHADE & SAVE	CUSTOMER CAL-POLY					
	DRG NO. 10391-PARTS		SH.# 1 OF 1	UNITS [mm]		









10391-9

ITEM	QTY	NAME	MATERIAL	DIM
2	1	PRT2	SQ.TU 1.25X1.25X16GA	48
1	1	HRZ_TU	SQ.TU 1.25X1.25X16GA	991

Parts List

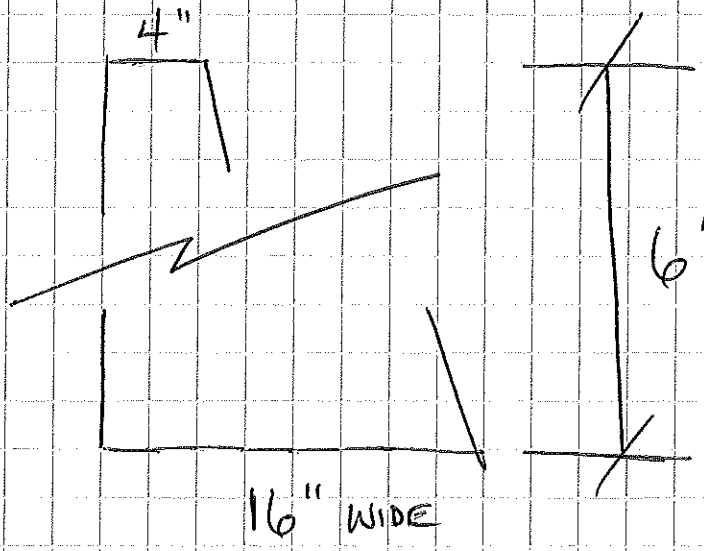
DRAWN BY: MS	DATE: 05/10/2011	REV# / BY / REV.DATE: -	FINISH: HDG	QTY.: 8	SCALE: NTS	
DESIGNED BY: GAD	CHECKED BY: ---	TITLE/NAME: TUBE CARRIER SUPPORT				
VREM SHADE & SAVE	CUSTOMER: CAL-POLY					
	DRG NO.: 10391-9				SH.# 1 OF 1	

SEPT 2011

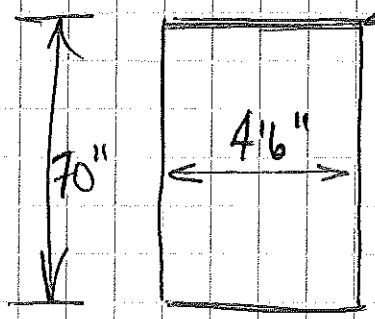
CAL POLY SEAL FABRIC
10391-10

6 PCS. BLACK/SILVER END COVERS
- 5' WIDE x 7' HIGH (35# EA)
  FOR ENDS OF BENCH TO BE CUSTOM CUT PER END FRAME
- 3 WILL BE FIXED PERMANANT AT 'N.' ENDS WITH CH-2510 CLIPS GREY TYPE
- 3 WILL BE CUSTOM FIT & MOUNTED WITH CH-2509 BLACK PVC FABRIC CLIPS THAT ARE REMOVEABLE ON 'S' ENDS

12 PCS. BLACK/SILVER 'TRIANGLE' COVERS FOR CLOSURE END OF 6 CURTAINS



3 PCS VRE 100 'S' END 'SHOWER' CURTAINS



Appendix C

PRODUCT SPECIFICATION SHEETS

- LS 100
- XLS 50 HARMONY REVOLUX
- BEAMFLICKER

T: +1 704 357 0457
F: +1 704 357 0460
A: 535 Griffith Rd | Charlotte, NC 28217 | USA
E: info.us@svenssonamericas.com
www.svenssonglobal.com/us

LS 100

Product information	
Article number	1758
Field of application	Energy saving, solar reflection, decoration
System	Sliding, hanging
Material composition	100% polyester
Pattern	
Standard widths (cm)	90, 180
Flame retardant	No
Warranty	5 years under all types of greenhouse covering, see Svensson's limited warranty for all terms, conditions and exclusions in writing.

Mechanical properties	Value	Unit	Test methods
Weight	228	g/m^2	
Thickness	0.5	mm	
Width of strips		mm	
Tensile strength* (length/width)		N	ISO 13934-1
Elongation* (length/width)		%	ISO 13934-1
Opening		mm	
Ventilation reduction		%	Svensson method
Insect to exclude			

Physical properties	Value	Unit	Test methods
Direct light, PAR** transmission	0.10	%	Integrated sphere
Diffused light, PAR** transmission	0.10	%	"
UV-light*** transmission	0	%	"
Shading efficiency			Svensson method
Energy saving	43	%	"
IR-transmission		%	Emissiometer
Emissivity upper side		%	"
Emissivity lower side		%	"
Humidity transport		$g/m^2 h$	EN 31 092, ISO 11 092

* Width 50 mm
** PAR = 400 - 700 nm, accuracy +/- 1%
*** UV-light = 300 - 400 nm

This sample is for illustrative purposes only and may vary in appearance and design from the delivered product. Although the information in this data sheet has been composed with care, Svensson does not accept any liability in respect of its accuracy. Further information concerning the product and its installation may be obtained from Svensson and its authorized distributors. Svensson's products and name are protected by patent and other intellectual property rights. The REVOLUX product range is flame retardant. No other products delivered by Svensson are flame retardant. AB Ludvig Svensson is an ISO 14001/9001 certified company.

Last updated 2012/08/06

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E: info.us@svenssonamericas.com
www.ludvigsvensson.com

XLS 50 HARMONY REVOLUX

Product information	
Article number	4765
Field of application	Energy saving, solar reflection, light diffusion, flame retardant performance
System	Sliding, hanging
Material composition	100% polyester
Pattern	2 white plastic, 1 plastic, 1 white plastic, 1 plastic
Standard widths (cm)	335, 430, 470, 530
Flame retardant	Yes
Warranty	5 years under all types of greenhouse covering, see Svensson's limited warranty for all terms, conditions and exclusions in writing.

Mechanical properties	Value	Unit	Test methods
Weight	63	g/m^2	
Thickness		mm	
Width of strips	4	mm	
Tensile strength* (length/width)		N	ISO 13934-1
Elongation* (length/width)		%	ISO 13934-1
Opening		mm	
Ventilation reduction		%	Svensson method
Insect to exclude			

Physical properties	Value	Unit	Test methods
Direct light, PAR** transmission	50	%	Integrated sphere
Diffused light, PAR** transmission	46	%	"
UV-light*** transmission		%	"
Shading efficiency			Svensson method
Energy saving	47	%	"
IR-transmission		%	Emissiometer
Emissivity upper side		%	"
Emissivity lower side		%	"
Humidity transport		$g/m^2 h$	EN 31 092, ISO 11 092

* Width 50 mm
** PAR = 400 - 700 nm, accuracy +/- 1%
*** UV-light = 300 - 400 nm

This sample is for illustrative purposes only and may vary in appearance and design from the delivered product. Although the information in this data sheet has been composed with care, Svensson does not accept any liability in respect of its accuracy. Further information concerning the product and its installation may be obtained from Svensson and its authorized distributors. Svensson's products and name are protected by patent and other intellectual property rights. The REVOLUX product range is flame retardant. No other products delivered by Svensson are flame retardant. AB Ludvig Svensson is an ISO 14001/9001 certified company.

Last updated 2012/08/06

BEAM FLICKER

e - SYSTEM

PARsource e-series

Photoperiod Control

An oscillating parabolic reflector with a high-intensity sodium lamp flicks beams of light from one end of the greenhouse to the other, providing intermittent light across the entire crop.

BEAM e flicker-

Optional diffuser available

- *A highly efficient, cost-saving oscillating light source*
- *Covers up to 30' x 90', depending on lighting requirements*
- *Delivers enough light throughout a greenhouse to either prevent or promote bud dormancy*
- *Saves up to 80% in energy costs vs. traditional lighting*
- *Lasts up to 20 times longer than traditional incandescent lighting*
- *Lightweight– easy to install*
- *Microprocessor controlled electronic ballast gains up to 15% efficiency over magnetic ballasts.*
- *US Patent# 5,095,414*

BEAMflicker Specifications

INPUT VOLTAGE OPTIONS: 120, 240

AMPERAGE (APPROX.):

Wattage	120 Volts	240 Volts
400 watt	3.8 amps	1.7 amps
600 watt	5.5 amps	2.6 amps

BULB TYPES: High Pressure Sodium

BULB WATTAGES: 400, 600

SIZE: 10"H x 12"W x 20"L

WEIGHT: 9.5 lbs

2 YEAR Warranty

e - BALLAST

SIZE: 3⅛" H x 4½" W x 10¾" L

WEIGHT: 12 lbs

800.634.9990

parsource.com