AUSTRALIAN-INTERNATIONAL

MODEL SOLAR CAR

CHALLENGE

2002

REGULATIONS

These regulations apply to the

Australian-international Model Solar Car Challenge

and to the

South Australian Model Solar Electric Challenge

5 February 2002

MISSION STATEMENT.

To promote and develop interest and expertise in using solar and renewable energies by school students throughout the world by using active learning processes in addressing real challenges. By so doing, it is hoped that the citizens, scientists and engineers of the future will be more likely to participate in developing a more environmentally aware approach to energy usage, both by more efficient use of old technologies and appropriate introduction of renewables.

OVERVIEW

This is a race for model solar cars built by school age students which compete over a 100 metre figure "8" circuit. Two cars race at a time guided by parallel guide channels attached to the track surface. Time trials are held over a 14 metre distance and the speeds are used to "seed" the cars, ie. allocate them to groups in such a way that the faster cars should not compete with each other in the earlier rounds. A "round robin" involving 3 preliminary rounds in which each car races three other designated cars, will begin the competition. At the end of these rounds, the cars with the greatest number of wins are allocated into groups which compete in an elimination competition in which the winners continue to the next round, the losers are eliminated and race no further. This process of elimination continues until a winner is decided by being the only undefeated car. Final rounds may consist of a number of "heats" in which each car may win one heat. However, the winner will be the car which wins most heats.

1. INTRODUCTION

1.1 Event name
The event shall be known as the "Australian-International Model Solar Car Challenge" (AIMSCC) and is conducted annually.

1.2 Committee
The Executive Committee of the Australian-International Model Solar Car Challenge is a voluntary committee consisting of State Coordinators and other invited interested persons and refered to herein as the Committee. The roles of the Committee include establishing the regulations for the year and organising the Australian event to which nominated teams from other countries will be invited. The Committee will also promote the event throughout Australia and world-wide to the best of their ability and within the available resources.

1.3 Aim
The aim of the event is to encourage student teamwork, enterprise and learning using an action based learning model as students work together to research science and engineering principles relating to solar energy, photovoltaic cells and optimisation of energy efficiency, by designing, constructing, testing and racing model solar cars.

1.4 Spirit of Intent
The Challenge is designed for students to learn. Teachers, parents or other adult advisers are encouraged to teach the students the appropriate scientific and technical principles, but the design and manufacture must be predominantly that of the students. Some components may need to be made for the car using equipment unavailable to the students, but they must understand the working of their car and must be able to make all necessary adjustments or repairs on the weekend of the race.
So that the competition remains financially accessible to as many schools as possible the Committee has framed these regulations so the power to weight ratio of the photovoltaic panel is similar for all entries, so that lower cost, mono-crystalline, poly-crystalline or amorphous silicon cells are competitive.

1.5 Competitors
The competition is open to invited Australian schools or other organizations for school aged students to secondary level, approved by the Committee, based on their performance in state or regional competitions. Invitations will also be issued to teams nominated by the organisers of affiliated competitions held in other countries who have national or regional events. Invitations may also be issued to individual teams where there is no national competition. All teams entering this event will need to meet the regulations listed below.

1.6 Statement of involvement
Cars entered in any given year should be substantially the work of students in that year. Forms confirming that the work is that of students and not teachers or parents will need to be signed by the students and coordinators and submitted to the organizers prior to the start of the event.

1.7 Correspondence
South Australian correspondence should be addressed to:

Mr Andrew Costi
Pembroke School
342 The Parade
Kensington Park SA 5068
Tel: (08) 8332 6111 Fax: (08) 8364 1525
email: acosti@pembroke.sa.edu.au

AIMSCC correspondence should be addressed to:

Mr Mark Needham
AIMSCC Executive Officer
22 Harding Street,
Glengowrie SA 5044
Tel (08) 8295 5986 Fax (08) 8295 8584 Mobile 041 610 4490
Email: markneed@chariot.net.au

2. INTERPRETATION OF THE REGULATIONS

2.1 AIMSCC make decisions

The AIMSCC event officials are empowered to make a decision on any case not covered or clarified by these regulations. In the case of dissent from an AIMSCC official's ruling, the dissenting team may be excluded from the competition.

2.2 Use of AlMSCC regulations

While state and international model solar car challenge coordinators are encouraged to conduct their local events so as to observe the regulations pertaining to the AIMSCC event, the regulations for each local event are determined by the local Coordinator. It is, however, the responsibility of each team invited to participate in the AIMSCC event to adhere to the AlMSCC regulations, regardless of the regulations of any State or Overseas event in which they may have participated.

2.3 Unfair practices

If during the event or at scrutineering AIMSCC officials discover that an entrant or crew has deliberately violated these regulations to gain unfair advantage over other entries, or has departed from the spirit of the event, that team will be excluded from the competition.

3 ENTRIES

3.1 Number of Australian teams

The AIMSCC Executive Committee shall request each State Coordinator to invite up to four teams who have proved themselves to be among the top entrants in their state event by criteria to be determined by each state coordinator. Additional entries may be invited at the discretion of the Committee.

3.2 Number of overseas teams

The AIMSCC Executive Committee shall request coordinators of events in other countries to invite one or more teams who have proved themselves to be among the top entrants in their event. Where a country does not have a national/regional event, the AIMSCC Executive Committee may invite one or more teams to represent that country, provided their entry conforms to these regulations.

3.3 Number in team

Each team will be expected to comprise at least two students (desirable for starting and catching the car).

3.4 Team representation

Each entrant must represent his or her school or other organization accepted by the Committee. If two cars are entered from the same school, the seeding process will be implemented in such a way that they will not compete in the same group during the round

robin competition. However, if successful, they will compete against each other before or during the quarter finals, ensuring that no school can win more than one of the major prizes.

3.5 Statement of work
All students must sign a form indicating that the design and construction was essentially their own work.

3.6 Posters required
All entries will be required to present a laminated or contact coated A2 Poster (size 420mm x 594mm) documenting the design and development of their car to the organizers prior to scrutineering. This record should document experiments and or calculations, which were used in the design of the Model Solar Car.

This poster will become the property of the organizers and may be used for promotion of the event, but will ultimately be returned by the State Coordinator.

3.7 Optional decorated egg competition.
To enhance the fun side of the event an optional hard-boiled or blown egg may be decorated and presented as a driver for judging. NB This will not be the driver for the race but may be used for display or photographic purposes.

3.8 Entry registration
Entrants must confirm their participation with the AIMSCC Executive Officer at least 21 days before the National event. If the State event is held less than 21 days prior to the national event, the State Coordinator must make appropriate arrangements with the executive officer Mr. Mark Needham. Potential overseas entrants should notify the executive officer of their intention to compete by October 1st. The invitations will be sent to the Coordinators before their event.

4. TRACK

4.1 Size and Shape
The outdoor track used in this event will be in a ‘figure 8’ configuration with a low bridge at the crossover point as shown in Attachment B. The corners will feature curves with an approximate minimum radius of five metres. The track length is approximately 86 metres with cars completing one full lap plus an extra 14 metres to reach the finish line.

4.2 Slope
The uphill and downhill sections of the track at the crossover point will have a minimum clearance between tracks of 300mm. The slopes will range between 1:16 to approximately 1:8.

4.3 Construction
The track will have a smooth surface with two parallel guide tracks of PVC channel (see Diagram 1) such as ‘UM20’ or ‘basket track’ or similar, screwed to a plywood base. As the track is assembled in sections, there may be minor misalignments which could lead to damage of a guide pin running inside the channel, hence making more robust external guides less prone to damage. The Committee will endeavor to ensure misalignments both horizontally and vertically will be less than 2 mm. If in the Committee's opinion, a car is inhibited in any race as a result of a serious track imperfection, that race shall be rerun as soon as possible.

NB. Thin metal (~1mm thick material) channel sections may be used to align the ends of adjacent plastic guide ways if in the Committee’s opinion, there is a significant alignment

problem. This could lead to a total width of up to 19mm, which should be allowed for if external steering guides are used.

4.4 Starting Position
Cars will start near the top of the downhill section of the track. Cars will be started by resting against the start gate which will be rotated away from the cars by a person appointed by the Committee.

4.5 Finish Position
The winning car will be determined by an electronic timing device initiated by a light/infra-red beam. The beam and detectors will be aligned either horizontally, approximately 50 mm above the track, or vertically within 10mm either side of the guide channel. It should be noted that in rare cases, the design of the winning car may introduce small errors in the recorded times of each car. In the event of an equipment failure, stopwatches operated by persons appointed by the Committee will be used. The race-day coordinator will adjudicate on any dispute as to the finishing position of any car and there can be no appeal against that decision.

5. SCRUTINEERING

5.1 Race Ready
All competing teams shall be required to register upon arrival at the venue by a time to be announced when the invitations are issued. Cars must be in a condition ready to start when presented for scrutineering. Scrutineers have the right examine each car at any time to ensure it conforms to these regulations.

5.2 Failure
Any car failing to pass scrutineering by the end of time allowed *may* not be permitted to start the event.

6. SERVICING

6.1 Service area
An official service area will be set aside for student team members to carry out repairs or modifications. Students capable of representing their State at the national level will be expected to be capable of operating independently of teacher or parent support and hence only students are to conduct car adjustment and maintenance on race day.

6.2 Modifications
Students may modify cars during practice or between rounds, but the scrutineers may reassess cars at any time. However, cars as presented at scrutineering immediately prior to the commencement of the elimination rounds of racing must be used for all elimination races. A modification to these cars between elimination rounds specifically excludes the changing of solar panels, car bodies, chassis and driver/passenger compartments irrespective of light conditions. Repairs to these major components are allowed. Changing driving wheels, gears, motors, steering mechanisms and panel voltage will be permitted between races.

6.3 Service crews
For the duration of each race, up to three students from each team will be allowed in the scrutineering or track areas**.** The organizing Committee will provide adult supervision.

Direction and/or physical assistance from adults at any time during the event is not permitted. It is recognised that during racing the student team members are under great psychological pressure, especially during the finals races, and may be confused as to the appropriate modification/repair to continue racing. The Committee will provide an independent person to facilitate the student team members to use their own knowledge as to the appropriate course of action.

6.4 Restricted areas
No person other than those nominated shall be allowed in the restricted area without permission of an AIMSCC official and must be accompanied by that official at all times whilst inside that area.

7. COMPETITION

7.1 Time trial
Following scrutineering, each car will be timed over a given distance on the designated track, for the purpose of seeding each car, to determine the groupings of teams who will compete in the 'round robin' section of the event. The time trial will start at the starting gate and end at the finish line of the figure 8 track, a distance of approximately 14 metres.

7.2 Structure of the races.
The event shall be conducted with pairs of cars competing against each other over tracks of equal length (100 m) in a series of 'round robin' and/or elimination races to be announced in the official schedule of events. Where results are to be determined by multiple heats, they will be scheduled so that all cars in the round will have completed their first heat prior to the start of the second set of heats, allowing some minutes to elapse between the first, second and third heats.

7.3 Timing
Each car will be timed over the course. Times will be posted on the result board.

7.4 Start
Cars will be presented at the start line within two minutes following the call for cars on the public address system. In the case of best of three or best of five heat races, cars will alternate between tracks. If the final race is needed (in best of 3 or 5 heat races) to determine the winner, the final race lanes shall be determined by a coin toss. The cars will be placed on the track in a ready to run state.

7.5 Stability
If the car comes off the tracks it shall be deemed unstable and will not be re-started in that race unless the officials are satisfied that the problem was caused by a deficiency of the track. There shall be no handling of cars during the race other than by officials or by people nominated by officials.

7.6 Poor light / adverse weather conditions
If light conditions do not enable the cars to complete the course, the car that travels the furthest, or, if two cars travel the same distance, the car which reaches that point first, will be judged the winner.

When both cars have come to a halt short of the finish line the race will be deemed to have finished if neither car has moved for a maximum of 30 seconds.

If a car stops for any reason, the car may be restarted under the marshall's discretion from any point on the track behind the stopping position, but the car must not be pushed to restart.

7.7 Practice and testing
Practice on the track will be allowed at any feasible time that marshals are in attendance.

7.8 Results
Final results will be decided after the provisional first four place winners have been rescrutineered and passed by the officials.

7.9 Prizes
Prizes will be presented to First, Second, Third and Fourth place getters. The presentation of prizes will be held as soon as possible after the completion of the event. Additional prizes for best poster, best team effort etc. will be presented to teams deemed worthy. The categories of such prizes will be announced at the time when invitations are issued.

8. CAR SPECIFICATION

8.1 Definitions
For the purposes of these regulations the following definitions will apply.

8.1.1 Solar Array and Support Structure
The solar cells connected together to provide the power which drives the car will be referred to as the array. That complete unit on which the photovoltaic cells (the array) is mounted is the array support structure. This structure must be fully removable and may form part of the car body, but must not form a part of the chassis, cabin or side panels as defined in 8.1.2, 8.1.3, and 8.1.4. The array support structure may carry the ON/OFF switch, and may allow for varying voltage by means of a mechanical switch controlled by the team prior to the race start. Mounting electronic switches or devices, eg for changing output voltages, on the array support structure is not permitted.

8.1.2 Chassis
That part of the car which can be identified as providing structural support for the body, array support structure, wheels, motor/s, cabin and side and vertical transverse panels.

8.1.3 Body
Any part of the car which provides an aerodynamic form or encloses a space and is attached to, or part of the chassis. The body may include the two side panels, chassis and cabin. NB. the cabin must be sealed when racing. see 8.20.

8.1.4 Side Panels
Either a designated part of the body or separate pieces attached to the chassis, conforming to the size requirements of these regulations.

8.1.5 Vertical Transverse panel
A cross sectional area across the width of the car, through which air cannot pass. This may be the inside of an aerodynamic body or driver cabin. Provision must be made for the scrutineers to verify this.

8.1.6 ON/OFF switch

A commercially available switch which will electrically disconnect the solar array from the motor. Alligator clips or plug and socket connections, while allowed as part of the electrical circuit, may not be used as the ‘on/off‘ switch.

8.2 No commercially built cars
Cars may not use any part of the chassis or body of any commercially available model car. This only refers to the structural frame, not to the drive train components such as gears, shafts, wheels or tyres or to suspension components. All external body covering is at the discretion of the entrants.

8.3 Size Limit
The maximum size of the car presented for scrutineering shall be no more than 650 mm long. The maximum height shall be no more than 180 mm high. The width must not exceed 320mm. (Wheels included).

8.4 Source of Power
The car is to be powered by photovoltaic cells as approved by the AIMSCC Executive. Approved photovoltaic cells will be commercially available mono-crystalline, poly-crystalline or amorphous silicon cells.

8.5 ON/OFF switch
Each car must be fitted with an ‘ON/OFF’ switch to minimise car set-up time whilst at the starting gate. The ‘ON’ position must be clearly marked.

8.6 Power Limit
The maximum power delivered by the photovoltaic cells will be 12 watts measured by the scrutineers using a light box (see attachment C) delivering approximately one Sun equivalent. For curved panels the panel output will be determined by placing the panel generally parallel to the top of the light box. It is expected that commercially available 10 watt solar panels will normally be used. The 12 Watt limit is included to allow for manufacturing tolerances.

If teams use individual cells to construct a panel, and the output as measured by the scrutineers exceeds 12 watts, the panel must be modified to limit output to conform to the 12W maximum. The team may modify the solar panel during the scrutineering process to reduce the output to comply with this regulation.

8.7 No energy storage systems
No energy storage system, either electrical, mechanical or chemical, which assists in the performance of the car will be permitted. Capacitors of less than 1 farad are allowed as part of the electrical system but the scrutineer/starter reserves the right to discharge them immediately prior to the start of the race

8.8 Array and array support structure weight.
The panel weight will be as per the table based on the measured power outputs using the light box as defined in attachment C. The ballast weight is calculated using the formula :-
Total array and support structure weight (grams) = (Panel power (watts) – 4) X 220
e.g.

POWER	WEIGHT
6W	440g
7W	660g
8W	880g
9W	1100g
10W	1320g

11W	1540g
12W	1760g

The Committee will provide scales to determine array and support structure weights, measured accurate to +/- 5 gm. eg. a car with a panel output measured at 8.3watts, will weigh between 1070 and 1080 gm.

Each array may include a single on/off switch and connecting wires, but all other mechanical, electrical or electronic devices must be separate from the array support structure and supported by the chassis.

8.9 Ballast
Additional weight required to be carried as ballast, may be secured in any part of the car, but must be easily removed for scrutineering.

8.10 Solar Array and Support Structure Removal
The array and its support structure must be easily removed from the car for weighing and the car must still be capable of free and stable movement along a flat surface with it removed.

8.11 Solar Array and Array Support Structure Size
To allow innovation in design, the array support may be of any size, provide it complies with paragraph 8.3. The vertical distance from the track surface to the lowest part of the array support structure will not be less than 75mm.

8.12 Motors
There is no restriction to the type and size of motor (or motors) that may be fitted to the car. However the motor manufacturer and/or part number must be made available to the scrutineer for assessment of energy storage systems.

8.13 Wheels
There is no limit as to the diameter of wheels. So as not to damage the track, knife edge wheels are not allowed. Each wheel must be at least 1mm wide or have a radius of 0.6mm on the running surface. Use of an active (moving) steering system will be viewed favourably when choosing quality engineering design awards.

8.14 Chassis and Floor
The car must have a rigid chassis independent of the solar array and its support. The car must have all components, such as the driver and passenger cabin, wheels motors etc attached to the chassis. The car must have a flat floor of at least 400 cm^2 attached to the chassis, but components such as axles, electronics, motors etc may be attached to the floor within that area.

8.15 Side Panels
The car must have side panels capable of retaining their shape at all times for attaching numbers and sponsors logos. These should be easily seen by spectators while the car is racing. Each side panel must be at least 200 cm^2 in area. The vertical height of at least one part of the panel, must be at least 75 mm. They will be mounted on each side of the car. The maximum curvature or slope of the side panel will be 25mm vertically and 75mm horizontally. The purpose of these panels is to allow easy determination from a distance of the name and/or number of each car. If the panel is not flat and rectangular, pre-determined calculations determining its area must be presented at scutineering.

8.16 Vertical Transverse Panel

Each car must contain either a solid flat panel made of a rigid material such as balsa, cardboard, plastic or foam being least 200 cm^2 in area or a demonstrable cross-sectional area consistent with the definitions. If the panel is not rectangular, calculations must be presented at scrutineering indicating that it meets the requirements. This panel must be mounted vertically across the width of the car, at 90°(±5°) to the direction of motion.

8.17 School and Car Name

Each entry should have its school name (possibly abbreviated) and car name shown on the car in letters at least 10mm high and visible when racing. These can be attached to the side panels or other parts of the body, provided that they do not interfere with official labels which will cover an area of up to 60mm x 100mm.

8.18 Steering

Each car must incorporate a means of steering along the guide channel of the track. Section 4.3 specifies any track variations that may be encountered. The steering mechanism may be either a vertical peg (as per slot car principal: Refer to Diagram 1a) or guides designed to run outside the channel (as per 1b).

The peg(s) or guide(s) should be capable of adjustment to heights between 5 mm and 12 mm above the track base.

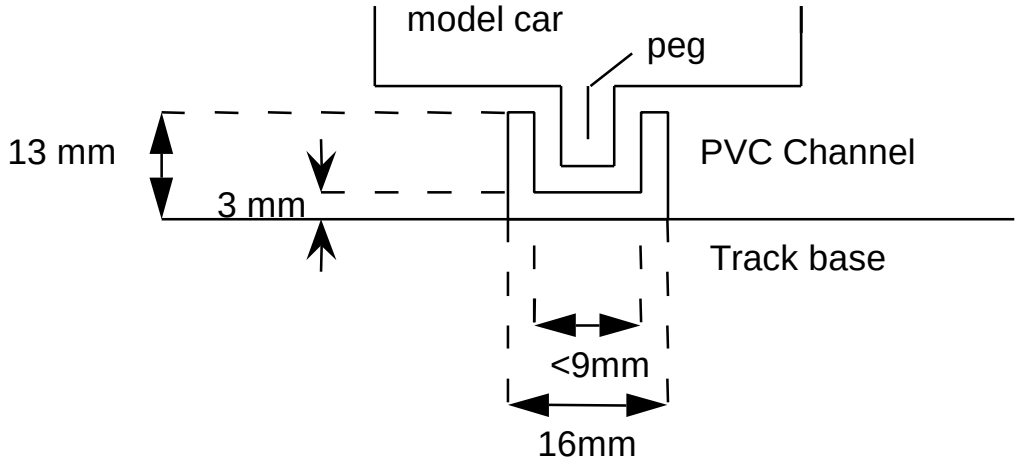


Diagram 1a - peg inside guide channel.

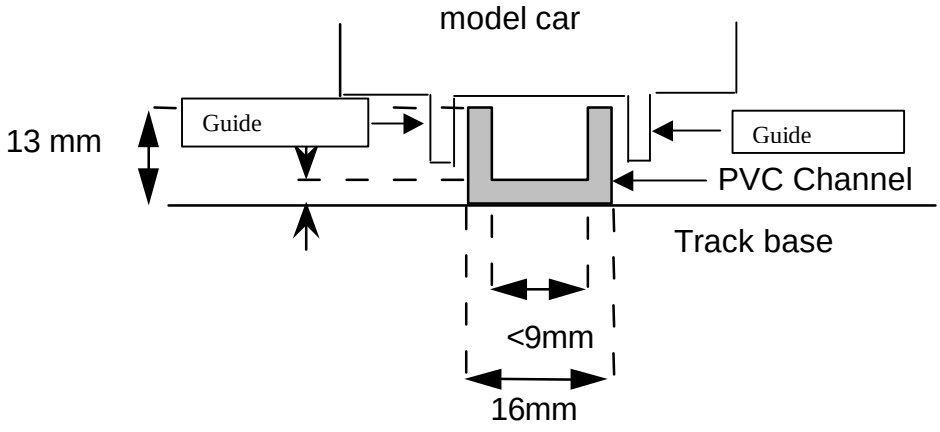


Diagram 1.b. - two guides outside the channel.

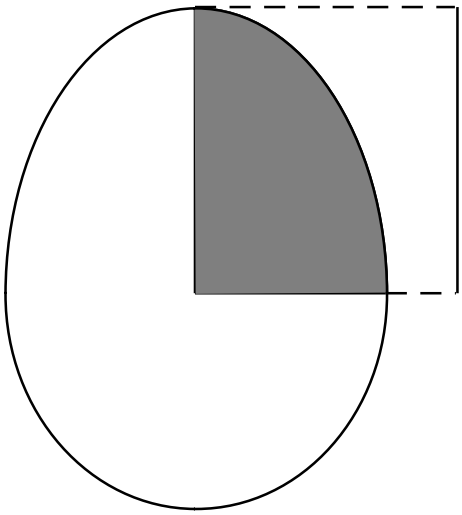
8.19 Driver

To ensure that the cars guarantee driver safety, the driver of the car will be a large egg (61g) supplied by the Committee. The egg must not be covered in a film or painted so as to increase its strength. In any race, a cracked, broken or dislodged egg will mean that the driver is injured, so the car concedes that race to its opponent. If an egg is damaged in one heat of a best of three or best of five final, a replacement egg will be provided for the remaining races.

8.20 Driver and Passenger Cabin

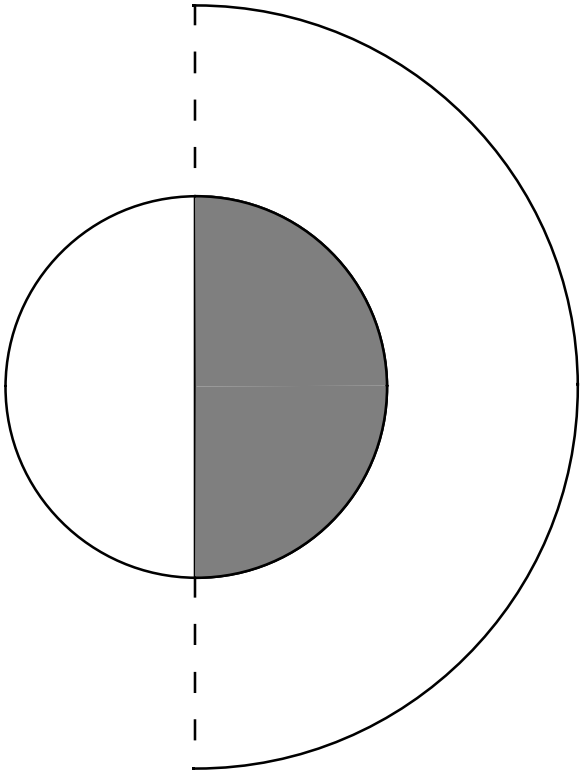
Each car must have a fully enclosed cabin at the front of the car in which the egg sits vertically (see attachment A). Adequate space and a seat must be provided inside the cabin for a second egg as a 'passenger'. The cabin must be fully sealable so that if the egg breaks nothing is spilt onto the track (such sealing may be adhesive tape). The cabin must also include a transparent (not translucent) windscreen at least 25 mm deep (in the vertical direction). This will allow at least the top half of each egg (if the passenger were carried) to be visible from straight ahead and through a 90’ arc on either side when viewed horizontally.

Attachment A: Views of egg indicating necessary visibility



The windscreen must allow this part of the egg to be visible when viewed horizontally from straight ahead or any position to 90' from the centre line.

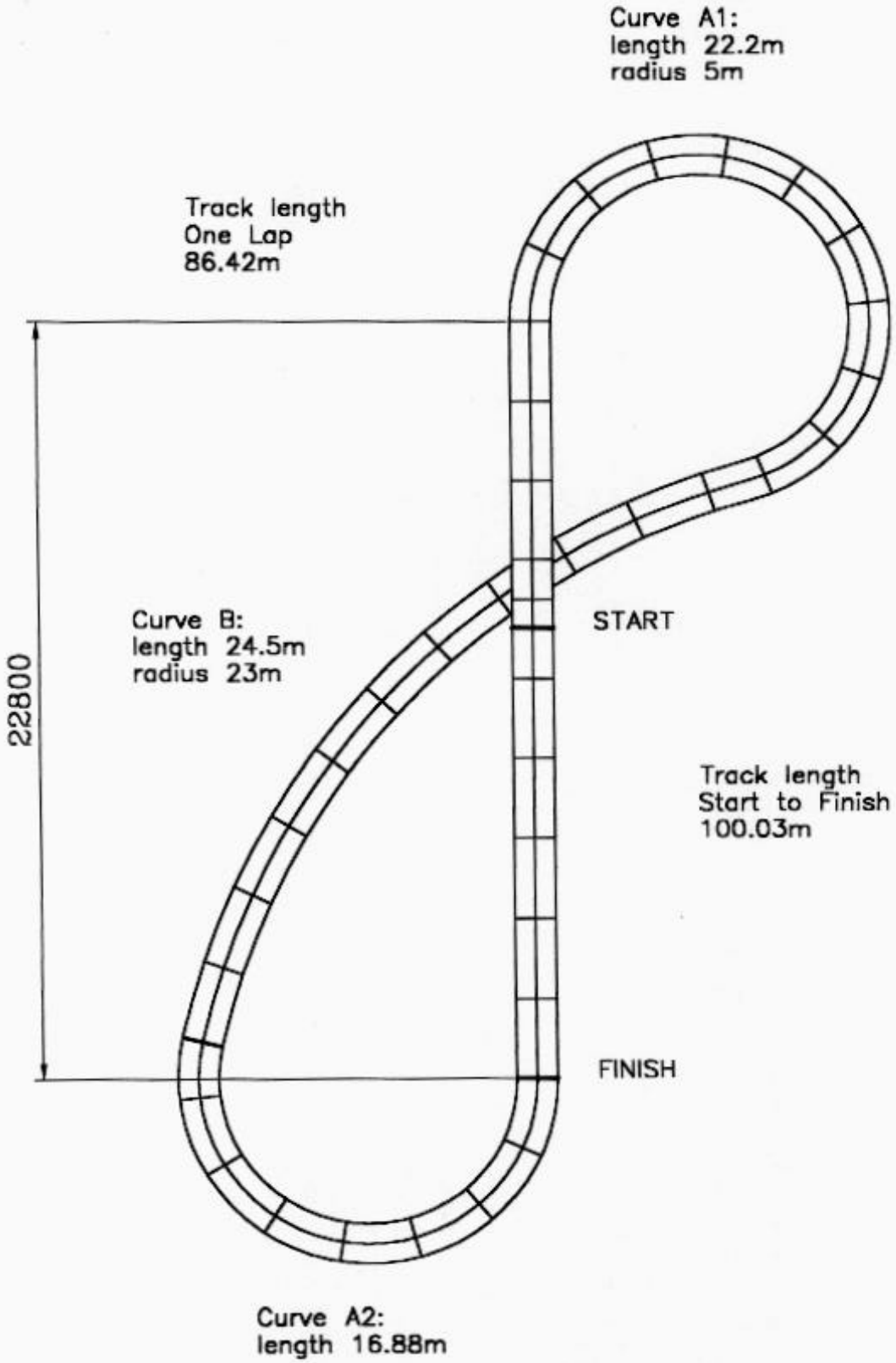
SIDE VIEW



The top half of the egg must be visible through the windscreen from any point on this arc.

PLAN VIEW FROM ON TOP.

Attachment B
Outdoor Dual Lane Track Specifications



FULL TRACK TOP VIEW

Scale: 1:200

ATTACHMENT C. LIGHT BOX CONSTRUCTION INSTRUCTIONS

Introduction

Starting with the 2001 championships, the Australian-International Model Solar Car Challenge regulations, will use a handicapping method based on the actual power produced by the cells that make up the solar panel. Obviously, a reliable low cost system of measuring the power produced by the solar panels fitted to the model solar racing cars, must be provided.

The attached drawings and specifications are a guide for constructing a one sun equivalent light box, suitable for testing the solar panels on model solar cars. All the dimensions and material specifications are the same as the prototype light box used at the 2000 championships in Sydney.

This light box has been designed to produce the same response from a solar panel that would occur when the same panel is exposed to full sunlight. No attempt has been made to color correct the incandescent light produced by the light box to form spectrally equivalent sun light. While this could be done by using appropriate 'blue' filters placed over the acrylic cover, it was not considered necessary.

The measurement of the power from the solar panel is carried out by a separate 'power monitor' which must first be connected to the solar panel under test. A separate paper will describe the construction of the 'power monitor'.

Description of the Light Box

The light source for the light box consists of 18, 50 watt 12 volt halogen lamps connected in series across the mains. In order to reduce the voltage down to the required 216 volts, a multi-tapped 100 VA transformer is used to reduce (buck) the 240 volt supply to the lamps. Where the mains supply is consistently above or below 240 volts, other taps on the transformer can be used to compensate. However, for the sake of cost, the voltage supply to the lamps is not regulated.

The lamps are held in place by small ceramic bases bolted to the aluminium base of the light box. On the other side of the aluminium base, the lamps are wired together using hard (high temperature) plastic or ceramic termination blocks. For protection, a double pole switch is used together with a fuse and the exposed metal parts are connected to mains earth.

The reflective surface on the sides of the box consists of recycled aluminium sheets from used lithographic printing plates stapled to the inside surface. This appears to be effective enough for the purpose. However, household type aluminium wrapping foil, could be used instead.

Medium density fibre board was used to construct the box with the edges nailed and glued together. The bottom cover consists of a piece of thin plywood while the top uses a clear acrylic cover screwed to the top of the box. The acrylic cover may be removed to gain access to the lamps.

Construction

Only the inside dimensions of the box are listed in the drawing. This is because the overall dimensions will depend on the thickness of the material being used.

Since the edges of the box are not subject to any appreciable loads, the bonding method can simply be gluing and nailing. Similarly, the bottom cover of the box is more or less there to keep fingers away from the mains voltage and can be any available sheet of material on hand. Three millimeter plywood to ten millimeter hard board could be used. The only stress that will be applied to this cover sheet will come from the four rubber feet attached near each of the corners.

The top of the box must be covered with a 3 mm (or more) thick clear acrylic sheet screwed to the top edge. The actual thickness is not critical since the light attenuation through clear acrylic is very low. Tinted or colored sheets are not suitable - only clear should be used.

The ceramic lamp bases are mounted on a 1.5 mm thick sheet of aluminium formed to fit inside the light box. Persons familiar with metal working should have little trouble with this operation. However, the availability of a metal bender is required to accurately form the edges. Ideally, the metal base should be a push fit inside the box where self tapping screws positioned on the outside of the box, can fix it into position.

The use of steel sheeting instead of aluminium, is not recommended because:-

1. the long term reflectivity of aluminium is better; and

2. the heat transfer property of aluminium is better.

However, the thickness of the aluminium sheet could be reduced to 1.2 mm without causing any problems.

As shown in figure 2, the lamp bases are mounted on the aluminium sheet with centres 100 mm apart. However, the ceramic lamp mounting bases are attached to the sheet by two 3 mm bolts positioned symmetrically on both sides of the lamp centres. Two other holes for the heat resistant connecting wires must also be drilled. In other words, four holes are required for each of the 18 lamps.

Much of the heat from the lamps is absorbed by the aluminium sheet, which can become quite hot. Therefore simply soldering the leads of the lamps together is not recommended. (The solder may melt.) Instead, heat resistant hard plastic or ceramic screw terminal blocks should be used. These are attached to the aluminium sheet at convenient places using 3 mm bolts. The 'voltage bucking' transformer, also needs to be attached at some convenient place on the aluminium sheet. However if a transformer other then the type specified is going to be used, make sure that it will fit first.

All 18 lamps must be wired in series using the screw terminal blocks. The 'voltage bucking' secondary of the transformer must also be in series. Refer to the Testing section to determine how the primary of the transformer should be wired. Note that if the transformer primary is reversed, the voltage across the 18 lamps will rise to about 264 volts, not 216 volts as it should be!

Mount the power switch and fuse holder on a small 50mm by 50mm (approximately) piece of aluminium or steel plate and attach it to one of the short sides after cutting a suitable hole in the box. The mains cord must be anchored securely to the side of the box using appropriate clamps. A small 'U' shaped groove can be filed on the bottom edge of the box near the switch and fuse plate, to allow the power cord to come out of the box. In this way, the cord will be held in place when the bottom cover is screwed in place.

Selecting and Handling of Lamps

There are a variety of 50 watt 12 volt quartz halogen lamps available from a number of different suppliers. Not all of them are suitable for use in the light box. The cheaper types tend to have wider manufacturing tolerances in both their current rating and accuracy of focus. Therefore their use is not recommended.

At the other end of the scale, the more expensive types do tend to have more even light spread and require less adjustment to obtain an acceptable light intensity over the full area of the light box.

Other lamps of medium quality are also available and are recommended for use in the light box. Some fiddling of lamp positions may be necessary in order to obtain an even light, but not as much as would be required for the cheaper types. The type listed in the specifications is readily available from the supplier, along with the ceramic bases.

The lamps specified have a protective cover over the bulb. This means that problems associated with touching the bulb with fingers, do not exist. However, any finger marks on the protective cover should be removed before applying power to the lamp. This can be done by using a paper tissue and metholated spirits.

Testing

Before turning on the lamps, check that the voltage between (A) and (B) (refer to figure 1) is about 216 volts. CAUTION. These voltages can be lethal. Only competent persons should carry out these tests using appropriate test equipment.

If the voltage reading is close to 264 volts, then the primary winding of the transformer should be reversed. This must be done with the mains plug removed from the power outlet. When the reading is close to 216 volts, the mains plug should again be removed before connecting the series string of 18 lamps into place.

When all is ready, the light box can be turned on. Since all the lamps are in series, one faulty lamp will stop the rest from working. Faulty lamps can be found by placing an ohm meter across appropriate terminals on the terminal blocks (once the power is turned off!).

As mentioned in the previous section, some fiddling of the lamp positions may be necessary in order to obtain an even light over the active surface, when using the recommended 'medium quality' lamps. This can be done by placing sheets of copying paper over the acrylic cover. The positions of the extra bright (or dull) lamps will show themselves and can be repositioned. Sometimes it may be necessary to reject a lamp completely, but this should be rare.

Once the light intensity variation over the total area of the acrylic sheet is acceptable, the light box can be tested for sunlight equivalence. Ideally a silicon solar panel with an area less then the acrylic top of the lightbox should be used. Silicon cell based light meters without color correcting filters can also be used.

Place the solar panel at right angles to the sun at midday suntime on a clear day and record the short circuit current (Isc) from the panel. Note that the midday suntime intensity variation between the beginning of October and the end of March for Sydney, Melbourne, Adelaide and Perth, is about 5%. (For Brisbane it may be slightly less and Hobart slightly more.) White woolly clouds within 10 degrees of the sun can increase the solar panel current by over 10%,

while high whispy clouds and air pollution can cut the current by over 30%. Therefore, it is important to carry out this test on a clear day. However, the ambient air temperature at the time of the test is not important.

Next, the test panel can be placed on the light box and the Isc measured. If the Isc reading from the light box is not within 5% of the reading obtained from the sun, the lightbox output can be adjusted by changing the taps on the transformer secondary winding. Note that a 5 volt change in voltage will change the Isc reading by about 5%.

That's about it. The light box should now be ready to test model solar racing car panels.

Things to Consider

Cost limitations meant that the mains voltage across the lamps is unregulated. A decrease in the mains voltage from 240 down to 230 volts will cause a decrease in the short circuit current from the solar panels of about 10%. Fortunately however, mains voltage variations of this magnitude in most places around Australia are rare and usually of short duration. Never the less, it is recommended that a separate AC voltmeter be used to monitor the mains voltage and this be recorded at the same time as the solar panel responses from the lightbox.

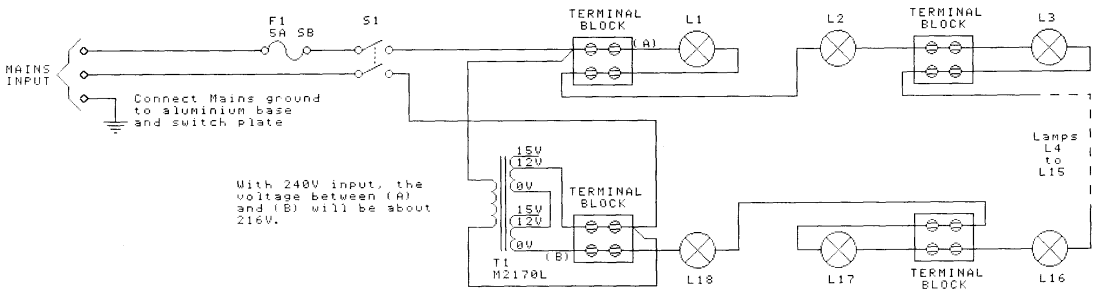


FIGURE 1
LIGHT BOX CIRCUIT

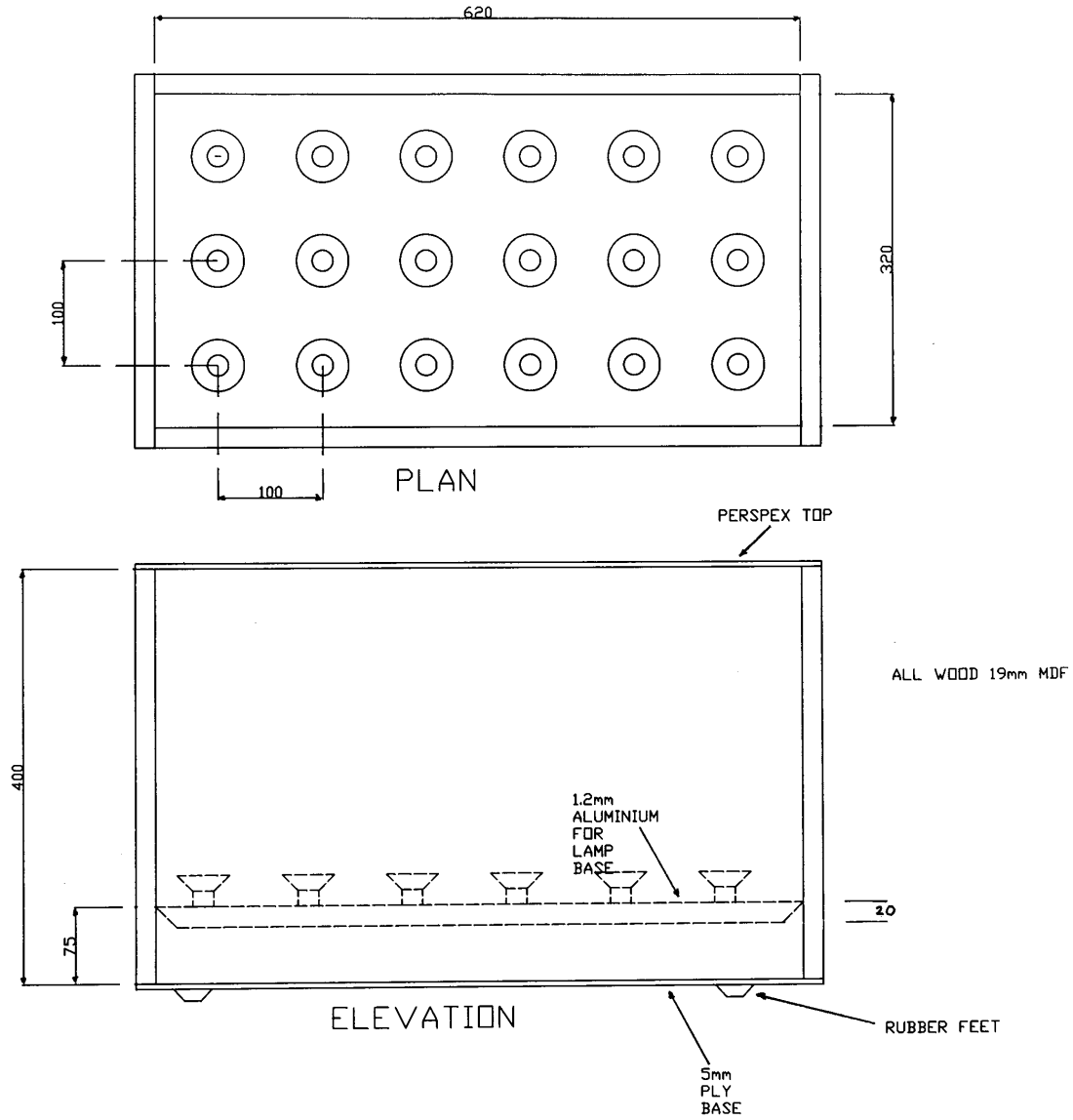


FIGURE 2: SOLAR ARRAY TESTING LIGHTBOX