6540 Arlington Boulevard
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Smart Water Application Technologies (SWAT) Performance Report

Testing Agency: Center for Irrigation Technology — **www.californiawater.org**

Testing Date: February-March 2009 | **Weather Station: CIMIS 80 Fresno State, Fresno**

Product Type: Climatologically Based Controller | **Reference #:**

Product: Tucor RKS with TRB-100 Tipping Rain Bucket [Serial #053916]

Product Description: The RKS controller in Tucor's RK controller series converts conventional systems to the Tucor Total-Cycle Management system. As tested, the RKS uses interpolated historic ET tables with a real-time tipping rain bucket for local rainfall accountability; optional choices are onsite or offsite weather stations.

SWAT Protocol*: Turf and Landscape Equipment Climatologically Based Controllers 8th Draft Testing Protocol (Sept. 2008)

The concept of climatologically controlling irrigation systems has an extensive history of scientific study and documentation. The objective of this protocol is to evaluate how well current commercial technology has integrated the scientific data into a practical system that meets the agronomic needs of turf and landscape plants. The evaluation is accomplished by creating a virtual landscape subjected to a representative climate to evaluate the ability of individual controllers to adequately and efficiently irrigate that landscape. After initial programming and calibration the controller is expected to perform without further intervention during the test period. Performance results indicate to what degree the controller maintained root zone moistures within an acceptable range. If moisture levels are maintained without deficit, it can be assumed the crop growth and quality will be adequate. If moisture levels are maintained without excess it can be assumed that scheduling is efficient.

***All SWAT protocol may be viewed at www.irrigation.org.**

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Input Data: CIMIS #80 reference crop is turfgrass using the Penman-Monteith formula
For more information: wwwcimis.water.ca.gov

Parameters: For field installation, these values would normally be collected during a landscape audit.	**Zone #1**	**Zone #2**	**Zone #3**	**Zone #4**	**Zone #5**	**Zone #6**
Soil Type: Affects how water is absorbed and amount of water storage in the soil reservoir	Loam	Silty Clay	Loamy Sand	Sandy Loam	Clay Loam	Clay
Vegetation: Determines the crop coefficient and therefore the water required for healthy plant growth	Fescue 75% Shade	Bermuda Full Sun	Ground Cover Full Sun	Woody Shrubs 50% Shade	Trees & Ground Cover Full Sun	Bermuda Full Sun
Slope, %: Affects run-off potential	6%	10%	8%	12%	2%	20%
Root Zone Working Storage (inches): Affects water available to plant and watering intervals	0.85	0.55	0.90	2.00	2.25	0.55
Precipitation Rate (inches/hour): Affects duration of watering time	1.60	1.60	1.40	1.40	0.20	0.35
Application Efficiency, %: The percent of water applied by irrigation distribution system that is absorbed in to the root zone working storage and is not lost due to spray drift and pattern loss	55%	60%	70%	75%	80%	65%
Area (square feet): Frames a virtual yard. Is not used in efficiency calculations.	1000	1200	800	500	650	1600
Soil Intake Rate (inches/hour): Affects watering duration & soak intervals of watering time	0.35	0.15	0.50	0.40	0.20	0.10
Allowable Surface Accumulation (inches): Affects watering duration & soak intervals of watering time	0.25	0.16	0.26	0.24	0.26	0.10
Maximum Allowable Run Time (minutes): Limits run time options to avoid potential runoff	12.0	6.6	17.3	14.4	N/A	24.0

Performance results are only valid if the controller must make adjustments for varying weather conditions such as rain and evapotranspiration (Eto). Therefore actual time undergoing testing may be longer than one month. Valid performance data is then downloaded from the 30 consecutive day period exhibiting the required minimum 0.40 of gross rainfall and minimum 2.50 inches of ETo.

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Evaluation Summary: Evaluation summary of performance during a 30-day period in which the controller was required to adjust for actual weather conditions including significant ETo and rain events without intervention.

Performance Parameters: Total inches for the test period are listed for each zone/crop	**Zone #1**	**Zone #2**	**Zone #3**	**Zone #4**	**Zone #5**	**Zone #6**
Eto (inches): Actual ET from weather station, reference crop is turfgrass, CIMIS	2.66	2.66	2.66	2.66	2.66	2.66
Etc (inches): ETo requirement modified by the crop coefficient (determined by the vegetation in each zone)	1.35	1.77	1.50	1.04	1.62	1.77
Rainfall (inches): Rainfall recorded at the weather station	1.13	1.13	1.13	1.13	1.13	1.13
Net Rainfall (inches): Allows an arbitrary loss of 20% R(net) = 0.8 (R).	0.91	0.91	0.91	0.91	0.91	0.91
Effective Rainfall (inches): Rainfall that was effectively stored in root zone working storage for use by crop.	0.81	0.75	0.87	0.91	0.91	0.77
Gross Irrigation (inches): Actual water applied	1.33	0.85	1.01	0.73	1.01	0.31
Direct Run-off (inches): Water applied that exceeded maximum allowable runtime	0.00	0.00	0.00	0.00	0.00	0.00
Soak Run-off (inches): Runoff loss attributable to scheduling multiple irrigation cycles without allowing sufficient soak time between cycles.	0.00	0.00	0.00	0.00	0.00	0.00
Effective Irrigation (inches): Water applied that was added to root zone working storage and usable by crop	0.73	0.50	0.73	0.57	0.83	0.19
Deficit (inches): Required water that was not available in the root zone working storage	0.00	0.27	0.00	0.00	0.00	0.57
Surplus (inches): Water applied in excess of root zone working storage	0.00	0.00	0.00	0.00	0.00	0.00
***Irrigation Adequacy, %:** Reflects how well irrigation met the consumptive use of vegetation. $Irrigation\,Adequacy(\%)=\left(\frac{ETc,in-Deficit,in}{ETc,in}\right)100$	100%	84.8%	100%	100%	100%	68%
Schedule Efficiency, %: Reflects how well irrigation cycles avoided direct, soak runoff and exceeding the root zone working storage capacity. Scheduling Losses (in.) = Direct Runoff (in.) + Soak Runoff (in.) +Surplus (in.) $Sch.eff\ (\%)=\left(\frac{Irr.(Net,in)-Sch.losses(in.)}{Irr.(Net,in)}\right)100$	100%	100%	100%	100%	100%	100%
***Irrigation Scheduling Excess, %:** Reflects water applied in excess of consumptive use of vegetation. Irr. Excess = 100 - Schedule Efficiency, %	0%	0%	0%	0%	0%	0%

*Listed on Performance Summary Report

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Overall Irrigation Efficiency Evaluation

The efficiency of an irrigation system is a function of four considerations: efficient irrigation controls, efficient application hardware, well-designed irrigation installation, and consistent maintenance. If all considerations are optimal in these four areas the irrigation system can be considered to be efficient over all.

Scheduling Efficiency is the only criteria tested by the Climatologically Based Controller protocol. This value is listed in the Performance Parameters part of this report.

Application Efficiency listed in the input parameter takes into account application hardware, installation and maintenance. This value is listed in the Input Parameters part of this report. These values are generally representative of industry norms and do not relate directly to any specific manufacturers product.

Overall Efficiency, % = [Schedule Efficiency, % x Application Efficiency, %]

Performance Parameters: Total inches for the test period are listed for each zone/crop	**Zone #1**	**Zone #2**	**Zone #3**	**Zone #4**	**Zone #5**	**Zone #6**
Schedule Efficiency, %: Reflects how well irrigation cycles avoided direct, soak runoff and exceeding the root zone working storage capacity. Scheduling Losses (in.) = Direct Runoff (in.) + Soak Runoff (in.) +Surplus (in.) $Sch.eff\ (\%) = \left(\frac{Irr.(Net,in) - Sch.losses(in.)}{Irr.(Net,in)}\right)100$	100%	100%	100%	100%	100%	100%
Application Efficiency, %: The percent of water applied by irrigation distribution system that is absorbed in to the root zone working storage and is not lost due to spray drift and pattern loss	55%	60%	70%	75%	80%	65%
Overall Irrigation Efficiency, %:	55%	60%	70%	75%	80%	65%

Manufacturer's Declarations on Crop Coefficient Application and Adjustability

Tucor RKS with TRB-100 Tipping Rain Bucket: Crop coefficients are programmable for each station from a predetermined list and can be customized by the user.

Of the following two statements: A applies.

A) Crop coefficients are remotely programmable or updateable for a single controller.

B) Crop coefficients are remotely programmable or updateable for a global application to numerous controllers.