

OUR STAMP ON THE FUTURE Through Technology, Best Practices and Awareness

Grounding & Troubleshooting Two-wire Systems

by Vince Nolletti Executive Vice President Paige Electric Co., LP



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Agenda:

- * Designing Surge Protection/Ground Grids for Two-wire systems:
 - Electrical Code considerations
 - * The ingredients of a successful surge protection system
 - * Decoder manufacturers' requirements on Bonding & Shielding
 - * Facilitate the measuring of earth ground resistance
 - Best wires and cables for lightning
 - Ground Grid splices
- * Troubleshooting the Two-wire system:
 - * How to quickly isolate electrical faults in Two-wire systems
- Installation
 - * Remember to "do it right the first time"!



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Electrical Code considerations:

- * The National Electrical Code®
- Local jurisdiction codes
- Indian reservation codes
- Irrigation designer codes
- ⋇ Etc.



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The ingredients of a successful surge protection system:

- Electronic devices with integral surge protection
- External Lightning protection devices
- Grounding electrodes and their positioning
- Bonding & Shielding
- Wires & cables selection
- * Proper Installation
- Routine Maintenance







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Grounding electrodes and their positioning: Ground Plates "Spheres of Influence":





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Grounding electrodes and positioning: The Ground Rod "Sphere of Influence":





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Grounding Requirements - Field

The IC System must have grounding throughout the wire path to allow any transient surges the opportunity to leave the wire path. The following requirements must be followed to properly ground the IC System:

- 1. Each ICSD must have an earth ground resistance of less than 50 ohms and be no more than 500 feet (150 meters) from the next ICSD.
- 2. Each ICSD can be located either next to a valve-in-head rotor or in-line valve. The ICSD should be accessible in case of maintenance. Either a ground rod or plate can be utilized to obtain an earth ground reading of 50 ohms or less.
- 3. The grounding requirement at the central control is to have less than 10 ohms of earth ground resistance. 5 ohms or less of ground resistance is preferable. The central control shall utilize

MAXI[™] Surge Protectors (MSP-1) on each wire path with MAXI Ground Plates (MGP-1) as required in the system

4. Although not required, an optional shielding wire can also be utilized to improve the grounding

of the system. If used, the shielding wire should be a 10 AWG (6 mm²) bare copper wire that connects to each of the grounding rods or plates in the system. The purpose of the shielding wire is to provide shielding for the MAXI wire path by attracting surges to the shielding wire. It also can reduce the overall earth ground resistance of the system by connecting the ground rods together. Rain Bird believes the decision to use a shielding wire on a project should be based on the localized conditions at the project and is not specific to a control system type or manufacturer type. A course would have a shielding wire regardless of control system, or it does not. It should be the decision of the irrigation designer.

IC System[™] Design Guide, v2.3

Rain Bird requirements on Bonding & Shielding

RAIN BIRD



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TORO requirements on Bonding & Shielding

TORO.		DISTRIBUTOR OPERATIONS BULLETIN
IRRIGATION BUSINESS		
DOB:	2016-13	
Date:	May 4, 2016	
To:	Toro Golf Irrigation Distributor Partners – U.S. & Canada	
From:	John Dalman, Sr. Product Manager, Golf Control Systems and	
	John Fuller, Sr. Product Manager, Golf Control Systems	
Subject:	Golf Control System Grounding	

This DOB is to communicate some changes to our specifications for golf control system grounding. We found that the instructions for our various control platforms had slightly different requirements, which were confusing to some irrigation consultants and contractors, so the main intent of this update is to provide a single standard that applies to all golf control systems. Also, our previous specifications did not specifically address bonding wires, so we have added clarifying information on that topic.

- Toro surge protection devices require an acceptable ground to dissipate excess energy. In all
 cases a ground is required and the lower the resistance the more effectively those surge
 protection devices will operate.
- Grounding for surge protection must be measured at the time of installation and Toro
 recommends a resistance reading of 10 ohms or less.
- The installation of a ground rod, a ground plate, and enhancement material at each ground device should be used as a best practice. When these devices are installed per the manufacturer's instructions this grounding strategy is considered effective; yet may not always achieve the 10 ohm or less recommendation.
- As a best practice, Toro recommends that all ground and surge devices be checked annually and/or after a significant lightning event.
- All other electrical equipment grounds must meet local electrical codes.
- Toro advises against the use of a bonding/shielding wire to protect the Toro components of Toro control systems.
- Grounding materials or equipment that is not specified in the Toro installation instructions must not be connected to the Toro communication/power wiring or the grounding for the communication/power wiring.
- Failure to comply with these recommendations may cause damage to the control system and void the Toro control system warranty.



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Hunter requirements on Bonding & Shielding

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In very large systems, the length of the wire run and the number of intervening devices (other decoders) may affect the ability to run simultaneous stations near the end of the wire run. This will not damage the equipment but may require adjusting station timing to prevent underpowering the solenoid outputs. The calculations near the end of this document help determine if there is adequate power for any given wiring scenario.

Earth Grounding

Earth Grounding of decoder systems is another part of installation that requires planning and careful installation. Properly grounded decoder systems perform very well even in regions with frequent lightning storms. Poor grounding often results in unnecessary equipment losses and irrigation down time.

Earth grounding rules for the ACC99D family decoder controllers are the same as for other ACC controllers. A large ground lug, or clamp, is provided for connection of bare copper wire to earth grounding hardware.

 Install the grounding wire and earth ground hardware at right angles from the two-wire paths, when possible

Decoder installations also require earth grounding in the two-wire path itself, to protect the decoder investment. The ICD family of decoders features integrated surge suppression and each decoder module is equipped with a bare copper wire for connection to earth ground hardware.

Earth ground should be connected at every 12th decoder, or 1,000 ft/330 m of wire run, whichever is shorter. The station size of the decoders is not taken into account for grounding purposes... every 12th decoder module is the rule.

The final decoder in any wire run should be grounded. This includes the final decoders in each of the different arms of a "T", if the arm is more than 500 ft/150 m.

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The ground wires on intervening ICD decoders are not used. It is not necessary to remove the unused ground wire or bury it Simply fold them out of the way (this allows future additional grounding or use of the decoder in another location).

Decoder grounding hardware should always be connected and placed at right angles to the run of the two-wire path.

The use of a separate bonding wire in the trench between all grounded decoder points is not required, but can dissipate surge energy and help prevent pipe damage in the event of a lightning strike.



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Grounding Irrigation Controllers





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Grounding, Bonding & Shielding Irrigation Controllers





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Measuring earth ground resistance:

There are two practical methods to accomplish this:

- 1. Use a clamp-on meter (at controller locations only) The grounding conductors and power wires must all be <u>connected</u> when taking the measurement.
- 2. Use a Megger[®] meter (at controller or decoder locations) The grounding conductors must all be <u>disconnected</u> when taking the measurement.



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Wires & cables selection:

- Simple twisted pair
 - Keep the conductors together
 - Creates inductance and slows-down electrical currents induced by lightning
 - Eliminates the outer jacket and the possibility of nicking the insulation of the inner conductors
- Twisted pair with outer jacket (loose tube)



* Parallel pair with outer jacket (tight)



Removal of the outer jacket should be done without damaging the insulation of the inner conductors!



Hunter (0.060" PE wall)



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Grounding Splices Recommendations for Controller Locations:

- Use NSi Industries Re-enterable connectors (Paige 270RCx series) for <u>underground</u> splices, just outside the controller.
- Use neutral bars for <u>above ground</u> splices within the controllers.





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Grounding Splices Recommendations for Decoder (and IC devices) locations, with external Surge Arrester, no Bonding/Shielding:





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Grounding Splices Recommendations for Decoder Locations, with Bonding/Shielding:





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Troubleshooting electrical faults:

- * Equipment manufacturers have done a wonderful job with built-in diagnostic features.
- * But the cause of some wiring faults are difficult to find!
- When a fault keeps blowing fuses, it is difficult for the controller to diagnose the problem.
- * Technicians usually try to find the problem by trial-and-error, by undoing splices.
- It is best to first isolate the problem to a specific zone. And then isolate the problem to a specific section of the circuit.



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Locate the strategic isolation points of the Two-wire circuit:





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Chose the appropriate Decoder Cable Fuse Device (DCFD):





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Or Decoder Cable Fuse Devices with internal lightning surge arresters:





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DCFD installation detail:





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Thank you for this opportunity!

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BONDING INTERPRETATION BY THE IEEE



BONDING RECOMMENDED BY IEEE STANDARD 142

SYSTEM GROUNDING

IEEE Std 142-1991

Normally, meeting all these criteria is possible only if the equipment is physically and electrically close to the source transformer.

Connection of the equipment ground to earth with an electrode that is physically separate from all other power system and structural grounding electrodes and is not bonded to any of these other grounding electrodes, will inevitably produce common mode noise, since it is not referenced to the power source ground. The magnitude of this common mode potential can be destructive to the equipment and hazardous to personnel, since a power system fault can raise the power system or structure several hundred or thousand volts above other earth references. This grounding method is in violation of the NEC, Article 250 [1].

For greater detail on the grounding of sensitive equipment, refer to Chapter 5 of this standard and to P1100 [7].



CONTROLLERS NOT BONDED (Violation of NEC according to IEEE)



CONTROLLERS THAT ARE BONDED (Violation (?) of the NEC)



IRRIGATING GOLF COURSE BUNKERS



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MANY CHALLENGES – A FEW TRIUMPHS




























<u>GOLF COURSE BUNKERS</u> COME IN A NEARLY INFINITE VARIETY OF STYLES, SHAPES, SIZES, AND CONSTRUCTION METHODS.

GOLF COURSE ARCHITECTS ALSO COME IN A WIDE VARIETY, BUT MOST OF THEM TEND TO HAVE: A VERY ACTIVE IMAGINATION, A FIRM BELIEF IN THEIR ABILITY TO DESIGN AND LOCATE BUNKERS, A FIRM BELIEF IN THEIR ABILITY TO MODIFY BUNKERS, A FIRM BELIEF IN THEIR ABILITY TO RELOCATE BUNKERS, AND A FIRM BELIEF IN THEIR ABILITY TO MODIFY BUNKERS AFTER HAVING RELOCATED THEM, ANY OF WHICH CAN HAPPEN AFTER THE IRRIGATION HAS BEEN INSTALLED, AND ALL OF WHICH DEFINITELY HAPPEN AFTER THE IRRIGATION HAS BEEN DESIGNED.

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DESIGN ISSUES, SUPERINTENDENT INPUT

- Wet or Dry Sand playing condition, wind loss, geography farther south
- Spray or Not Spray, etc. Biases maintenance, PR, damage, washouts
 - Fixed Spray or MSMT

Mar Jacobs Ale

- Small radius rotor in block system
- Green or Fairway size rotors
- Drip
- QCV
- South and West facing slopes only
- Framing mounds only not flat (fairway) side?
- New Superintendent = New Philosophy :
- Lately, more superintendents want dedicated bunker irrigation





















Artificial Turf Irrigation Challenges



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Irrigation Consulting, Inc. (Pepperell, MA)

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- Why Irrigate?
- Infilled system versus carpet
- Site Evaluation
- Planning/Design
- Construction
- Operation

• Why Irrigate?

- Field Hockey FIH Standards
 - Field Certification
 - Optimum Playing Conditions
 - Ball Speed and Control
 - Reduce Friction Forces
 - When Athlete Falls (Health and Safety)
 - Ligament and Joint Strain (Health and Safety)
 - Force Between Cleat and Carpet (Non-Infill)
 - Extended Life of Irrigated Carpet
- Infill
 - Cleaning
 - Heat Mitigation
 - Evaporative Cooling



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Infilled Fields Versus Carpet

- Infilled systems typically have nylon (plastic threads) attached to a backing with +/-50% depth filled with crumb rubber and/or sand
 - Irrigation for cleaning and heat control
 - Small effect in ambient heat with a 0.10" application.
 - Not typically irrigated with automatic system
 - Coconut/Cork-o-nut infill has greater irrigation need (dust control)
- Carpets (interwoven/knit nylon or PE fibers) placed over "e-layer" and or shock pad.
 - Commonly irrigated (NCAA)
 - FIH requirements
 - Coaches preference

Planning and Design (Carpet)

- Goals and Expectations
- Water Supply
 - Groundwater Well
 - Yield/Quality
 - Domestic Water
 - Other?
- Existing Infrastructure
 - Mainline
 - Cannons
 - Nozzles
 - Controls

Goals: FIH Compliance (International Hockey Federation)

- 3,000 to 5,000 gallons to take a field from dry to satisfactory moisture content (Field 300 feet x 180 feet; 54,000sf)
- Net application of +/- 0.10"
 - Applied before and after events over a long duration
- Restore wetting levels during 8-minute halftime (+/- 0.05")
- Delivery of approximately 300 gallons per minute during halftime
 - 2,400 gallons during halftime
- Sprinklers versus Cannons

Pop-Up Sprinklers Versus Cannon

- Cannons
 - Above Grade
 - Risk of Injury if placed within fenced play area
 - If placed too far away from field, cannon adjusted away from spectator, press and athlete areas (less than 180 degree application area)
 - Impact Driven
 - Low Pressure Requirements
 - 50 psi to 90 psi
- Sprinklers
 - Below Grade
 - Gear/Piston Drive
 - High Pressure Requirement
 - Inlet of 100 psi to 120 psi
 - Arcs are typically set precisely at 180 degrees or 90 degrees

Sprinkler Versus Cannon



Sprinkler Irrigation for Field Hockey







Design Considerations for Field Hockey Sprinkler Systems

- Flow
 - 300 to 350 gpm (Requirement of Halftime Watering)
 - Single Sprinkler (Underhill and Hunter)
- Pressure
 - Water Supply Pressure 120 to 140 psi
- Water Hammer / Surge
- Layout
 - Sprinkler Placement
 - Mainline Routing
- Materials

Satisfying Peak System Demand

- Direct Connection to Public Water Supply
 - Booster Pump Likely (60 to 80 psi static typical)
 - Single or Two Pump System
 - 3600 rpm (Typically)
 - Water Service Should be Sized at 6-inch
 - Tank Unlikely But Not Out of the Question
- Groundwater Well Supply
 - Tank Likely
 - Vertical Turbine
 - 1800 rpm (Typically)
 - Iron and Manganese Test (Staining)

Water Hammer/Surge

- Function of:
 - Pipe Velocity
 - Closing Speed of Valve
 - Thickness of Pipe
 - Material (E, modulus of elasticity)
- To Reduce Surge:
 - Reduce velocity
 - Increase pipe size
 - Increase valve closing speed
- Add Surge Pressure to Static and Dynamic Operating Pressures to Assess Strength of Overall System - Identify the weakest link in the chain
- Use Strong Pipe (consider reviewing and reducing E)
 - PVC Almost 3 time Greater E than HDPE
- Install Pressure Relief Valve

Operation/Programming

- Single Sprinkler at a Time
- Six Primary Sprinklers
 - 4 Corners
 - 2 Sidelines
- Halftime
 - Corners at 1 min/sprinkler (4 min)
 - Sidelines at 2 min/sprinkler (4 min)
 - 8 min total
- +/- 2,500 gallons of Water
Field Results

- Surge Happens
- Keep Velocity Low
- Vertical Turbine/Tank Systems Experience Lower Surges Than Centrifugal Pump Booster Systems
- HDPE Improvement
- Identify Pressure Rating of All Components
- Resist VE!!

Oops!



ASIC Seattle 2017 Irrigating Thoroughbred Turf Tracks



Cardinal Rules to Track Design

- Fittings/pipe failures are unacceptable
- Uniformity, especially on the inner lanes, cannot be compromised
- Regardless of turf health, irrigation will never happen unsupervised
- Thoroughbreds/jockey are high strung and extremely vulnerable to injury both on and off the track

Configuration on a NA Typical Turf Track



Configuration on a "European" Style Turf Track



Configuration on a European Turf Track



Running SurfaceConfiguration Turf Track



Current Expectations



















Varying Sprinkler Configurations



Varying Sprinkler Requirements



Varying Sprinkler Requirements



And Still the Need for Alternate Irrigation



Air Valves



Always Challenging Infrastructure Installation



Always Challenging Infrastructure Installation



Always Challenging Infrastructure Installation



Dealing with Corrosion



Challenging Routings/Secure Piping



Challenging Routings/Piping Conditions



Questions