Cable Sizing

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An apparently simple request from Wayne Bell opened up a big can of worms at my desk. He wanted to provide frost irrigation for a vineyard utilising the same mainline as the drip irrigation system. For this, he would require eight valves to run at the same time. No problem, I said, we will use the controller to activate a relay, and have a separate transformer power the eight valves. All I need to do is calculate the size cable we would need to run. Well, easier said than done.

First, I had to throw away any standard tables we had in the office regarding lengths of run, for they addressed only one or two valves connected together. I was sceptical that rules of thumb may not apply. The more I looked into things, the more complicated it became. Here are the results of my findings.

The key to cable sizing is to provide a minimum voltage to the furthest valve so that it can have enough juice to pull up the plunger, which is being pushed down by a spring and by mainline water pressure. To answer this, we must know what is the minimum voltage that will operate a solenoid. If we knew the voltage at the controller, then we could determine the allowable voltage drop that we could have through the cable. The voltage drop equation is straightforward:

$$V_{Drop} = I \times R/M \times L / 1000$$

V_{Drop} = Voltage Drop, Volts
I = Current, Amps
R/M = Resistance in milliohms / metre
L = Length in metres

We can break down the equation further to analyse the issue.

Allowable Voltage Drop (V_{Drop})

Different controllers put out different voltages and the voltage available can be reduced depending on the number of valves being run together, as for example when there is a master valve. I conducted an experiment on three controllers at the office, measuring the voltage output and was surprised by the results.

	Voltage Output (Volts)			
Controller	No Load	1 Valve	2 Valves	4 Valves
Sterling	24.0		23.0	22.5
Hunter ICC	26.5		25.5	25.0
Hunter EC	25.0	23.5	22.5	

It is interesting to note that the Sterling and the EC open field valves and the master valve at roughly the same time, whereas the Hunter ICC provides a small delay before the master valve is actuated. The above tests were conducted with solenoids under no water pressure.
There isn't much information on the minimum pressure that a solenoid will operate. However, Baccara rates their irrigation solenoid at –20%/+10%. At standard 24V the minimum operating voltage would be 19.2 Volts (24V less 20%).

The Allowable Voltage Drop $\mathbf{V_{Drop}}$ depends on the type of controller and the solenoid being used. However, for a normal application one could work on a 4 – 5 Volt drop.

Resistance (R/M)

The following cable resistance values for low voltage irrigation cable were provided by our cable suppliers:

Wire Gauge mm2	Resistance (milliohms/metre)
0.5mm2	38.40
1.0mm2	21.20
1.5mm2	13.60
2.5mm2	8.36
4.0mm2	4.61
6.0mm2	3.80

Current (I)

Solenoids require a large current to move the plunger, called the inrush current. Once the plunger has moved, they require less energy to keep the valve opened, also know as holding current. Different solenoids have different electrical characteristics. Inrush current should be used in sizing the cable. The following table indicates the electrical characteristics of our more common solenoids:

Solenoid Type	Inrush current (amps)
New Hunter ICV, PGV, HPV, ASV	0.48
HR, Rain Bird	0.41
Hunter HBV	0.34
Old Hunter ICV, PGV, HPV, ASV	0.28
Hunter SRV valve	0.28
Bermad, Baccara AC 2.2W Std	0.28
Bermad Rectified DC	0.13

Care should be taken with replacing existing Hunter with new valves due to the higher wattage solenoids being supplied.

When more than one valve is operating together and sharing the common, the current through the common must account for the additional current through the cable. In most irrigation situations, we run individual wires to each valve, and tie them together to the same common. Therefore, the current flowing down the control wire and back the common will be different. Often a larger common is used. Voltage drop on each segment should be calculated separately and added together to give the total drop.

No more rules of thumbs!