WIRE SIZING NOTES

These notes relate to 24 VAC wiring for solenoid valves. For voltages above 30 VAC consult the appropriate electrical standard for wire sizing and installation.

The Nelson *800 Series Control Valve Application Guide* (800AG-4) has excellent notes on wire sizing for 24 VAC solenoid valves in section 6.0, "Electrical Applications". The notes contain an introduction to the concepts, tables for quick reference, and calculation examples based on resistance.

The notes below are an additional reference. They explain some of the terminology used in wire sizing and show an alternative method of calculation based on voltage drop. Example installation specifications are also included.

Other useful references on this subject are:

- The Irrigation Association Certification Program Reference Manual. Section 5.1
- Turf Irrigation Manual by Richard B. Choate, pages 321 - 334

Allowable Voltage Loss (AVL)

This is the design limit for the voltage loss between the controller (or power source) and the solenoid. If the controller has an output of 26 volts under load, and the minimum operating voltage of a solenoid is 20 volts then the AVL is 6 volts.

The output voltage of a controller is affected by its input voltage and by the number of valves it operates at a time. An input voltage of 120 VAC will give a higher output voltage than an input voltage of 110 VAC. If two or more solenoid valves are operating at a time there is more load on the controller so the output voltage will drop. Consult the manufacturer of the controller for detailed information.

The minimum operating voltage of a solenoid is affected by operating pressure. In a high pressure system, more energy is required to trip the solenoid. The *800 Series Control Valve Application Guide* gives the details for the Nelson valves on page 14 and 15.

Choice of Solenoid

The solenoid you select when ordering a Nelson 800 series valve will dramatically affect the size of wire required to control the valve. For example the E40 24 VAC solenoid has an inrush current of 0.3 amps and the E42 24 VAC solenoid has an inrush current of 3.6 amps.

The solenoid needs to be matched to the following components in the system:

- Valve size
- Power source voltage
- Power source current
- Distance from power source to solenoid.

Solenoids with large orifices are recommended only for the larger valves. For example the E42 solenoid is a fast opening and closing solenoid for the 6" and 8" valves only.

The solenoid needs to operate at the same voltage as the power source. If an irrigation controller has an output of 24 VAC use a 24 VAC solenoid. Irrigation controllers have a limitation on the current load that can be placed on them. Generally, 0.3 amp solenoids (E40 or E43) are used in applications using irrigation controllers. The controllers may be able to operate up to 4 valves at a time.

If an independent step-down transformer is used to supply the 24 VAC, higher current solenoids may be used, e.g., the E41. Check the current output of the transformer. Common applications for this solenoid are on valves near pumps or filter stations. The distances are small and a strong power source is available. The higher current solenoids have the advantage of greater reliability. There is more power on the solenoid coil to overcome seal drag and any grit around the plunger.

Most irrigation systems that have a central irrigation controller and the valves in the field use 0.3 amp inrush solenoids. The distances from the controller to the solenoids mean that the wire size is too expensive if higher current solenoids are used.

Practical Issues

There are several practical issues to keep in mind when sizing wire.

Wire comes in certain coil lengths. It may be cheaper to buy a wire size large enough to use for all valves rather than use smaller wire on some valves and larger wire on others. Installation to avoid splices is easier with larger coil lengths. The wire should be type UF for direct burial.

It is often a good idea to lay a spare wire to the farthest point in the scheme. This can be used at a later date to replace a damaged wire or to add a valve or data collector.

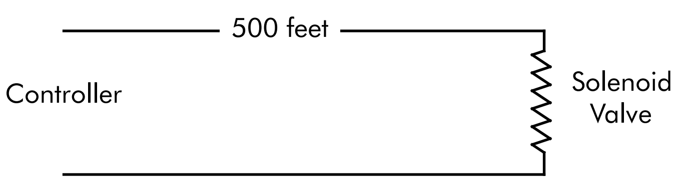
Some cables are single strand and some are multi-strand. A #18 cable may come with one strand of solid copper or it may have three strands twisted together to form the same size. A multi-strand cable is always a better bet. If a single strand cable breaks, the circuit is broken. If one strand of a multi-strand cable breaks, the circuit is still live.

Voltage Drop Calculation Examples

The Voltage Drop table at the back of these notes is used to calculate the voltage drop in the two examples outlined below. The distance used in the calculation is the distance from the power source to the solenoid. The voltage losses in the table are configured so the one-way distance will give you the voltage drop out-and-back.

Single Solenoid Valve

- Controller output 26 VAC



- Minimum solenoid voltage 21 VAC
- Inrush current 0.3 Amps
- Distance from controller to valve 500 feet

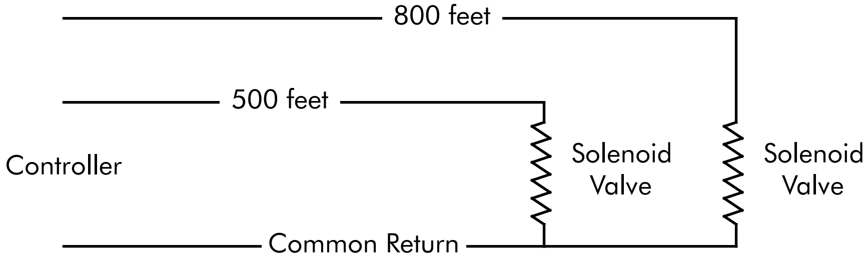
Allowable Voltage Drop (AVL) = 26-21 = 5 VAC

Using the attached table, #18 wire has a voltage drop of 0.41 VAC / 100 feet.

Voltage drop = 0.41/100 * 500 = 2.05 Volts.

This is less than our AVL so the wire size is OK.

Two Solenoids Operated Together



In this example there are two solenoid valves. The first is 500 feet from the controller. The second is a further 300 feet, or a total of 800 feet from the controller. The solenoid valves may be run separately but they may also be run together. The wires need to be designed to meet this flexibility.

• Controller output	25 VAC with two solenoids operating
• Minimum solenoid voltage	21 VAC
• Inrush current	0.3 Amps
AVL (allowable voltage drop)	= 25-21 = 4 VAC

The current loads in the lead out wires are different than the current load in the common return wire. The process in this example is to calculate the voltage loss out to each valve, and then to calculate the loss in the common return wire. They are then added together. The distances should be halved when using the Voltage Drop table because this table assumes a loss for an out-and-back calculation.

Calculating the Individual Lead Out Wires

Try #18 wire. From the table the loss= 0.41/100 Volts per 100 feet for 0.3 amp load.

800 foot lead out	#18 wire	0.41/100*800/2 = 1.64 volts
500 foot lead out	#18 wire	0.41/100*500/2 = 1.03 volts

The common return has a 500 foot section running two valves with a load of 0.6 Amps. The last section is 300 feet and carries a load of 0.3 amps.

Calculating the Common Return Wire

Try #16 wire. From the table, loss = 0.51/100 volts per 100 feet for a 0.6 amp load. = 0.26/100 Volts per 100 feet for a 0.3 amp load.

Loss in 500' section = 0.51/100*500/2 = 1.28 volts

Loss in 300' section = 0.26/100*300/2 = 0.39 volts

Total loss in the common return = 1.67 volts

Total voltage drop to the furthest valve is equal to the loss in the lead out wire plus the loss in the common return.

1.64 + 1.67 = 3.31 Volts

This is less than the AVL of 4 volts so the wire sizes are OK.

Installation Specification Example

Install electric control wire in the pipe trenches wherever possible. Place wire in the trench under the pipe. Install the wire with slack to allow for thermal expansion and contraction. Expansion joints in the wire may be provided at 200 foot intervals by making 5-6 turns of the wire around a piece of 1/2" pipe instead of slack. Where it is necessary to run wire in a separate trench, provide a minimum cover of 24" (or follow the local code).

Provide sufficient slack at site connections, at remote control valves in control boxes, and at all wire splices to allow for raising of the valve, or splice to the surface without disconnecting the wires when repair is required.

Make wire connections to remote control electric valves. No wire splices are allowed in the pipe trench. All splices should be located at a valve box.

Install an unconnected spare control wire from the controller through each intermediate control valve box. Enough slack wire shall be left in each control valve box to allow its use if necessary. The spare wire should run from the controller to furthest valve position.

VOLTAGE DROP TABLE

Volts/100′

Copper	Wire Size AWG (American Wire Gage)					
AWG	18	16	14	12	10	8
sq.mm	0.82	1.31	2.08	4.17	5.82	8.36
Amperes						
0.1	0.14	0.09	0.05	0.03	0.02	0.01
0.2	0.27	0.17	0.11	0.07	0.04	0.03
0.3	0.41	0.26	0.16	0.10	0.06	0.04
0.4	0.54	0.34	0.21	0.13	0.08	0.05
0.5	0.68	0.43	0.27	0.17	0.11	0.07
0.6	0.81	0.51	0.32	0.20	0.13	0.08
0.7	0.95	0.60	0.37	0.24	0.15	0.09
0.8	1.09	0.68	0.43	0.27	0.17	0.11
0.9	1.22	0.77	0.48	0.30	0.19	0.12
1.0	1.36	0.85	0.54	0.34	0.21	0.13
1.1	1.49	0.94	0.59	0.37	0.23	0.15
1.2	1.63	1.02	0.64	0.40	0.25	0.16
1.3	1.77	1.11	0.70	0.44	0.28	0.17
1.4	1.90	1.19	0.75	0.47	0.30	0.19
1.5	2.04	1.28	0.80	0.51	0.32	0.20
1.6	2.17	1.36	0.86	0.54	0.34	0.21
1.7	2.31	1.45	0.91	0.57	0.36	0.23
1.8	2.44	1.53	0.96	0.61	0:38	0.24
1.9	2.58	1.62	1.02	0.64	0.40	0.25
2.0	2.72	1.71	1.07	0.67	0.42	0.27
2.1	2.85	1.79	1.12	0.71	0.44	0.28
2.2	2.99	1.88	1.18	0.74	0.47	0.29
2.3	3.12	1.96	1.23	0.77	0.49	0.31
2.4	3.26	2.05	1.28	0.81	0.51	0.32
2.5	3.40	2.13	1.34	0.84	0.53	0.33
3.0	4.07	2.56	1.61	1.01	0.64	0.40
3.4	4.62	2.90	1.82	1.15	0.72	0.45
3.8	5.16	3.24	2.03	1.28	0.81	0.51
4.2	5.70	3.58	2.25	1.41	0.89	0.56
4.6	6.25	3.92	2.46	1.55	0.97	0.61
5.0	6.79	4.26	2.68	1.68	1.06	0.67