Chemigation

Larry Schwankl
University of California, Davis

Chemigation

Chemigation is the application of a chemical through the irrigation system by mixing the chemical with the irrigation water.

- Drip irrigation systems are particularly well suited to chemigation.

Chemigation: What is commonly injected?

- Fertilizers
- Micronutrients
- Insecticides
- Herbicides
- Nematicides
- Chlorine and acid

Chemigation - Why inject?

- Plant response.
- Efficiency of chemical use.
- Lower cost.
- Convenience.
- Safety.
- Environmental issues.

Drip Chemigation

Do not put on too much water during the irrigation.

- Over-irrigation may leach water soluble chemicals (e.g. nitrates) out of the root zone.
  - Once leached, it is no longer available to the plant and it may contaminate the groundwater.

Injection Systems

Injection Systems

- The injection point for chemicals should be downstream of the irrigation system filters.
- This keeps chemical from going out with the backwash water when the filters are cleaned.
- There should be a good screen filter on the line from the injector to the irrigation system.

Injection Systems

Batch Tanks = Differential Pressure Tanks

Injection Systems

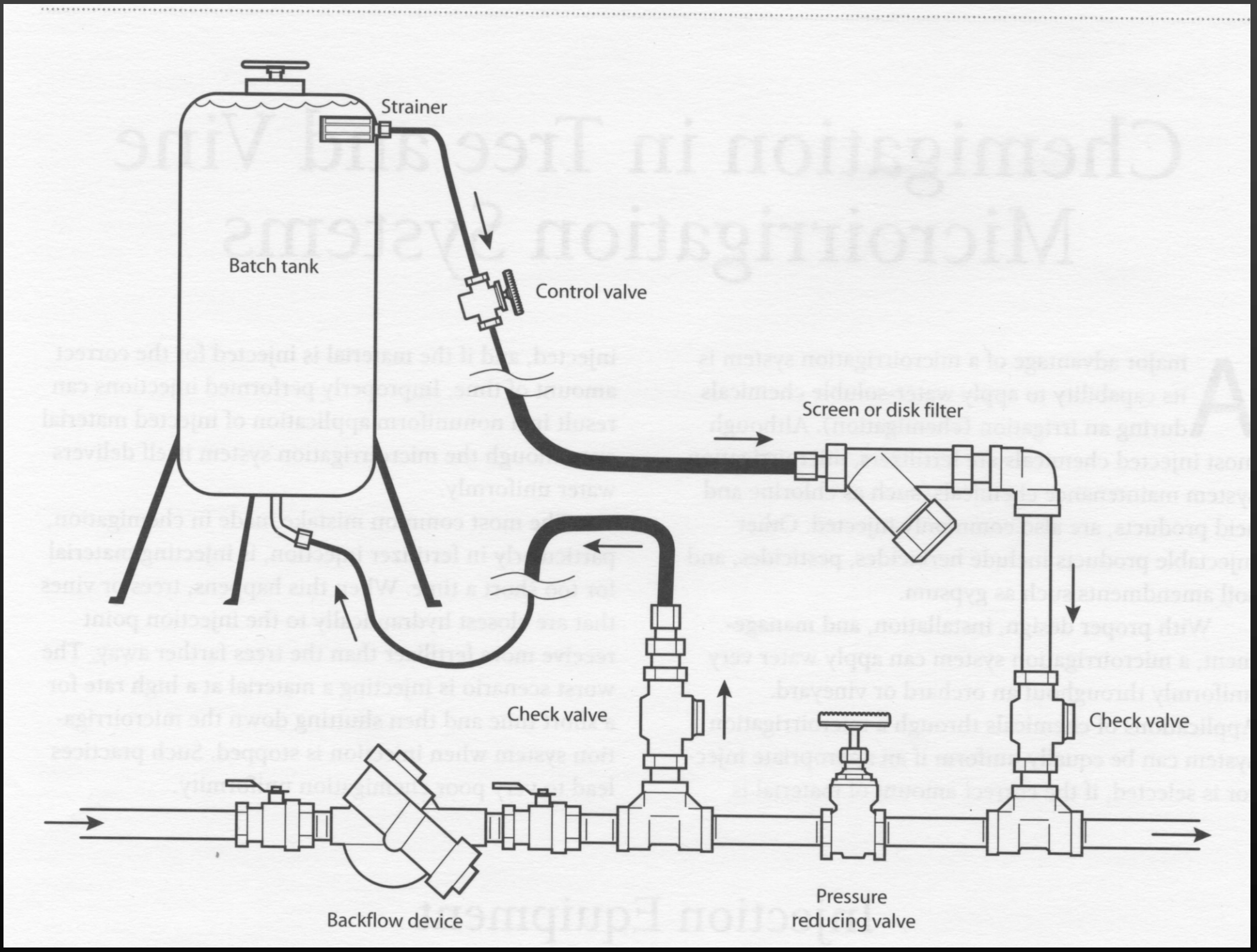
Batch Tanks:

Tank inlet connected at a point of higher pressure than the outlet.

Advantages: simple and low-cost.

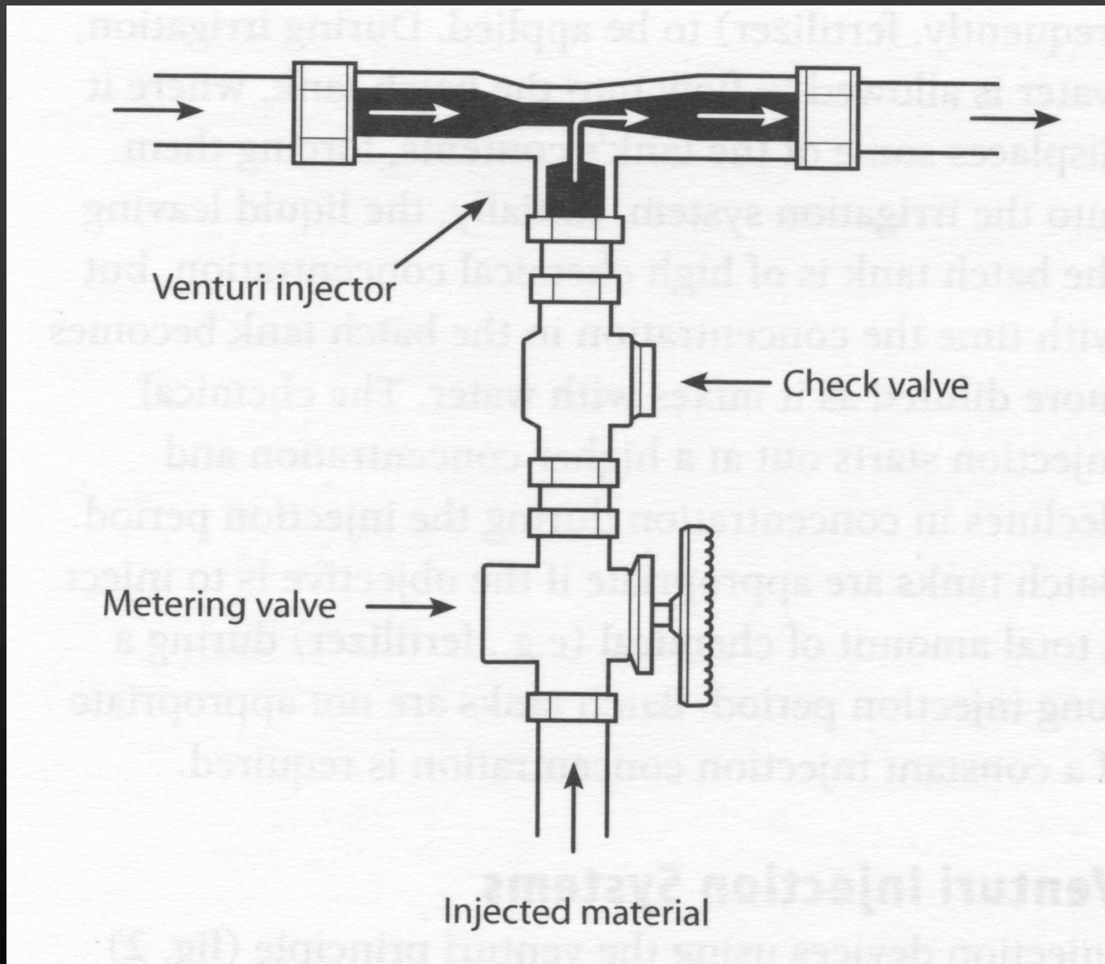
Disadvantage: concentration decreases with time.

Batch Tank:


Strainer
Batch tank
Control valve
Screen or disk filter
Check valve
Check valve
Backflow device
Pressure
reducing valve

Batch Tank

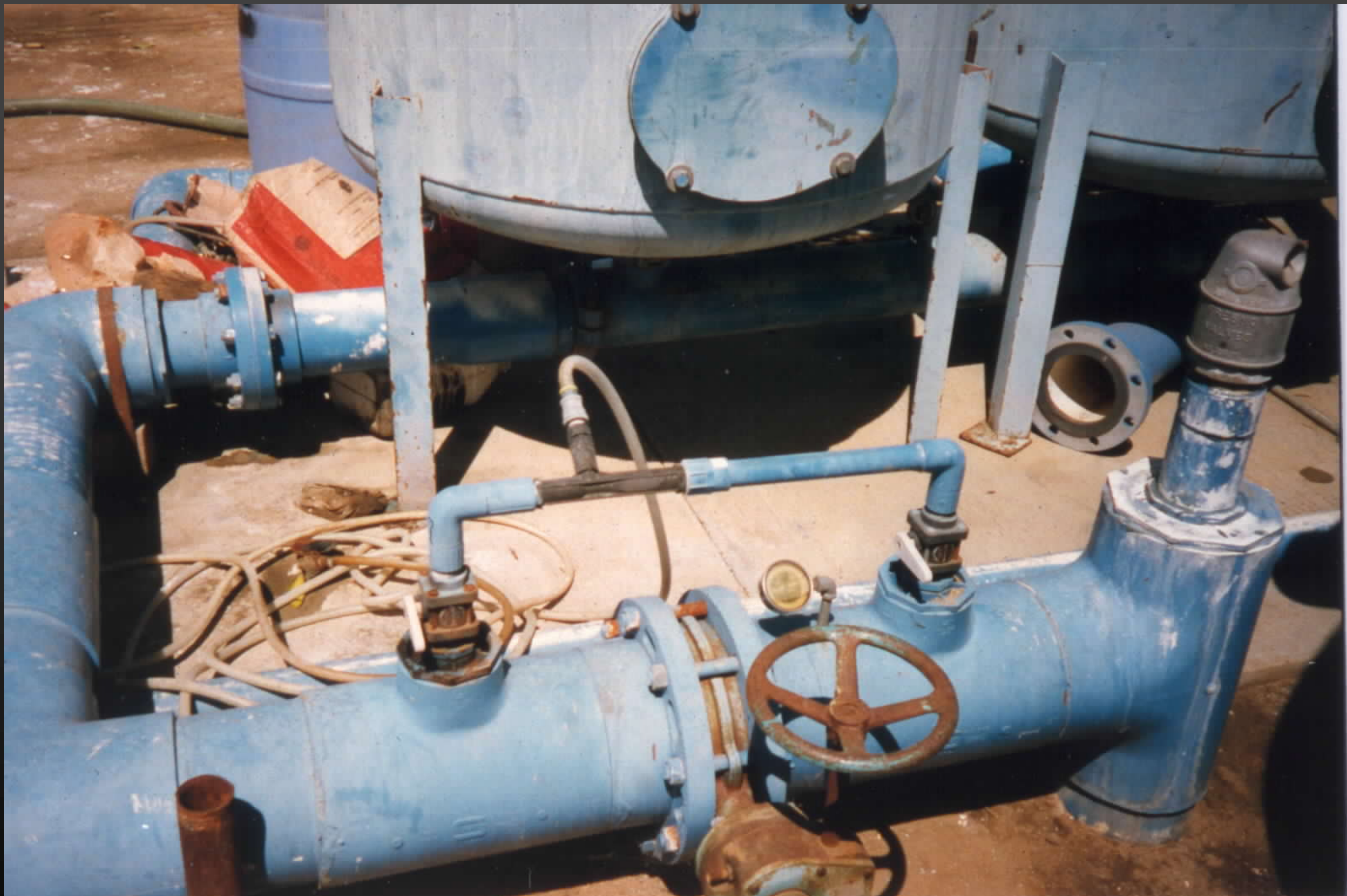
Venturi Injector



Injection Systems

Venturi Injectors:

Chemicals are drawn in as a result of a pressure difference caused by a constriction.



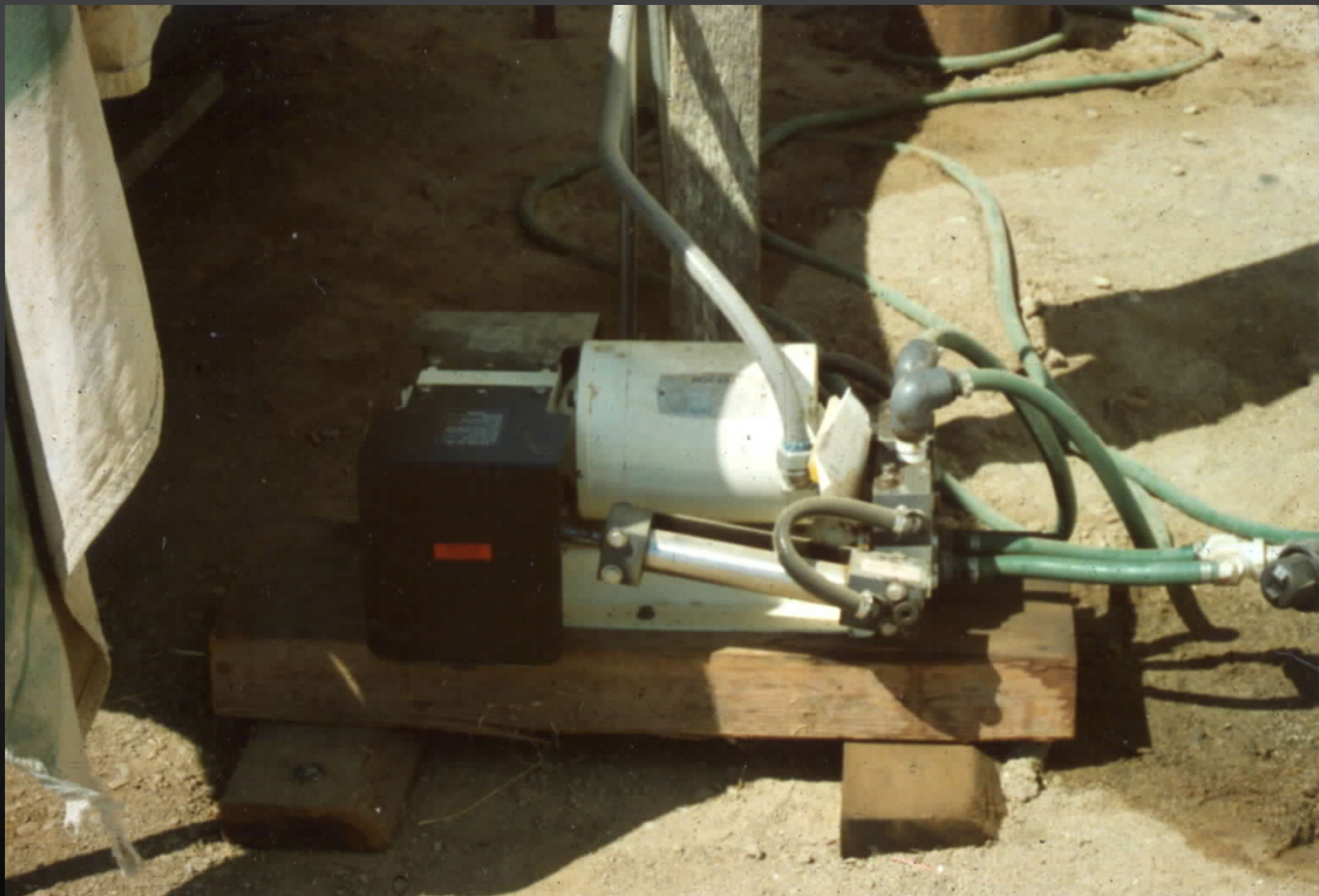
Injection Systems

Venturi Injectors:

Chemicals are drawn in as a result of a pressure difference caused by a constriction.

Advantages: simple and low cost.

Disadvantage: not quite as accurate as pump injectors.



Injection Systems

Positive Displacement Pumps:

Injection Systems

Positive Displacement Pumps:

Powered by electricity, gasoline, or water.

Injection Systems

Positive Displacement Pumps:

proportional type = constant dilution ratio.

constant rate = injection rate independent of irrigation system flow rate.

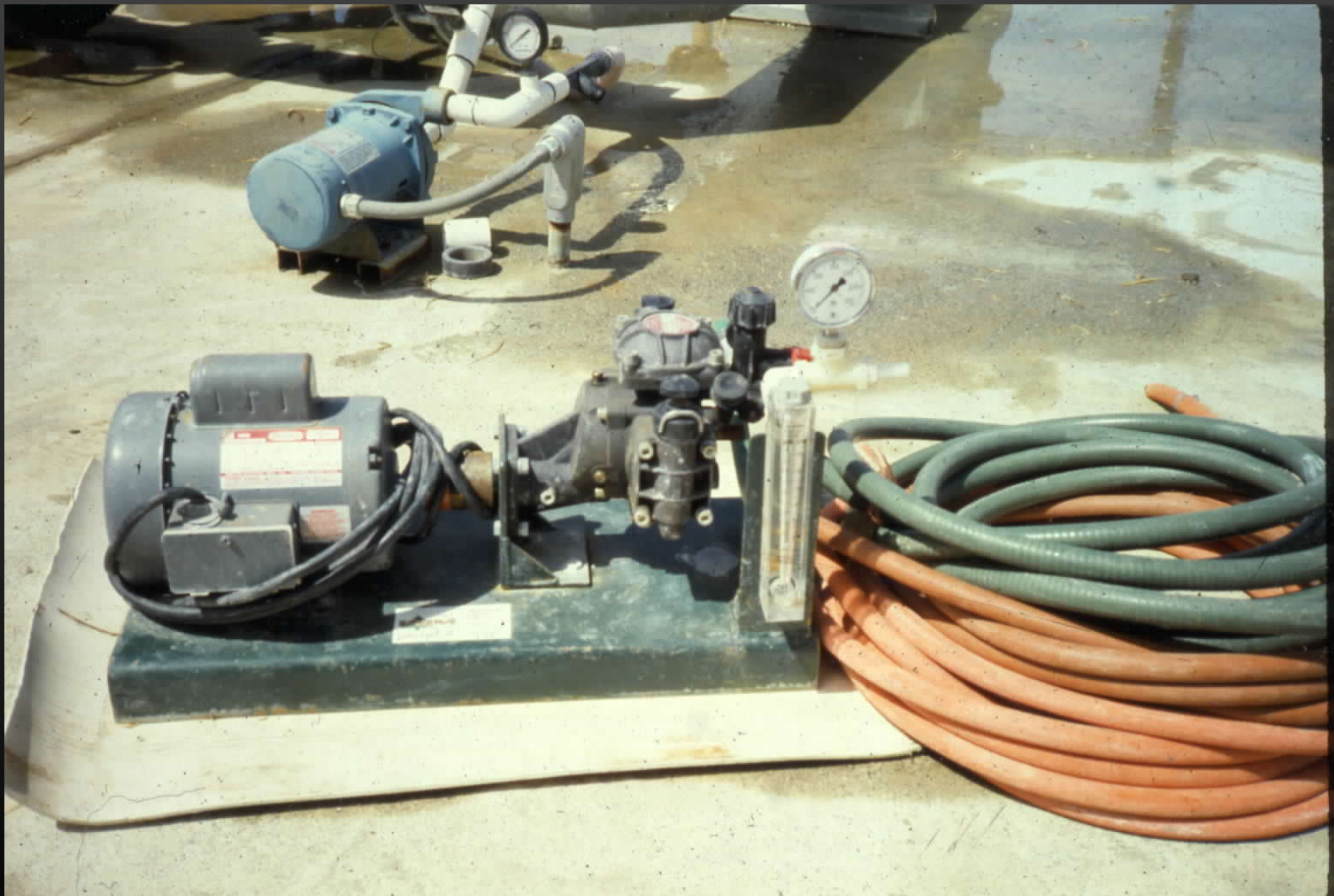
Injection Systems

Positive Displacement Pumps:

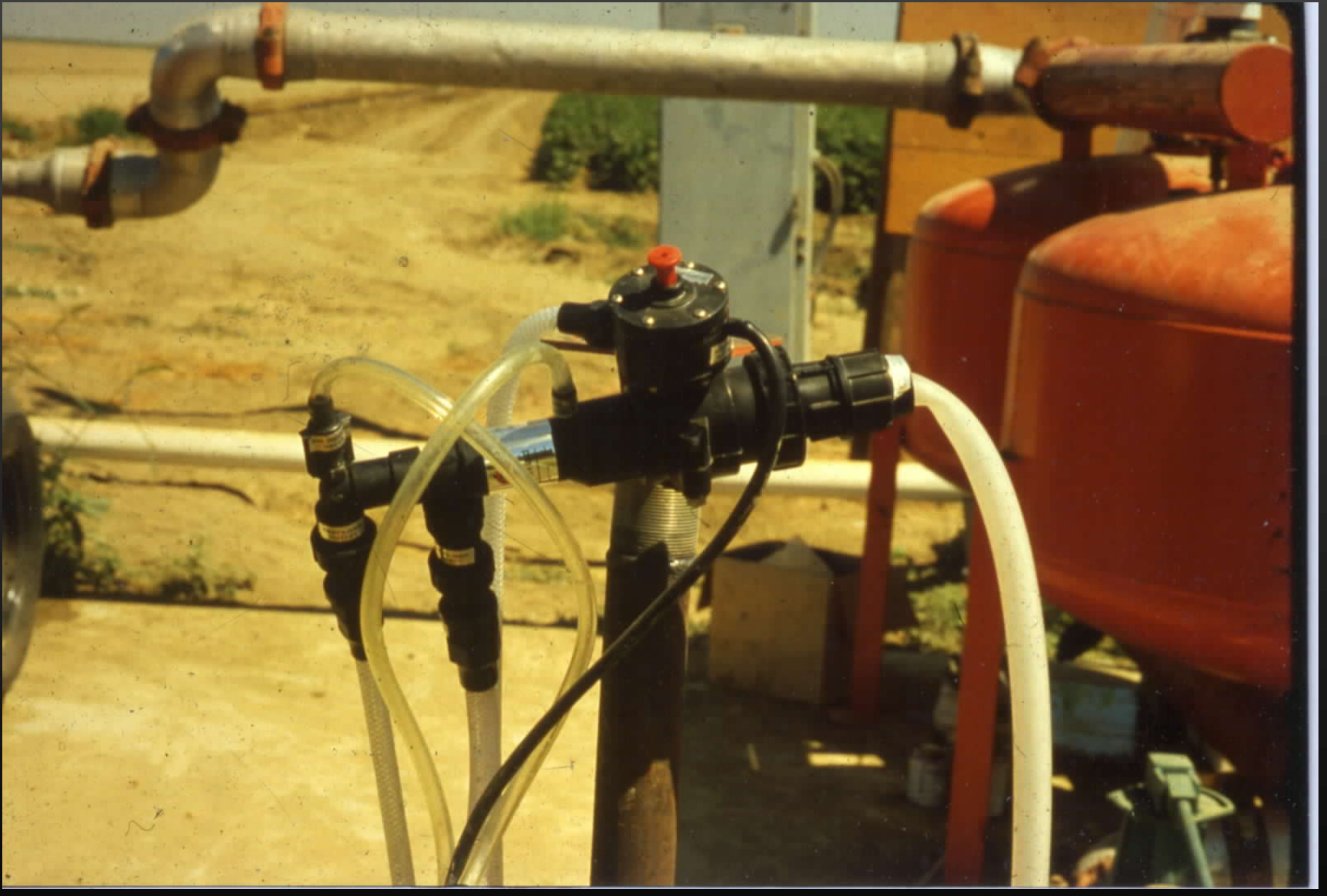
Advantages = most accurate & easily controlled.

Disadvantage = cost.

Diaphragm Pump



Water-driven injector:



Water-driven injector:

Solutionizer Injector:

Injection Systems

Solutionizer Machines

Originally designed for injecting gypsum, but now used for fertilizer (e.g. potassium sulfate) injections.

Material is injected as a slurry. It goes into solution after it enters the irrigation system's pipeline

Solutionizer injector:

Injection Systems

Solutionizer Machines

Injection point should be upstream of irrigation system filters.

There are contaminants in the gypsum and solid fertilizers which must be filtered out.

Chemigation Uniformity in Drip Irrigation Systems

Uniform Chemigation

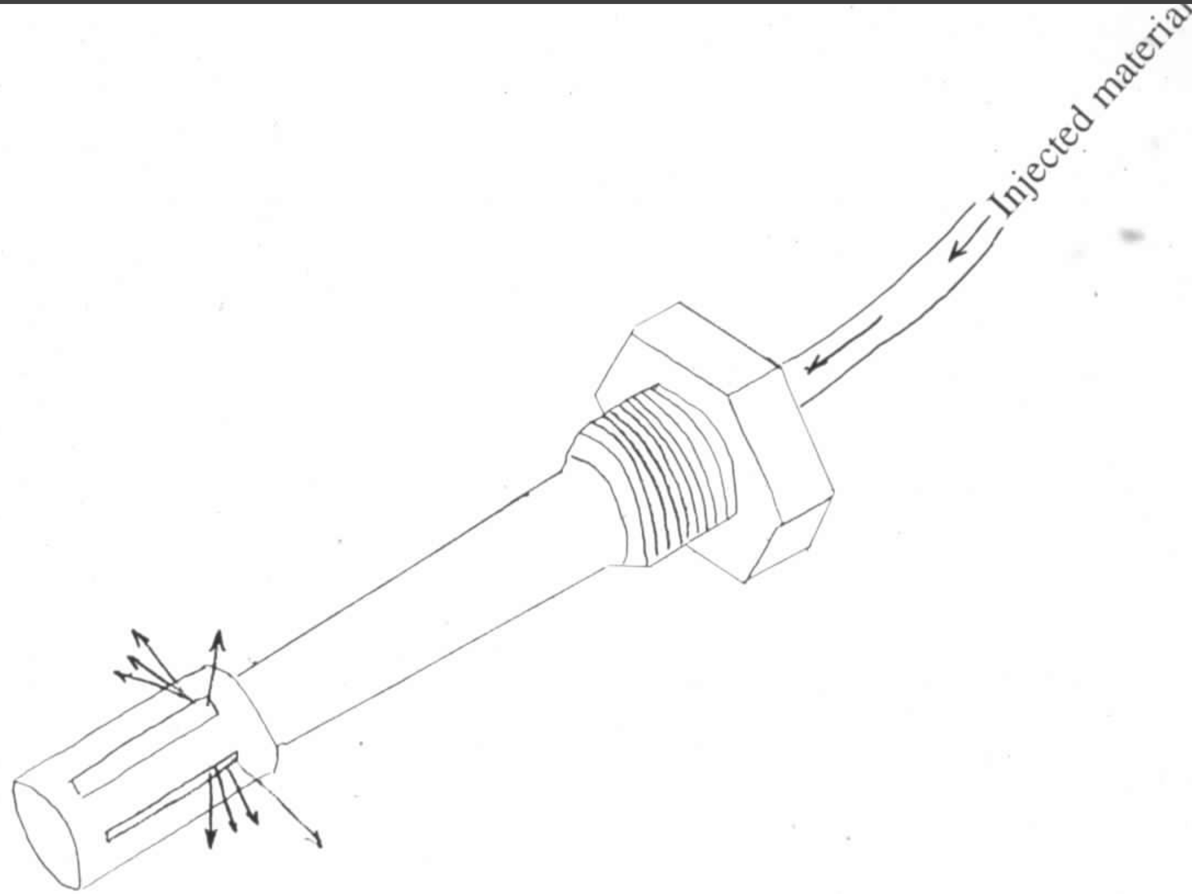
We want to have the material injected into the drip system to be applied as evenly (uniformly) as the water applied by the drip irrigation system.

Uniform Chemigation

A well-designed, well-maintained drip system which applies water uniformly will apply injected chemicals uniformly if the injection is done properly.

Uniform Chemigation

It is important to ensure that the injected chemical mixes thoroughly with the irrigation water prior to the first emitter.



A device for injecting chemicals into the midstream of the irrigation pipe to promote better mixing of the irrigation water and injected chemical. The device is installed using a tee or saddle attached to the pipe.

Uniform Chemigation

First, it is important to remember that once you start injecting, the injected material doesn't immediately start coming out of all the drip emitters.

- It takes time for the injected material (and the water) to travel through the drip irrigation system.

Uniform Chemigation

The following series of slides show the movement of a red dye injected into a drip lateral line.

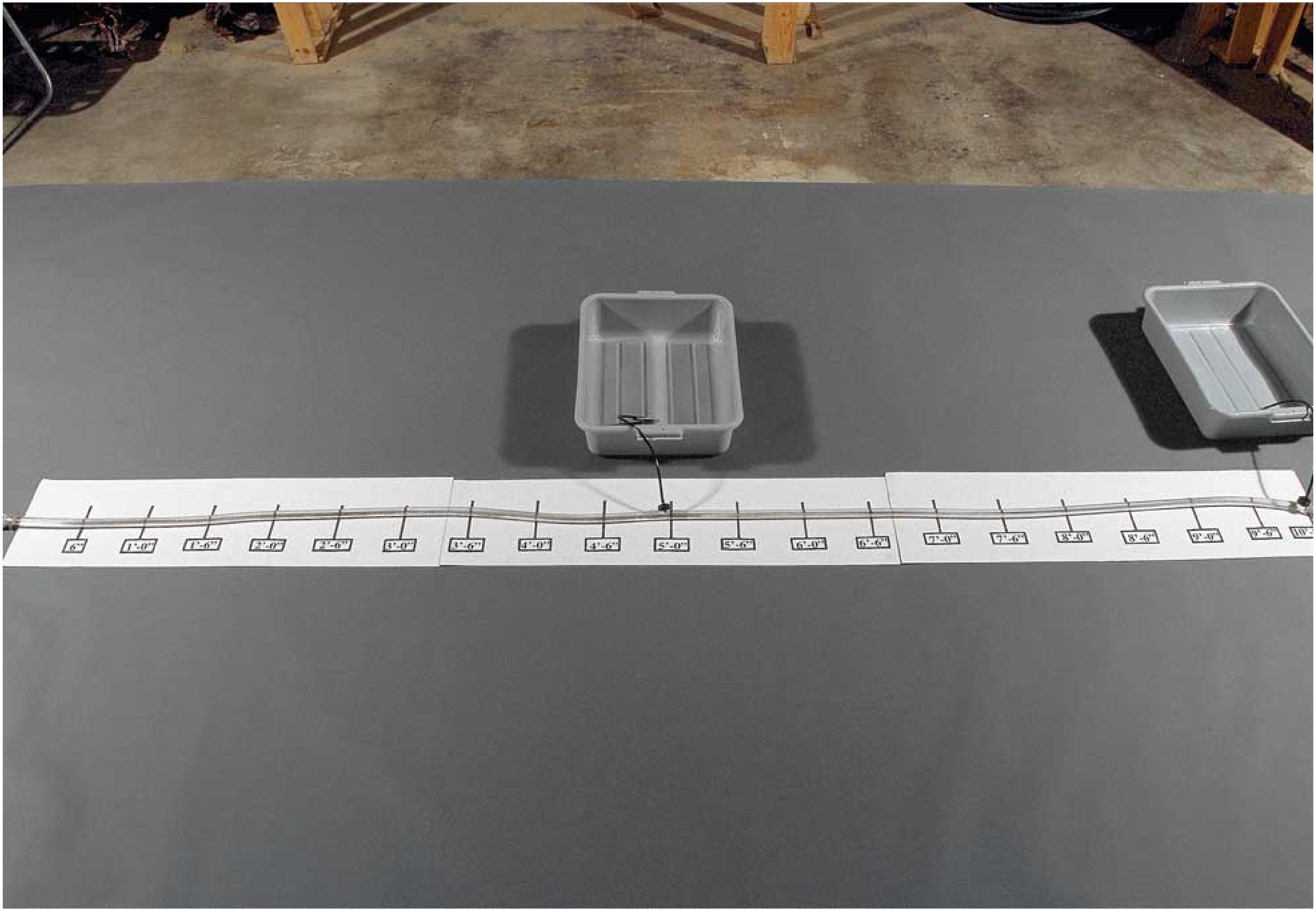
The length of tubing is 10 feet (3 meters) with a 1 gph (4 lph) drip emitter at the 5-foot (1.5 m) mark and another 1 gph (4 lph) emitter at the 10-foot (3 m) mark.

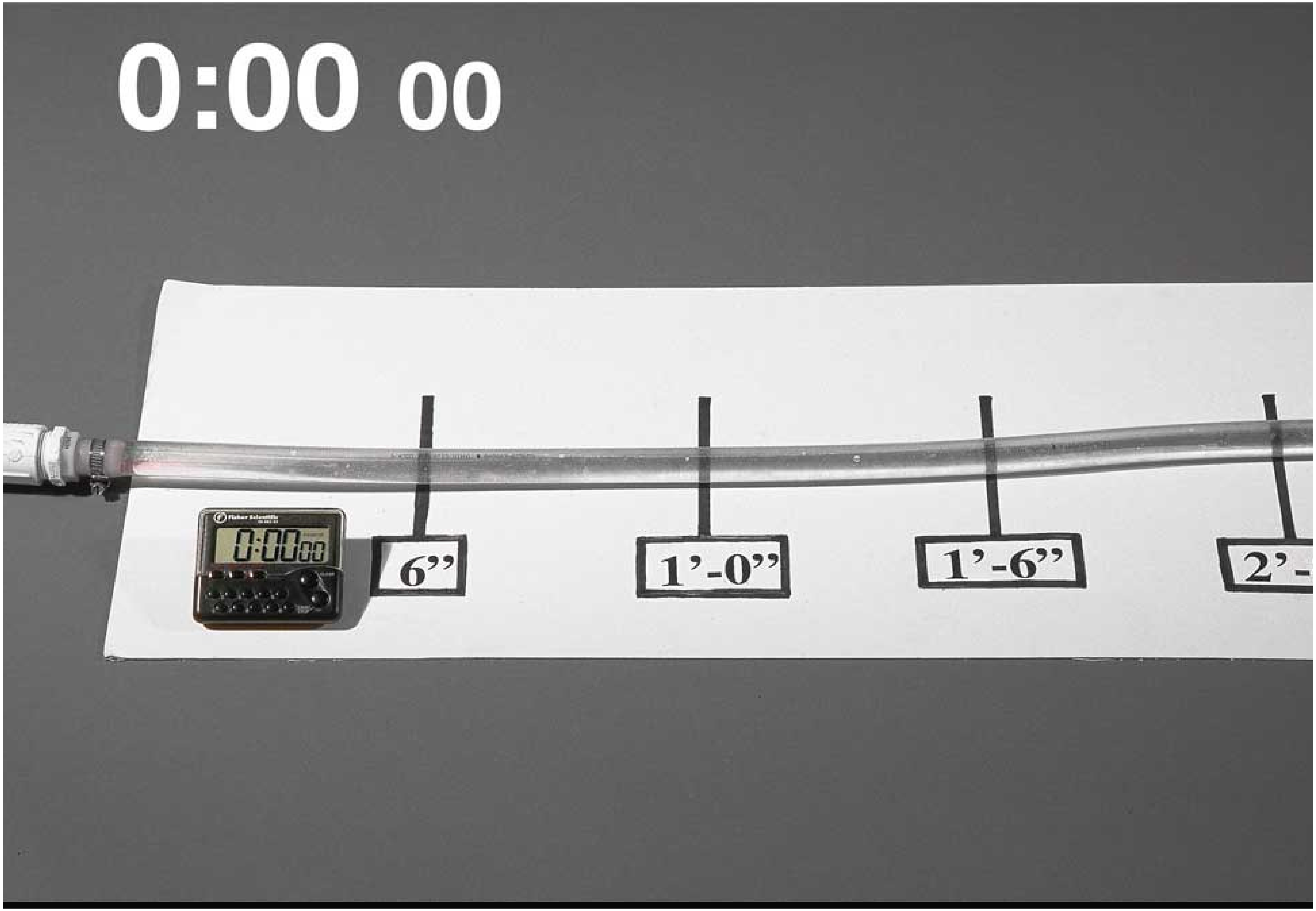
The time displayed is the time, since injection, began for the injected material to travel to the distance shown.

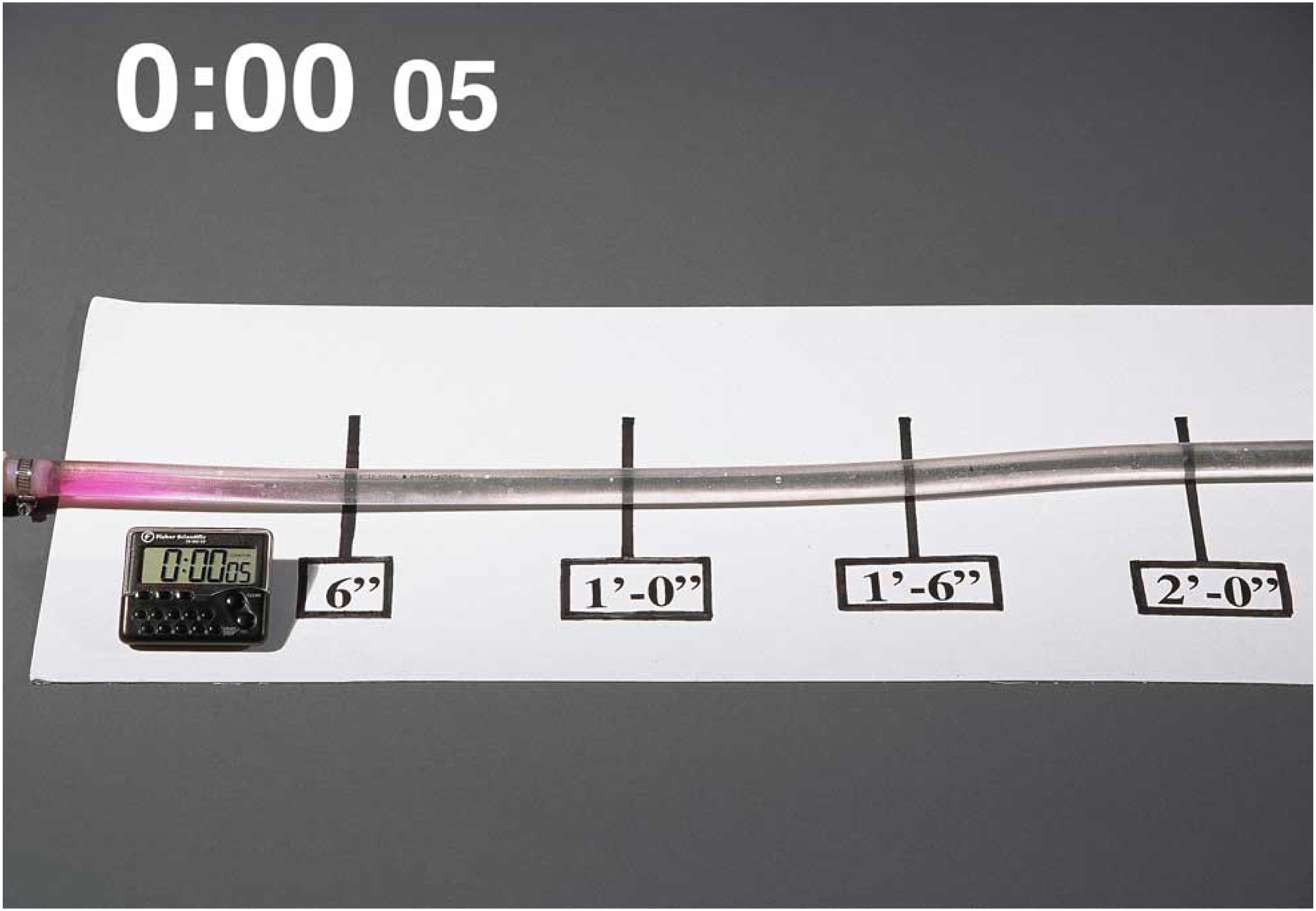
Uniform Chemigation

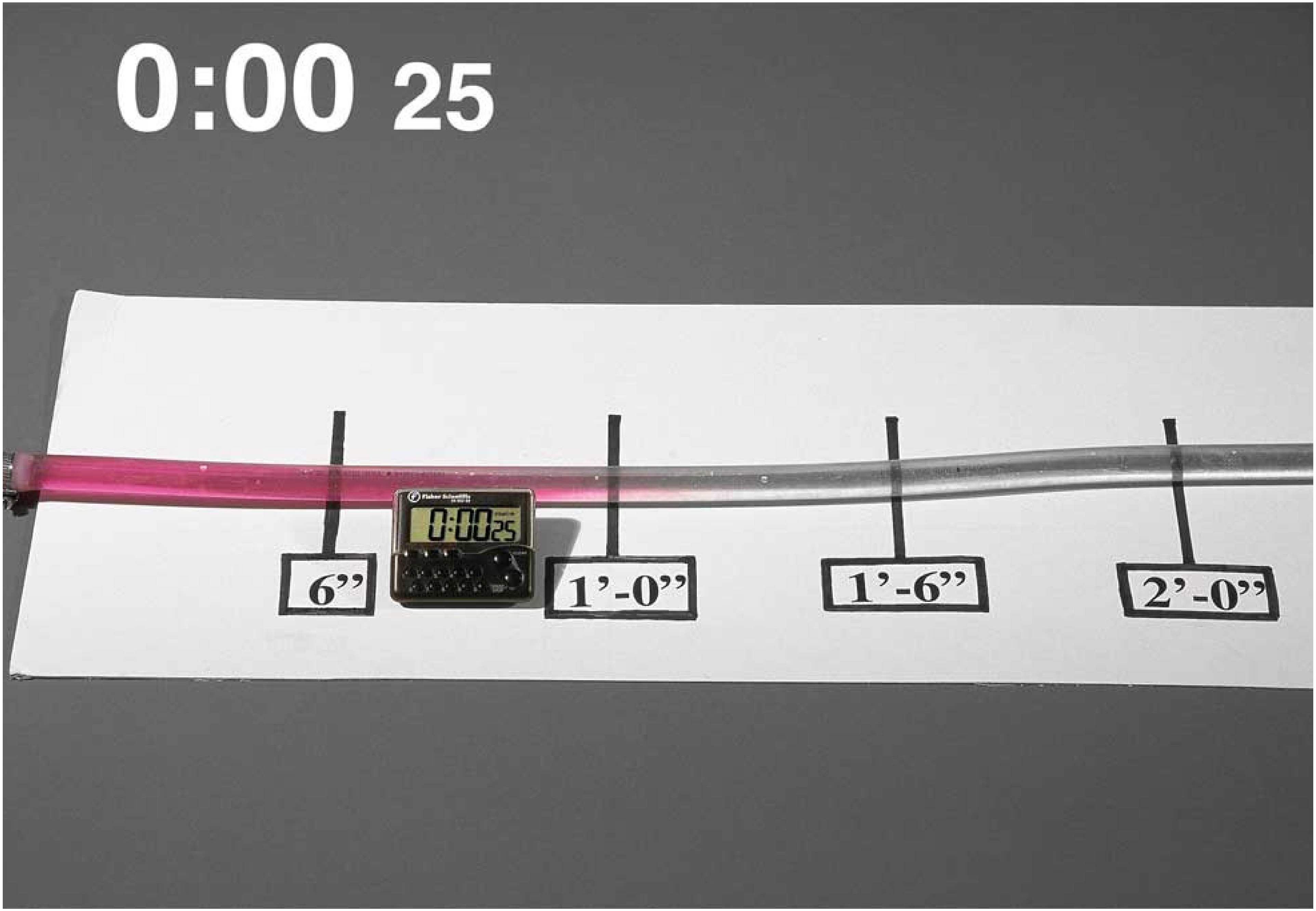
The flow rate in the drip tubing along the first 5-feet (1.5 m) is 2 gallons/hr (8 lph).

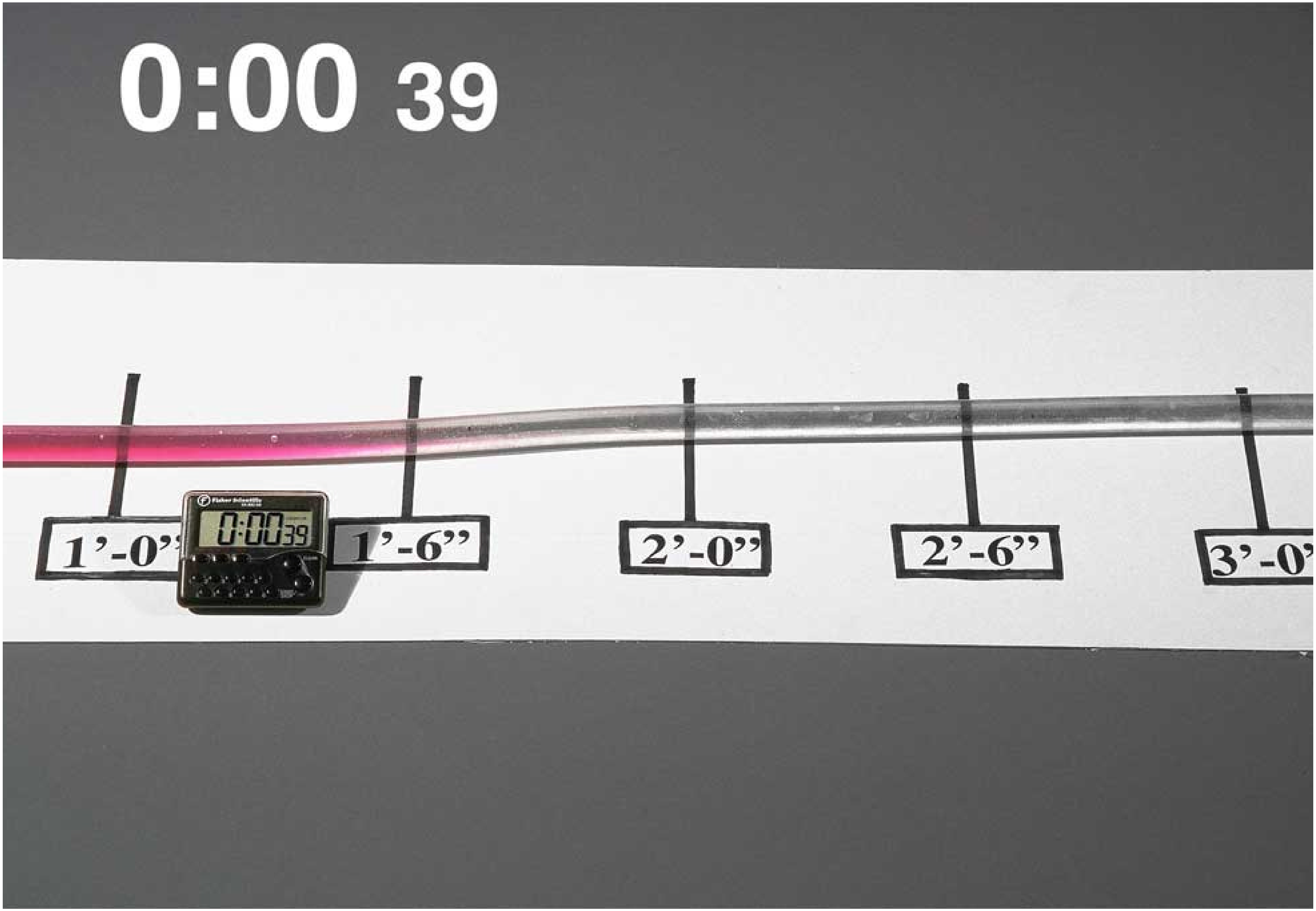
The flow rate in the drip tubing along the 5-foot (1.5 m) to 10-foot length (3 m) is 1 gph (4 lph) - the lesser the flow rate, the slower the flow velocity in the drip tubing.


6"
1'-0"
1'-6"
2'-0"
2'-6"
3'-0"
3'-6"
4'-0"
4'-6"
5'-0"
5'-6"
6'-0"
6'-6"
7'-0"
7'-6"
8'-0"
8'-6"
9'-0"
9'-6"

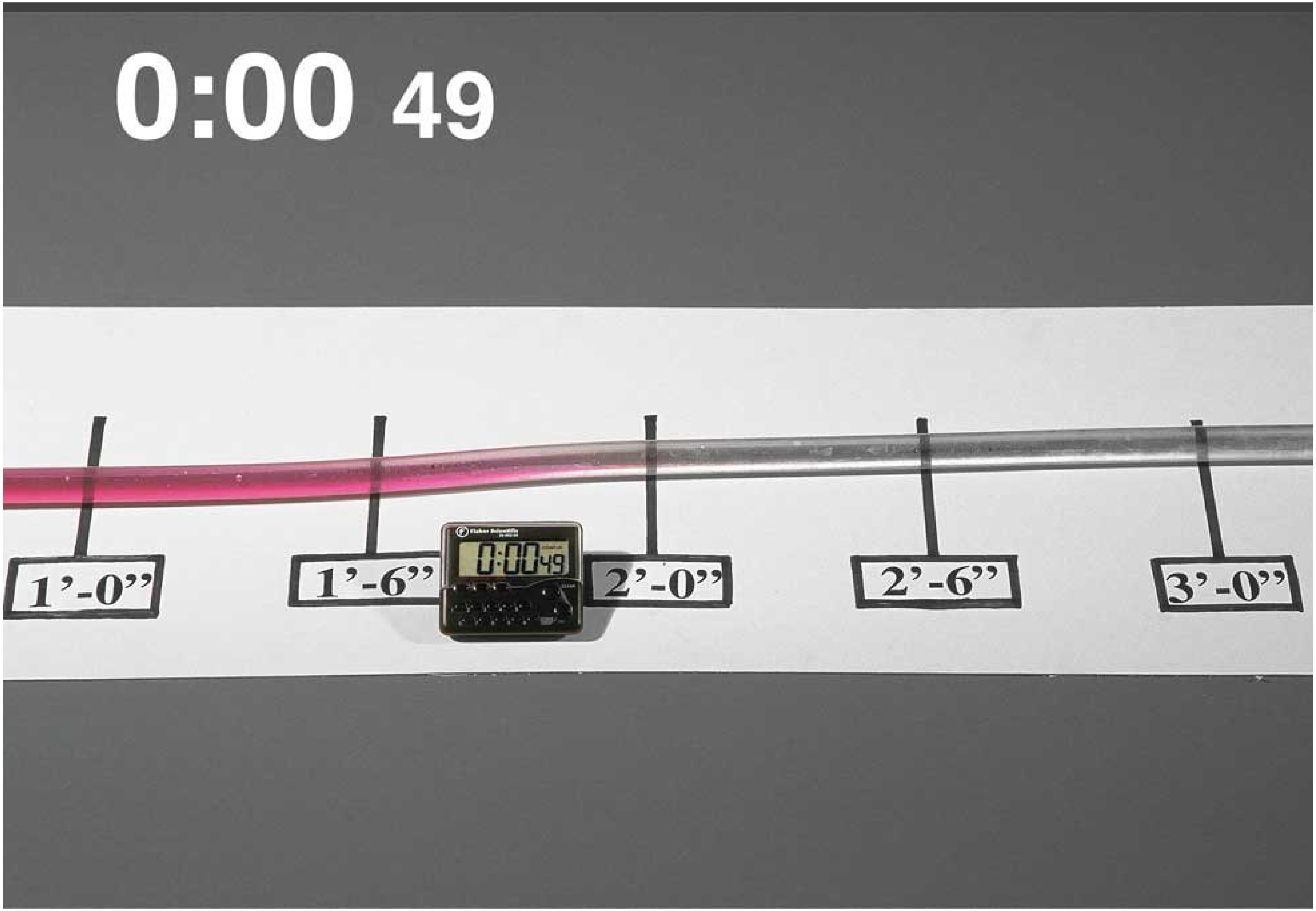

0:00 00
6”
1’-0”
1’-6”

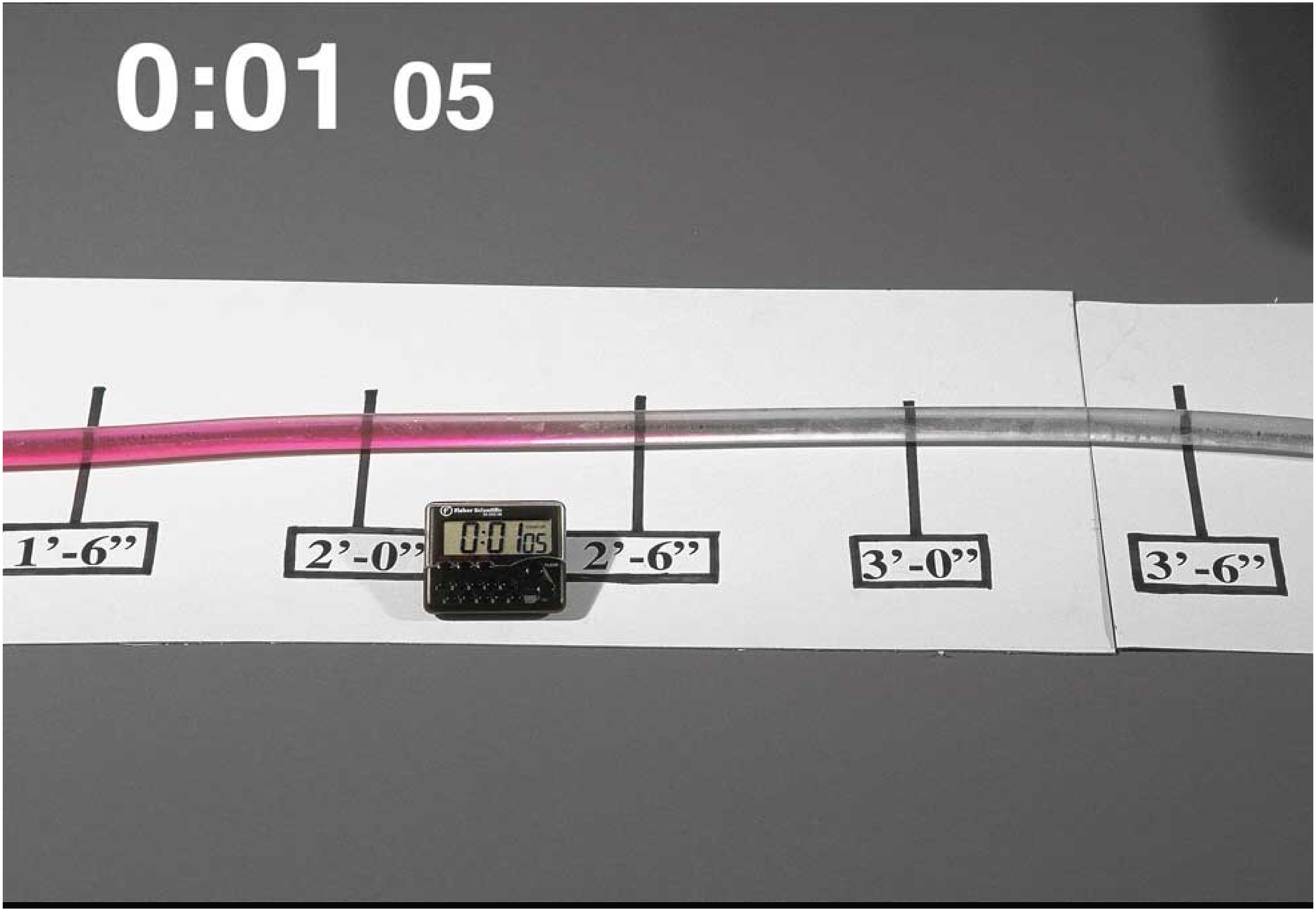

0:00 05
0:00 05
6”
1’-0”
1’-6”
2’-0”

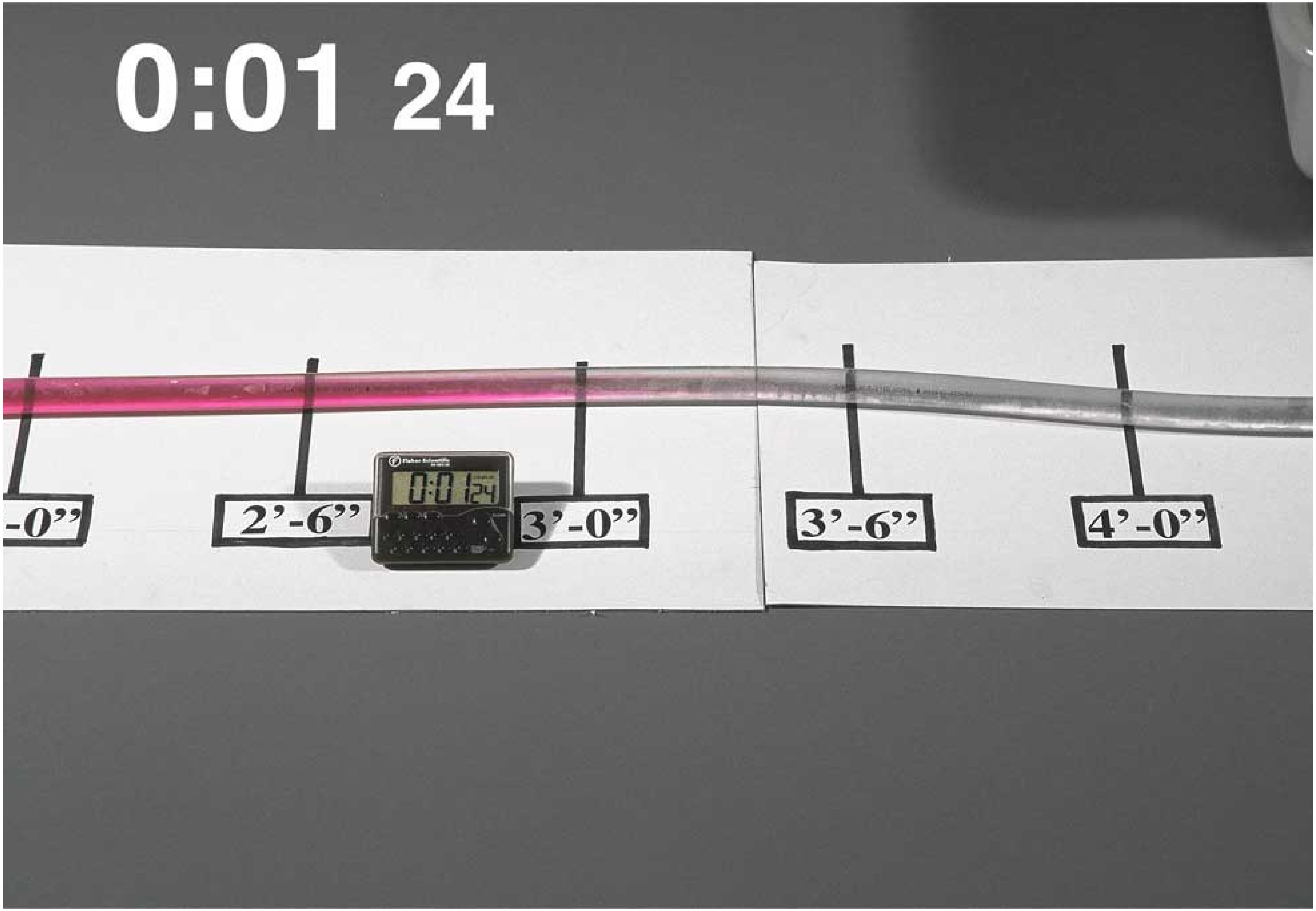

0:00 25
0:0025
6”
1’-0”
1’-6”
2’-0”

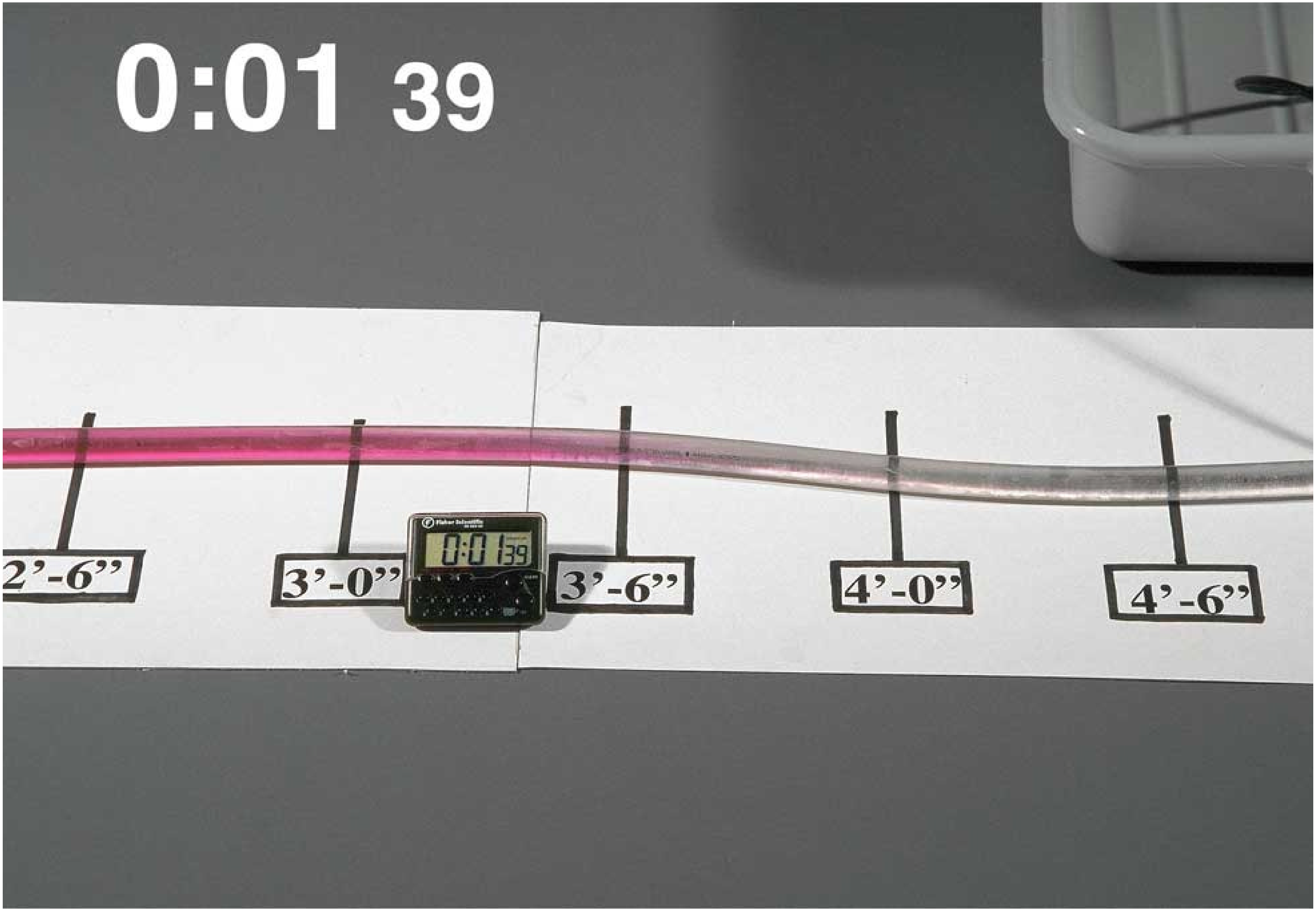


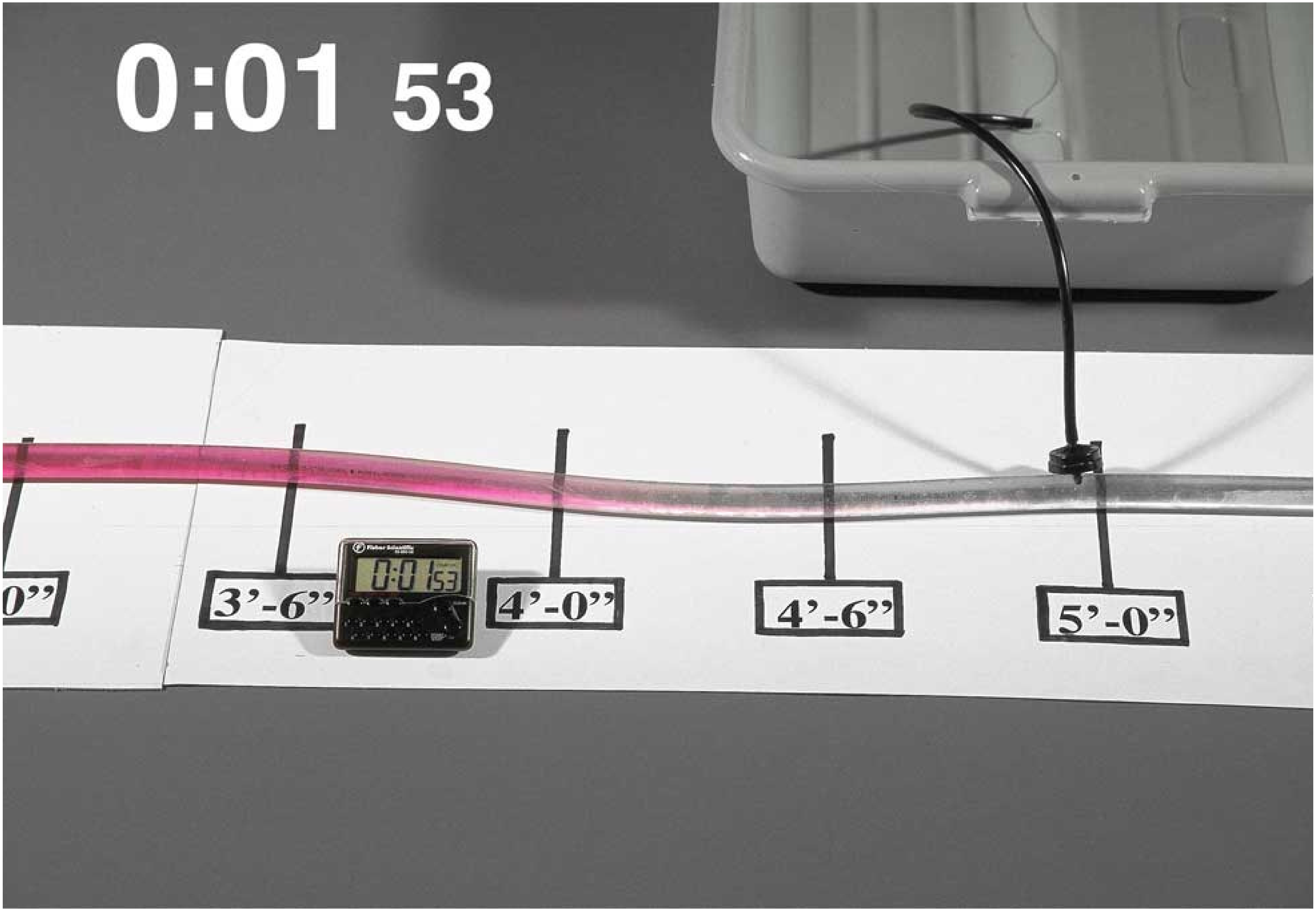
0:00 39
0:0039
1'-0"
1'-6"
2'-0"
2'-6"


0:00 49
1’-0”
1’-6”
2’-0”
2’-6”
3’-0”
0:00 49

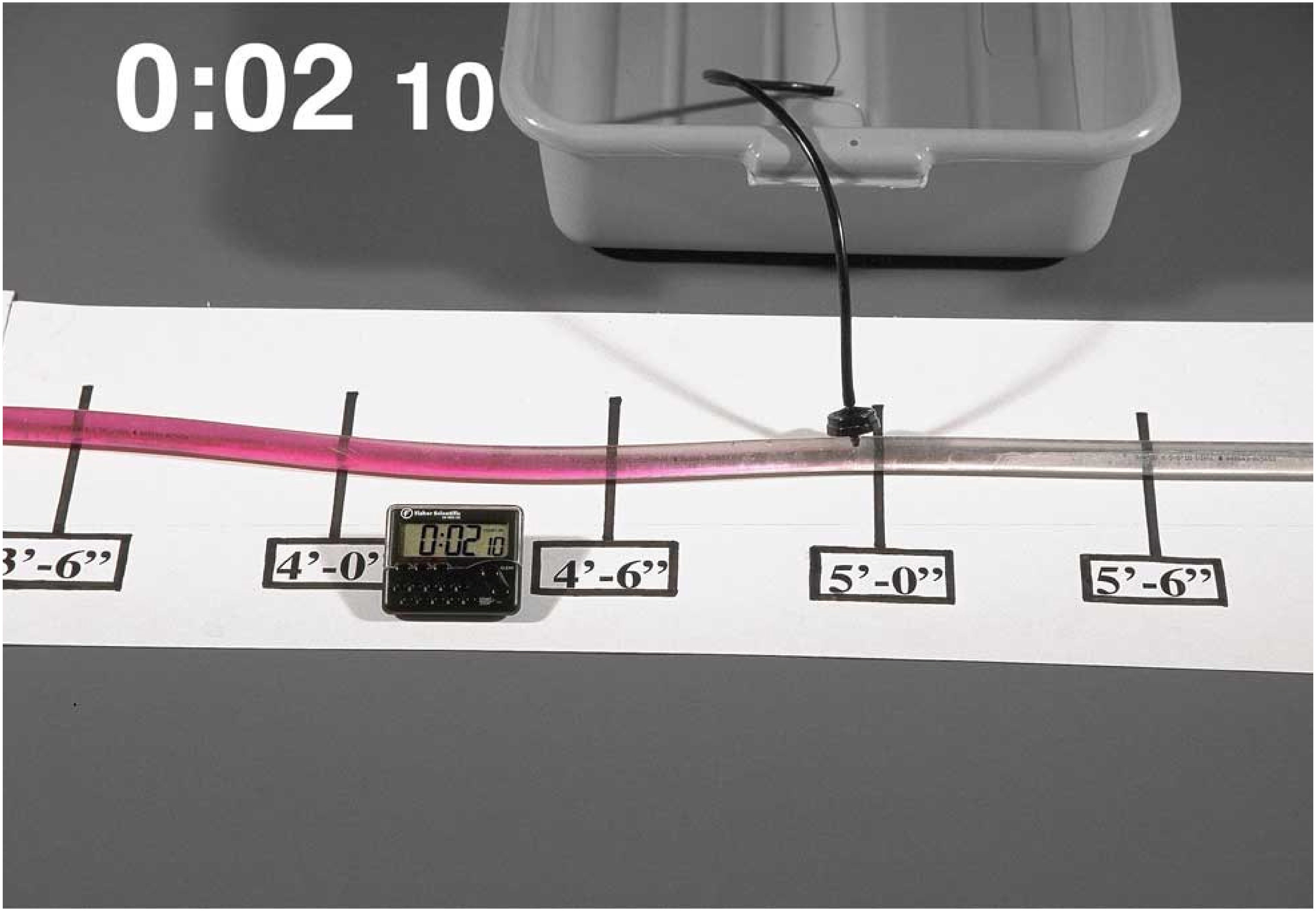

0:01 05
1'-6"
2'-0"
2'-6"
3'-0"
3'-6"
0:01 05


0:01 24
-0"
2'-6"
3'-0"
3'-6"
4'-0"

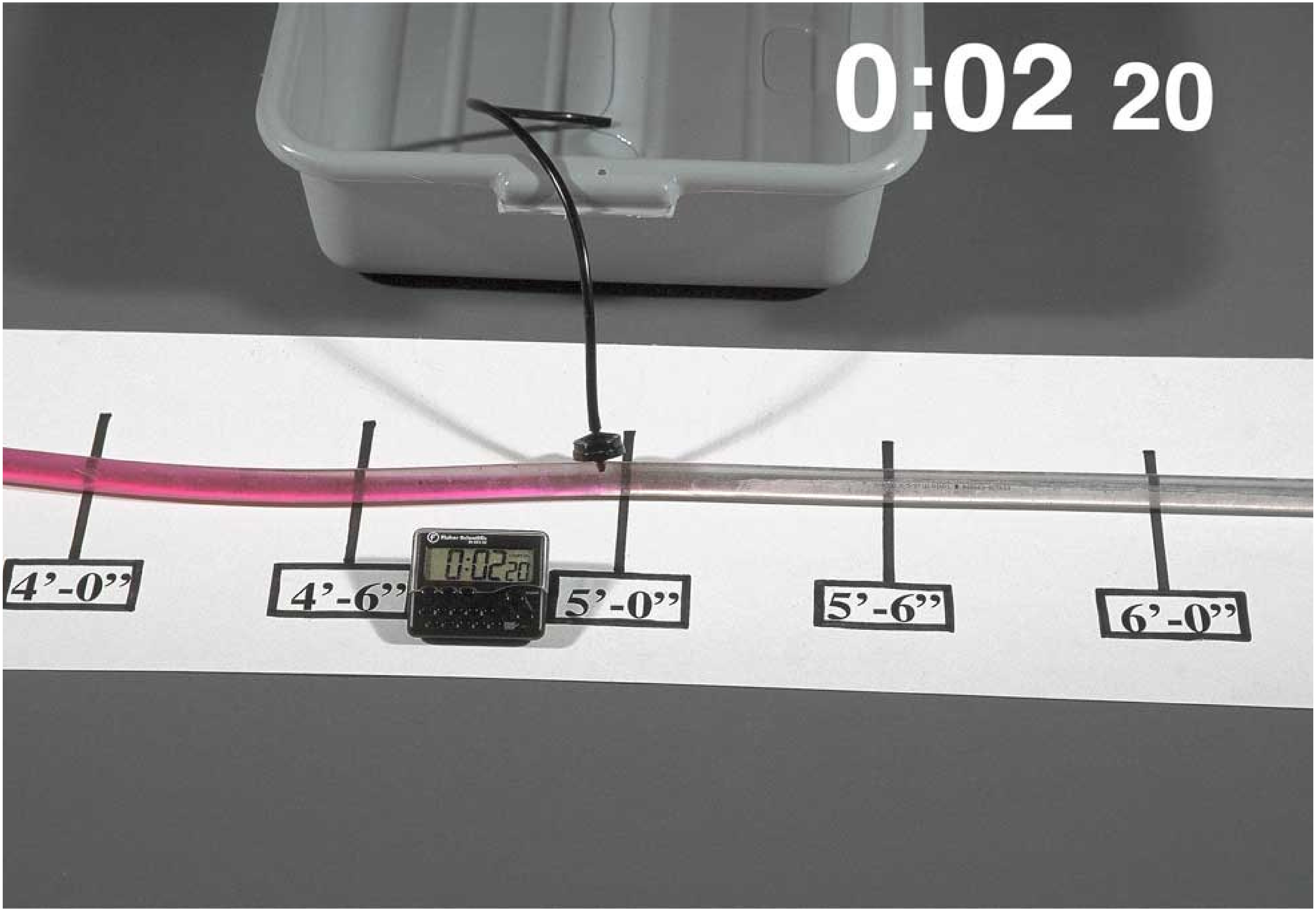

0:01 39
2'-6"
3'-0"
0:01 39
3'-6"
4'-0"
4'-6"

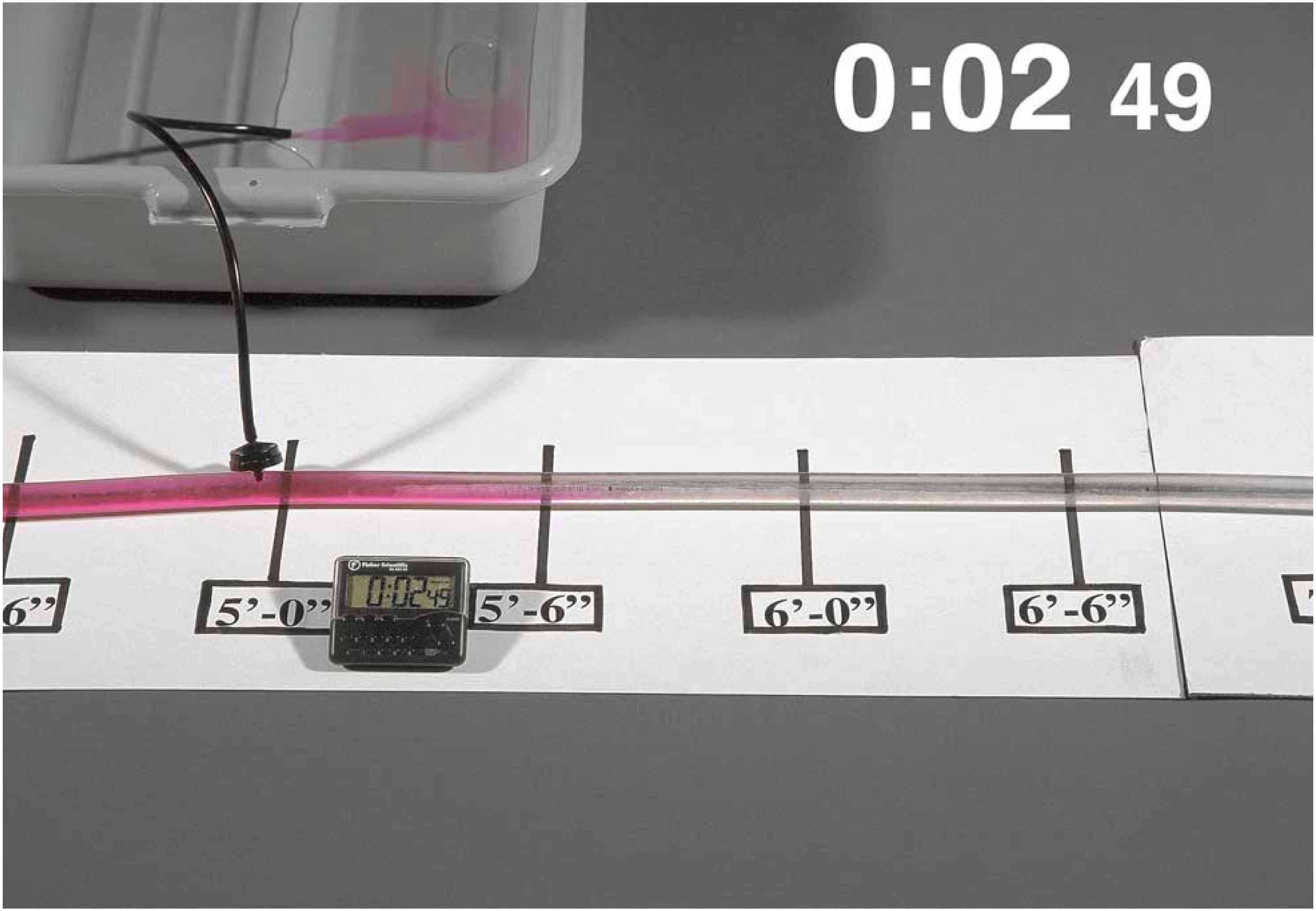


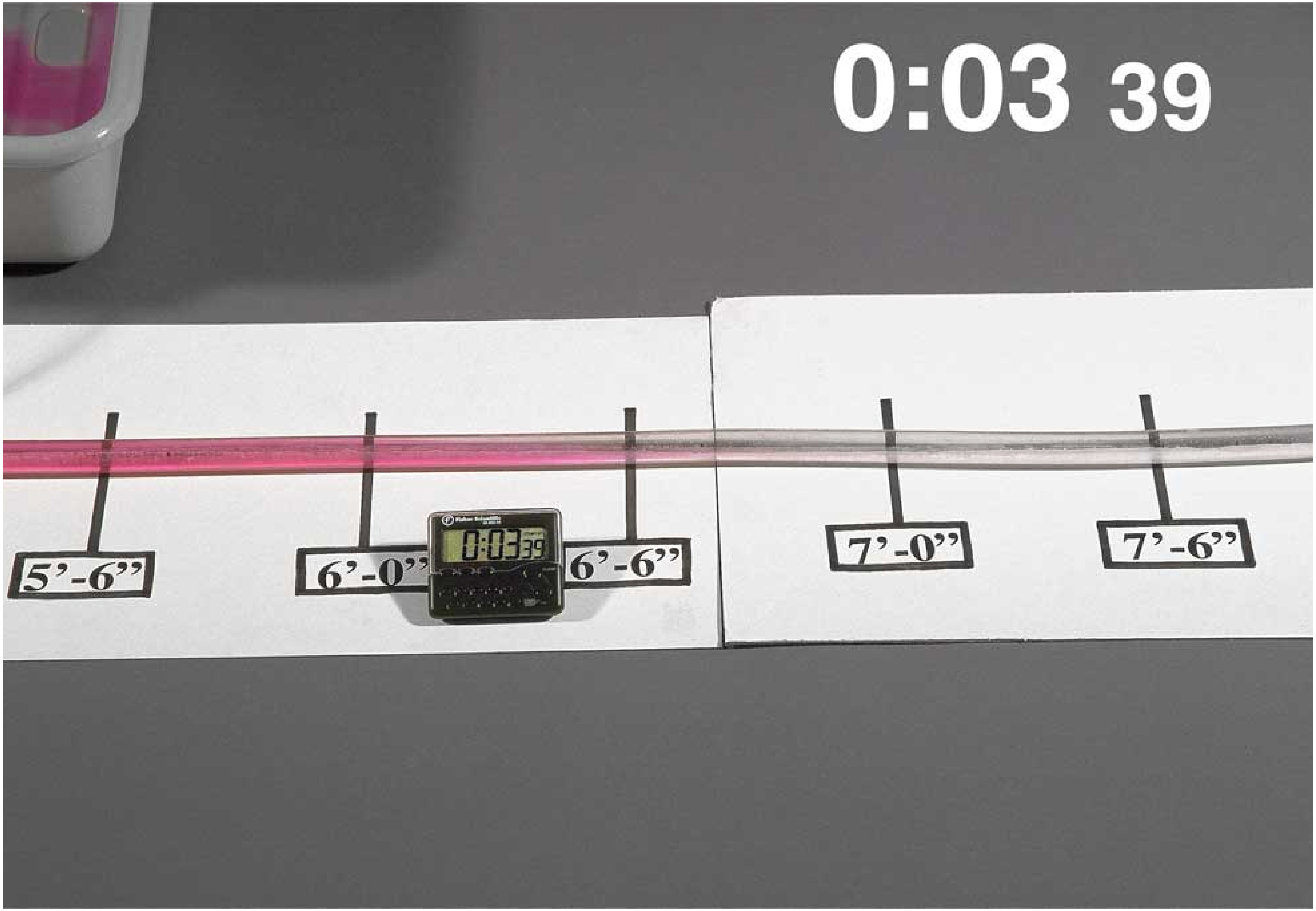
0:01 53
0''
3'-6''
4'-0''
4'-6''
5'-0''

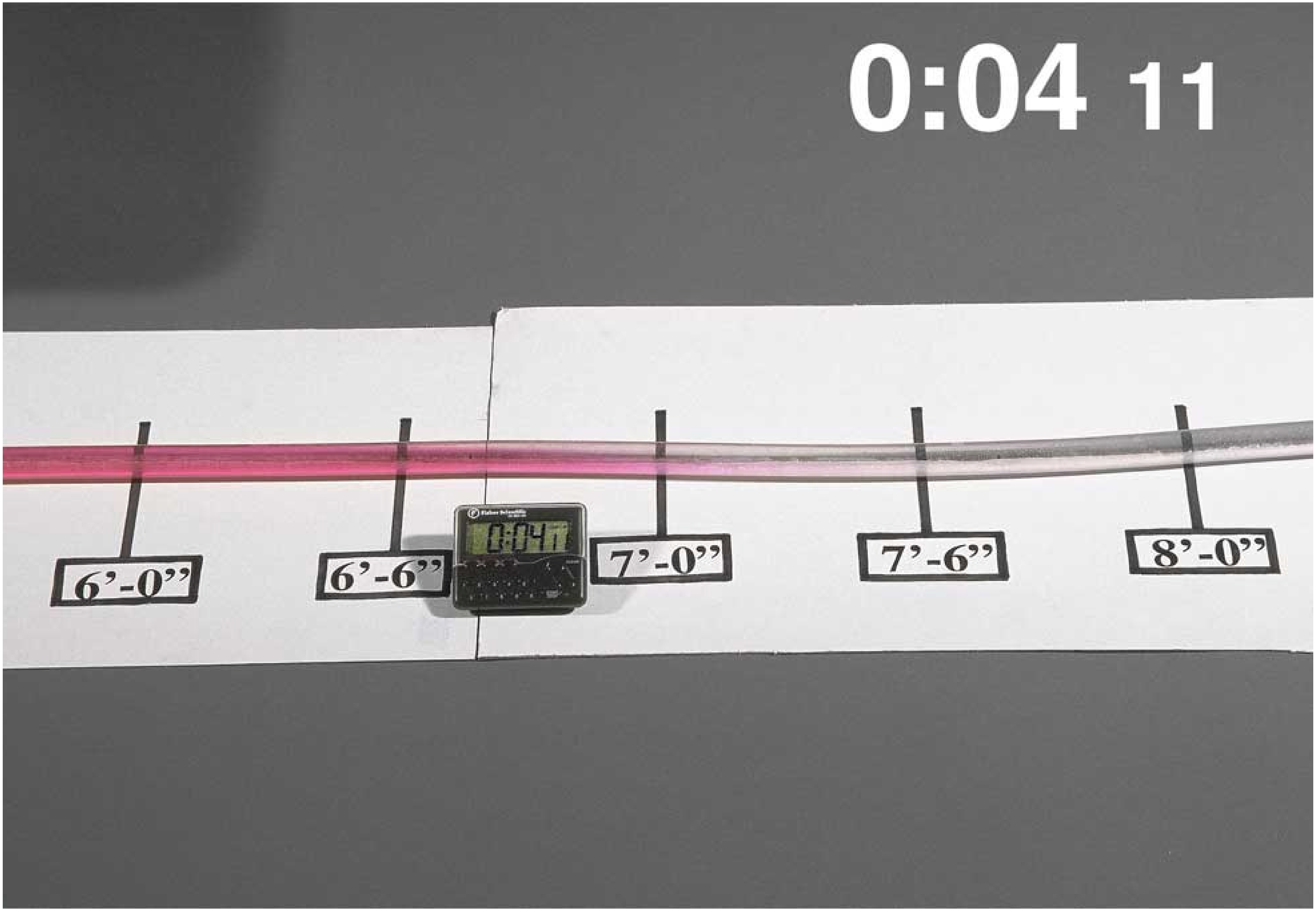


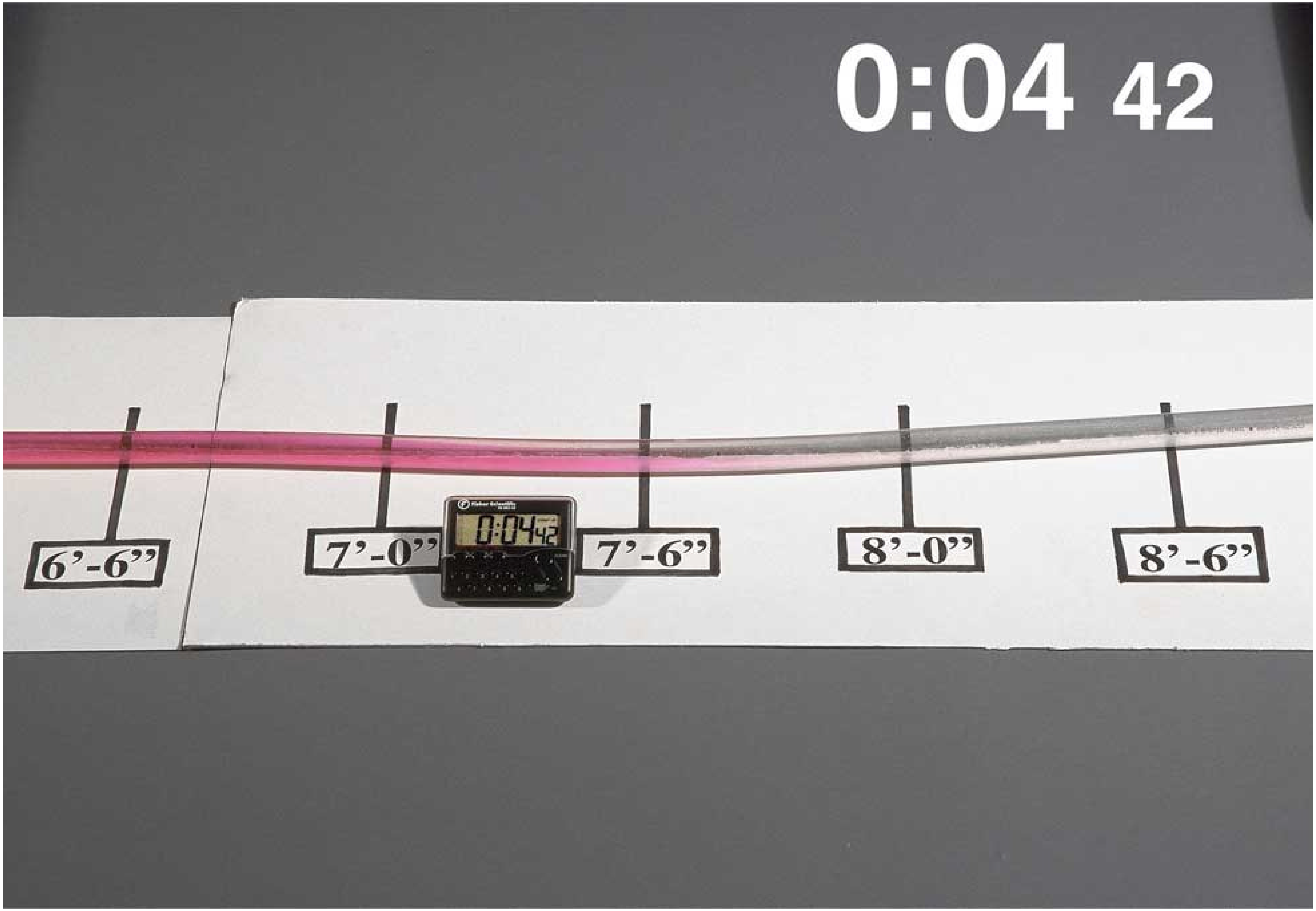
0:02 10
3'-6"
4'-0"
4'-6"
5'-0"
5'-6"

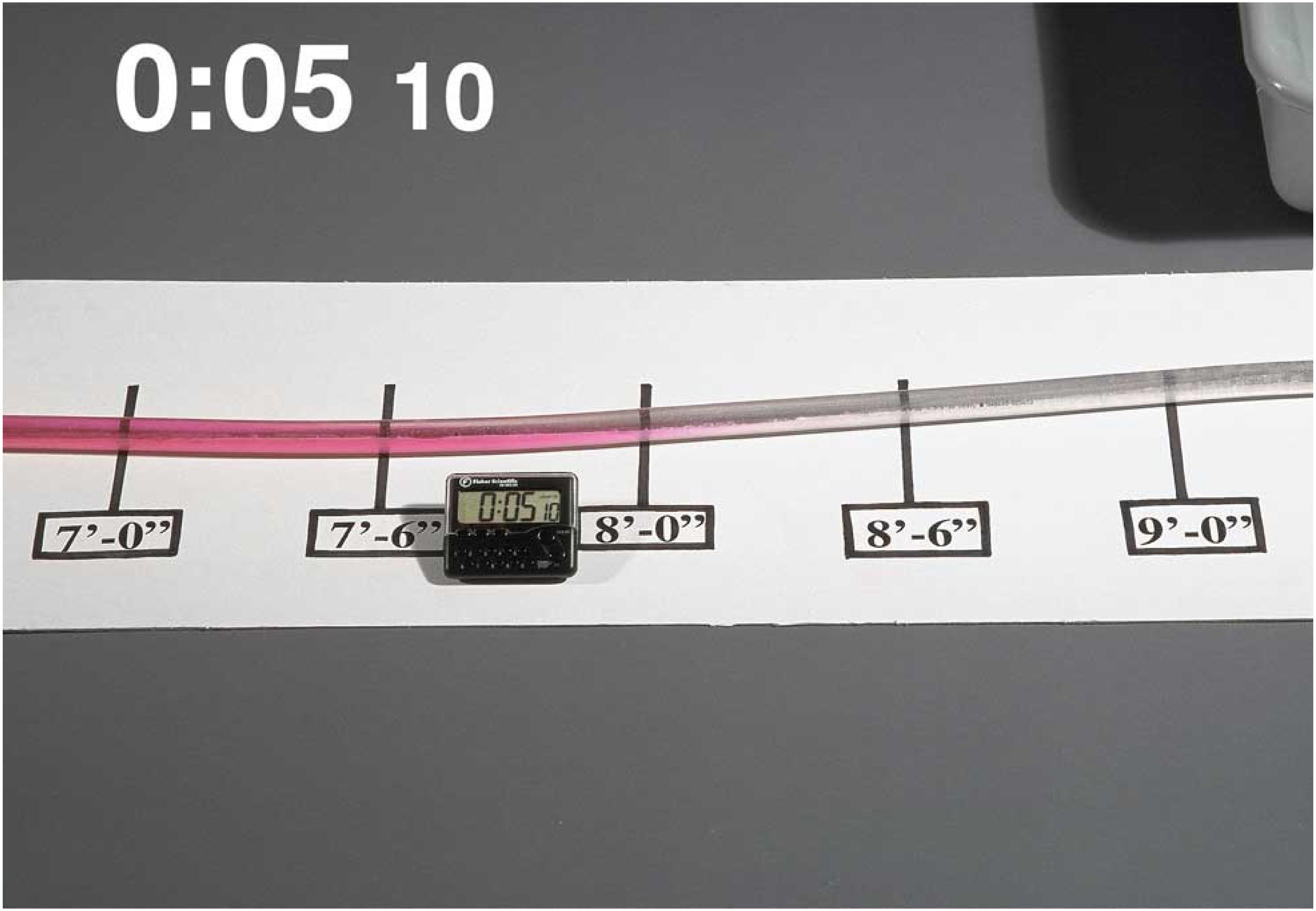

0:02 20
4'-0"
4'-6"
0:02 20
5'-0"
5'-6"
6'-0"

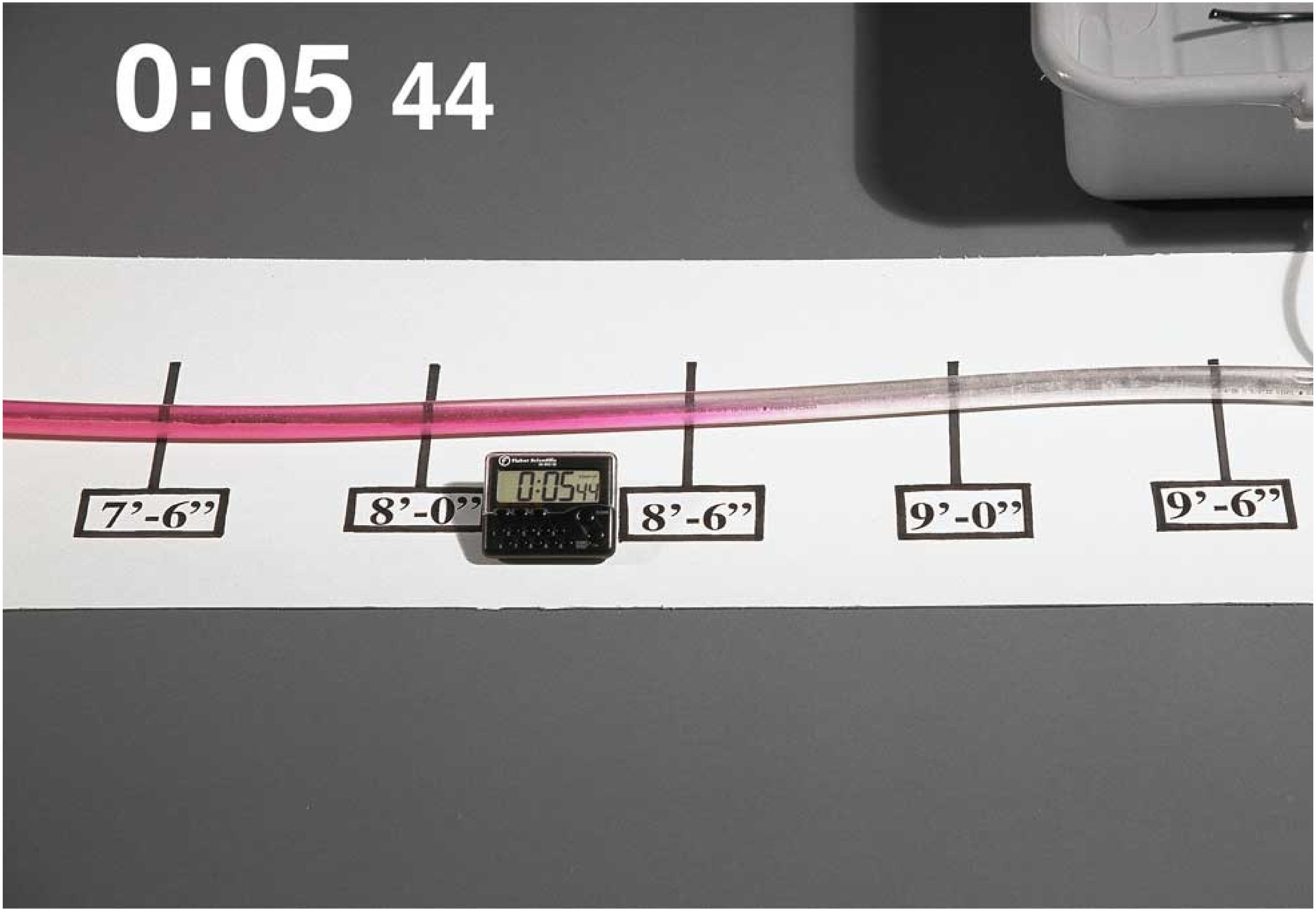

0:02 49
6”
5’-0”
5’-6”
6’-0”
6’-6”

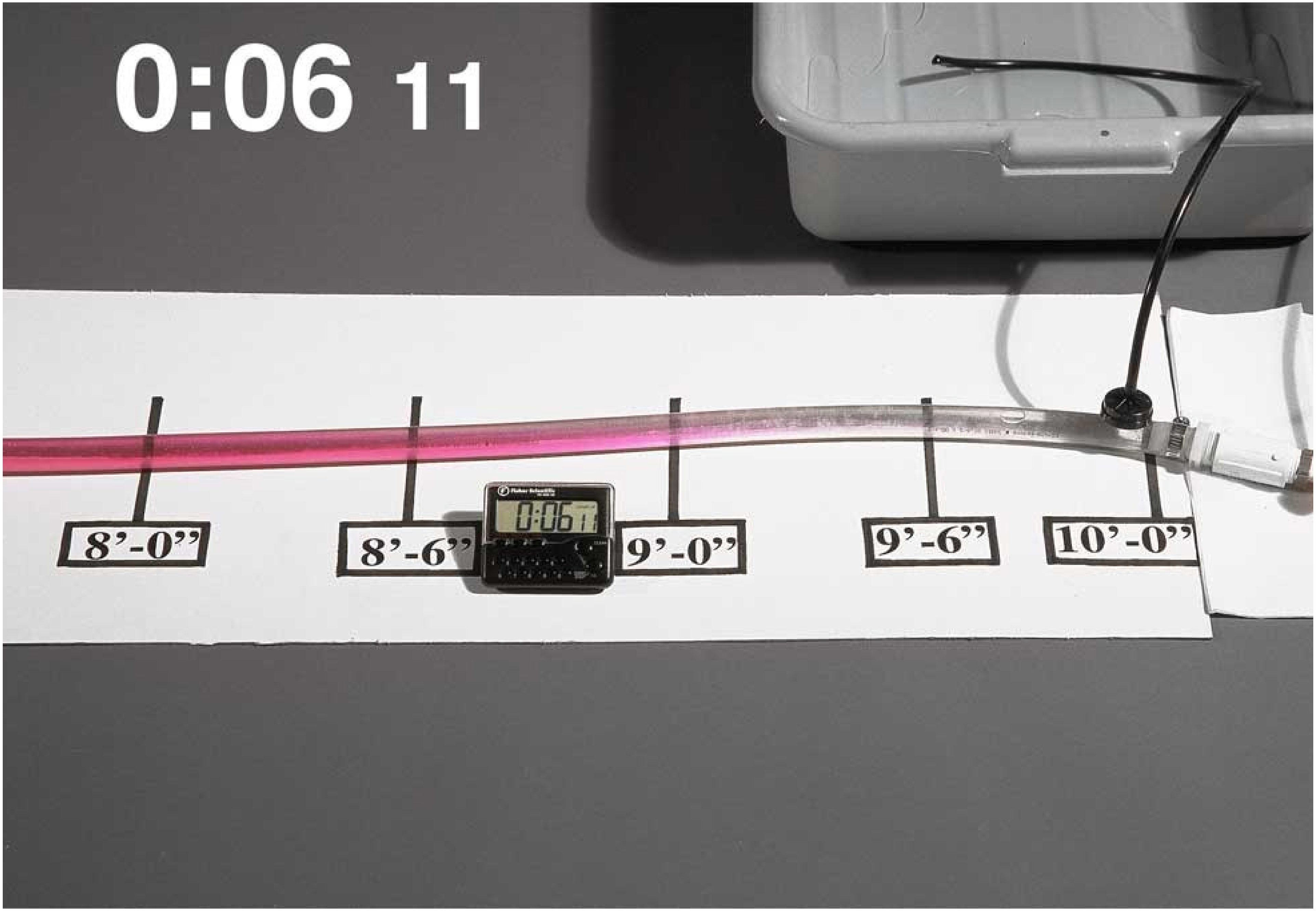

0:03 39
5'-6"
6'-0"
6'-6"
7'-0"
7'-6"

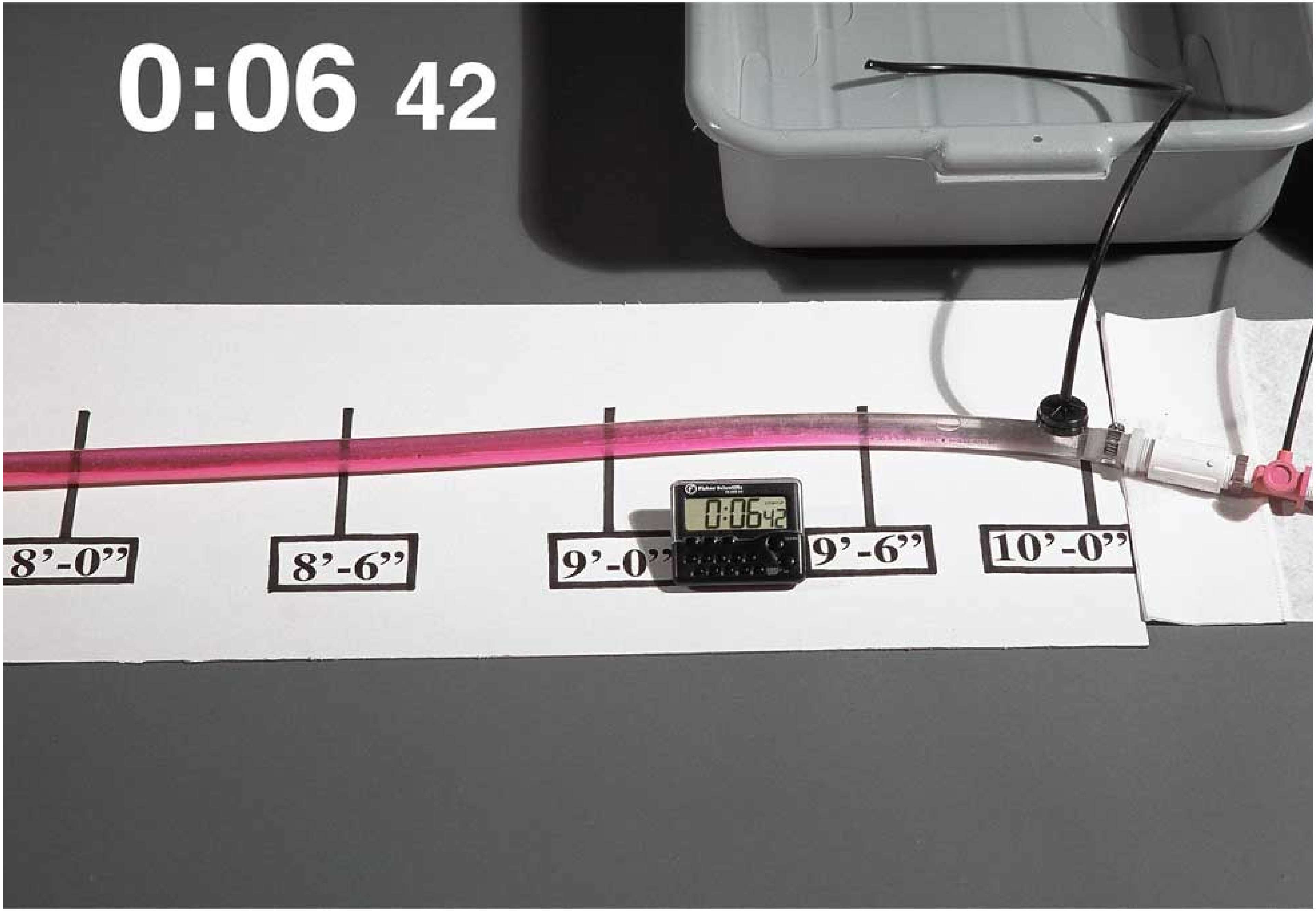

0:04 11
6'-0"
6'-6"
7'-0"
7'-6"
8'-0"


0:04 42
6'-6"
7'-0"
7'-6"
8'-0"
8'-6"

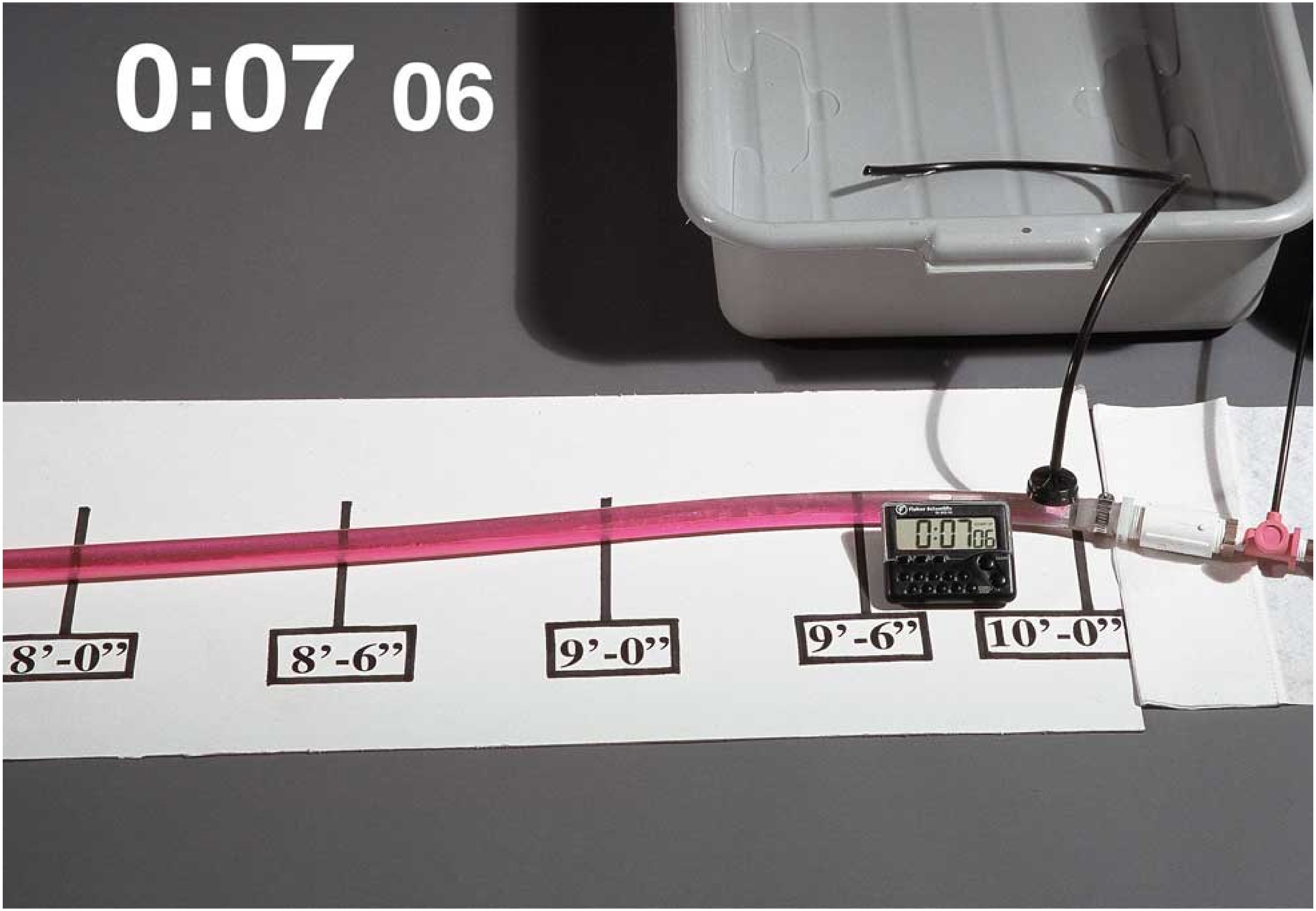

0:05 10
7'-0"
7'-6"
0:05 10
8'-0"
8'-6"
9'-0"

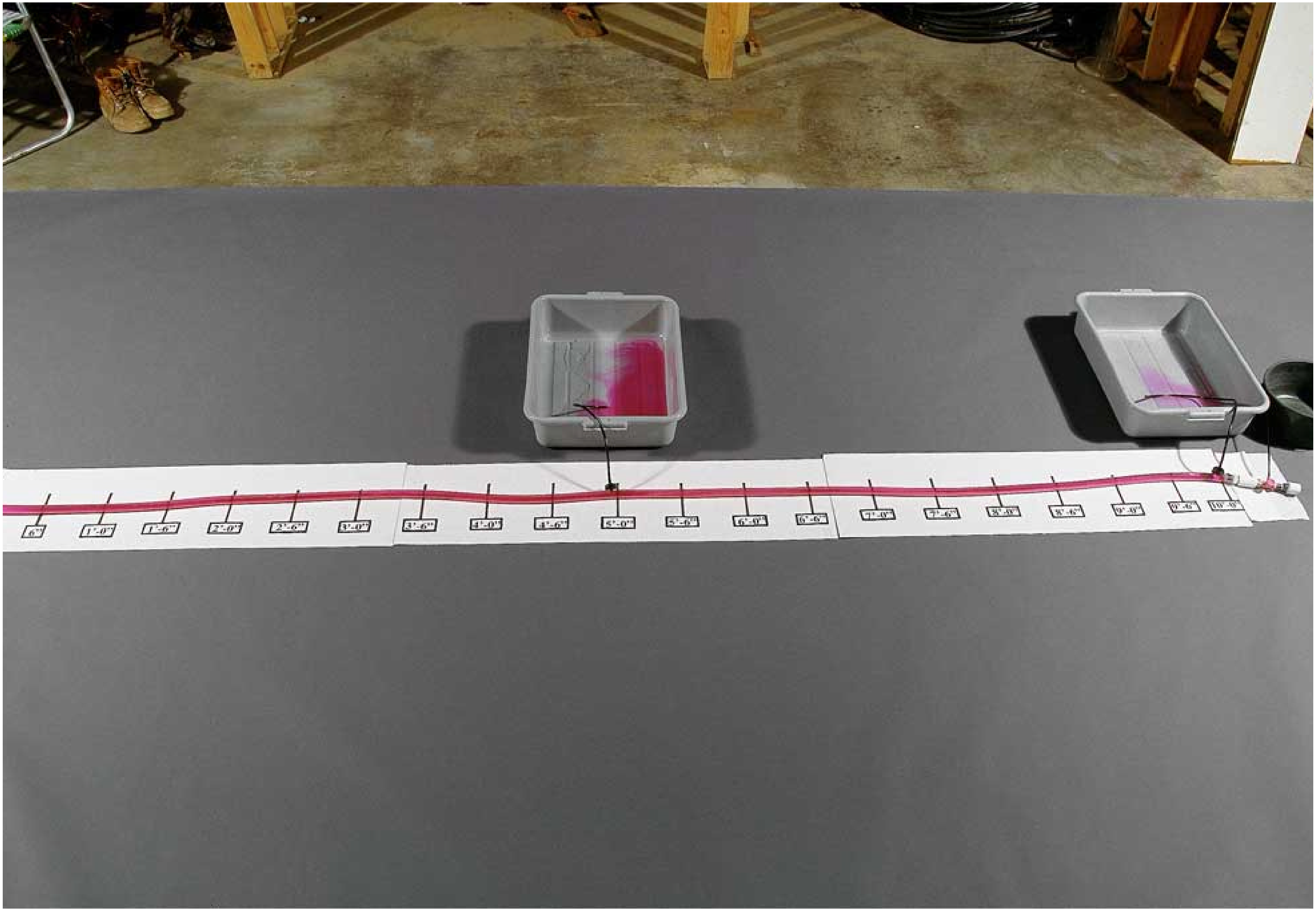

0:05 44
7'-6"
8'-0"
8'-6"
9'-0"
9'-6"


0:06 11
8’-0”
8’-6”
9’-0”
9’-6”
10’-0”



0:06 42
8'-0"
8'-6"
9'-0"
9'-6"
10'-0"
0:06 42


0:07 06
8'-0"
8'-6"
9'-0"
9'-6"
10'-0"
0:07 06


6"
1'-0"
1'-6"
2'-0"
2'-6"
3'-0"
3'-6"
4'-0"
4'-6"
5'-0"
5'-6"
6'-0"
6'-6"
7'-0"
7'-6"
8'-0"
8'-6"
9'-0"
9'-6"
10'-0"

Uniform Chemigation

In summary, it took about 2-1/2 minutes for the injected chemical to move the first 5 feet (1.5 m), and 4-1/2 minutes to travel the last 5 feet (1.5 m). A total of 7 minutes to travel the total 10 feet (3 m).

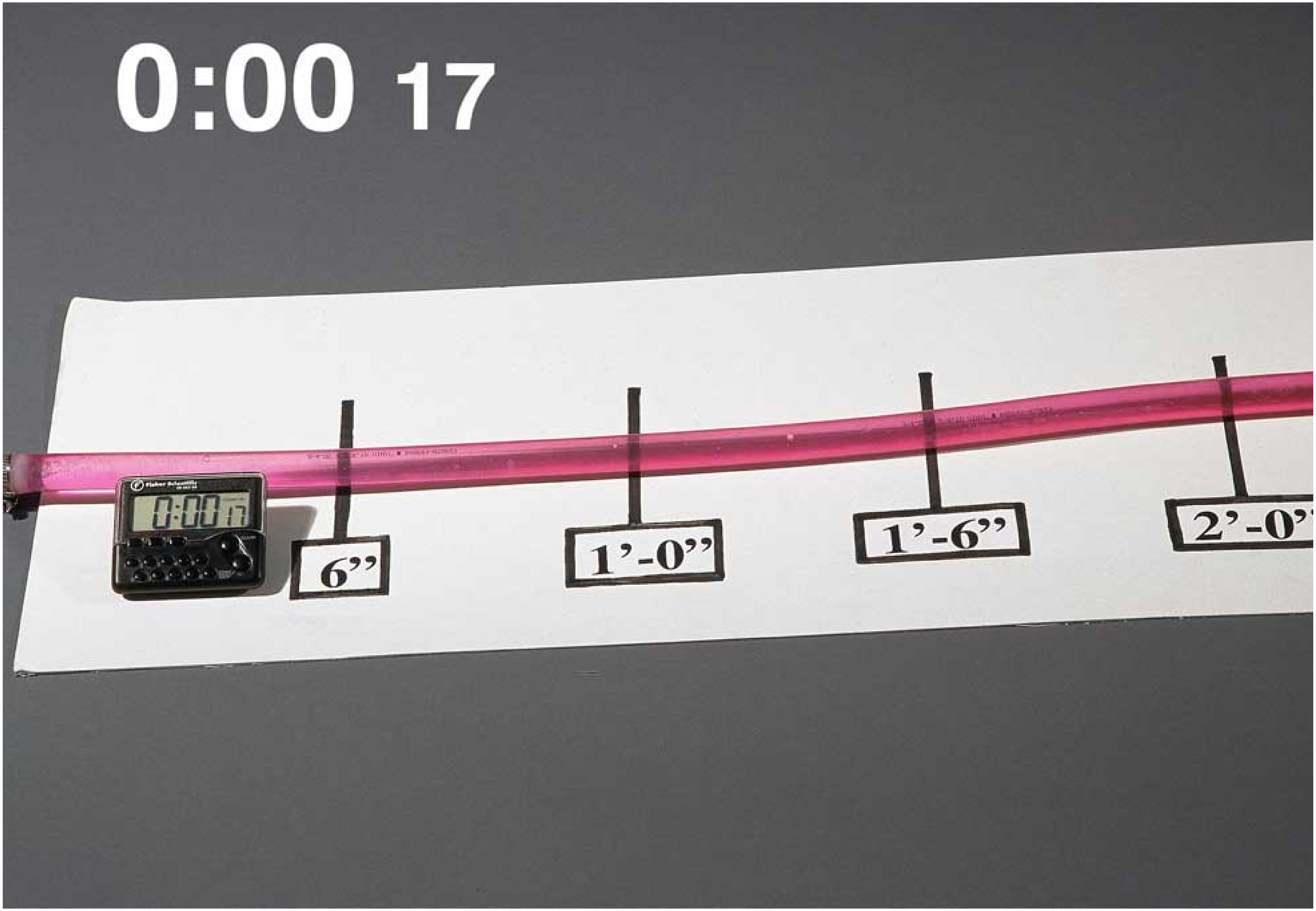
This simulates the last sections of a drip lateral. The flow velocity is SLOW.

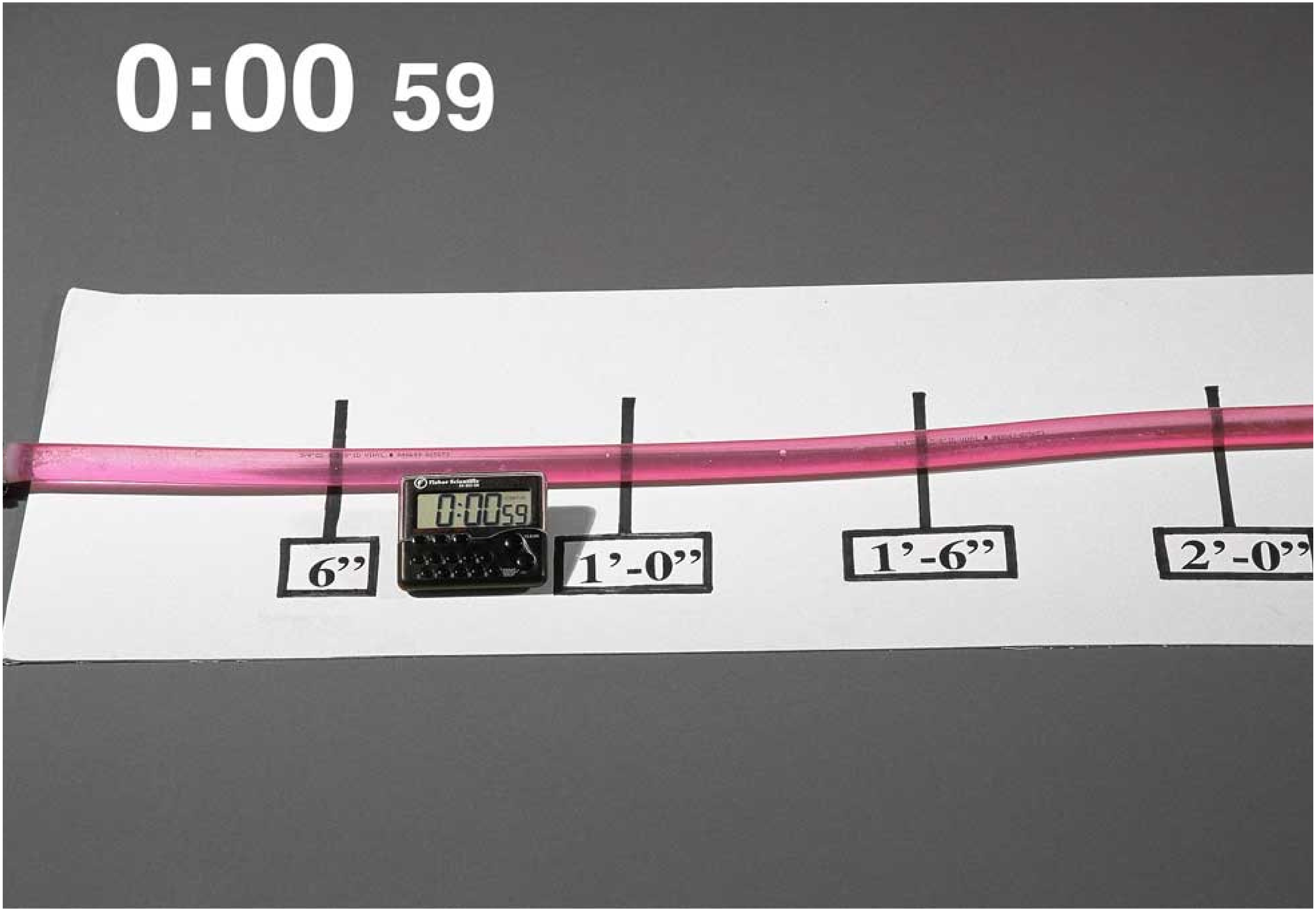
Luckily, at the head of the drip lateral, the flow rate is higher and the flow velocity is faster.

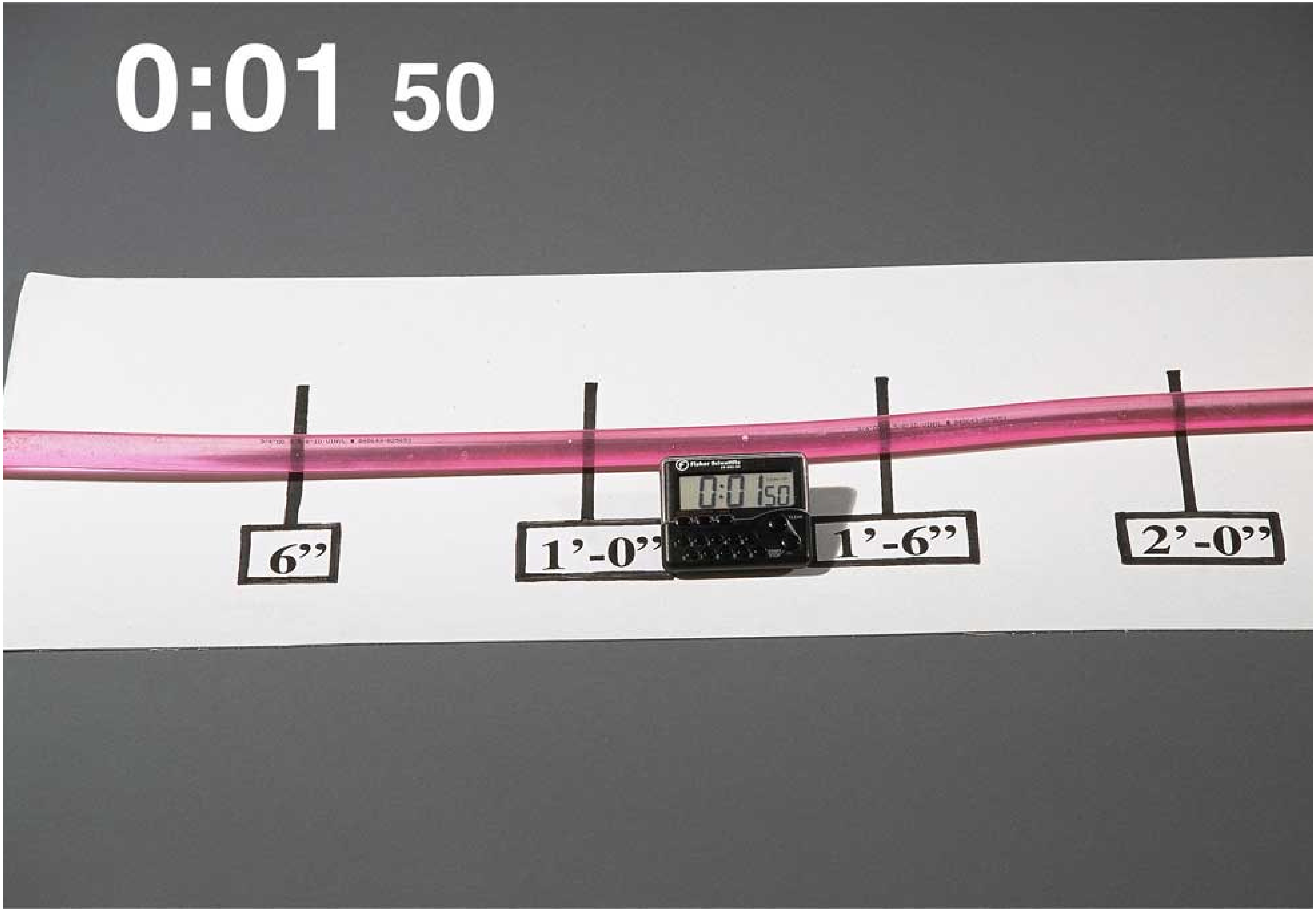
Uniform Chemigation

What happens when we stop the injection?

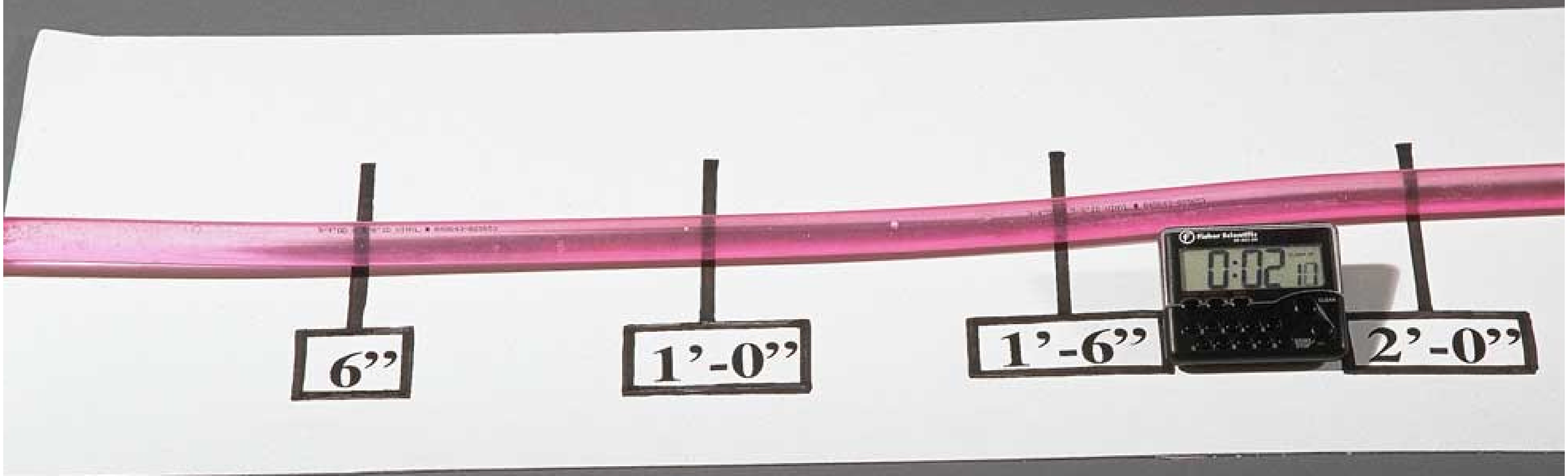
The following slides show the same drip system as before with the time indicating how long it has been since the injection of the dye was stopped.

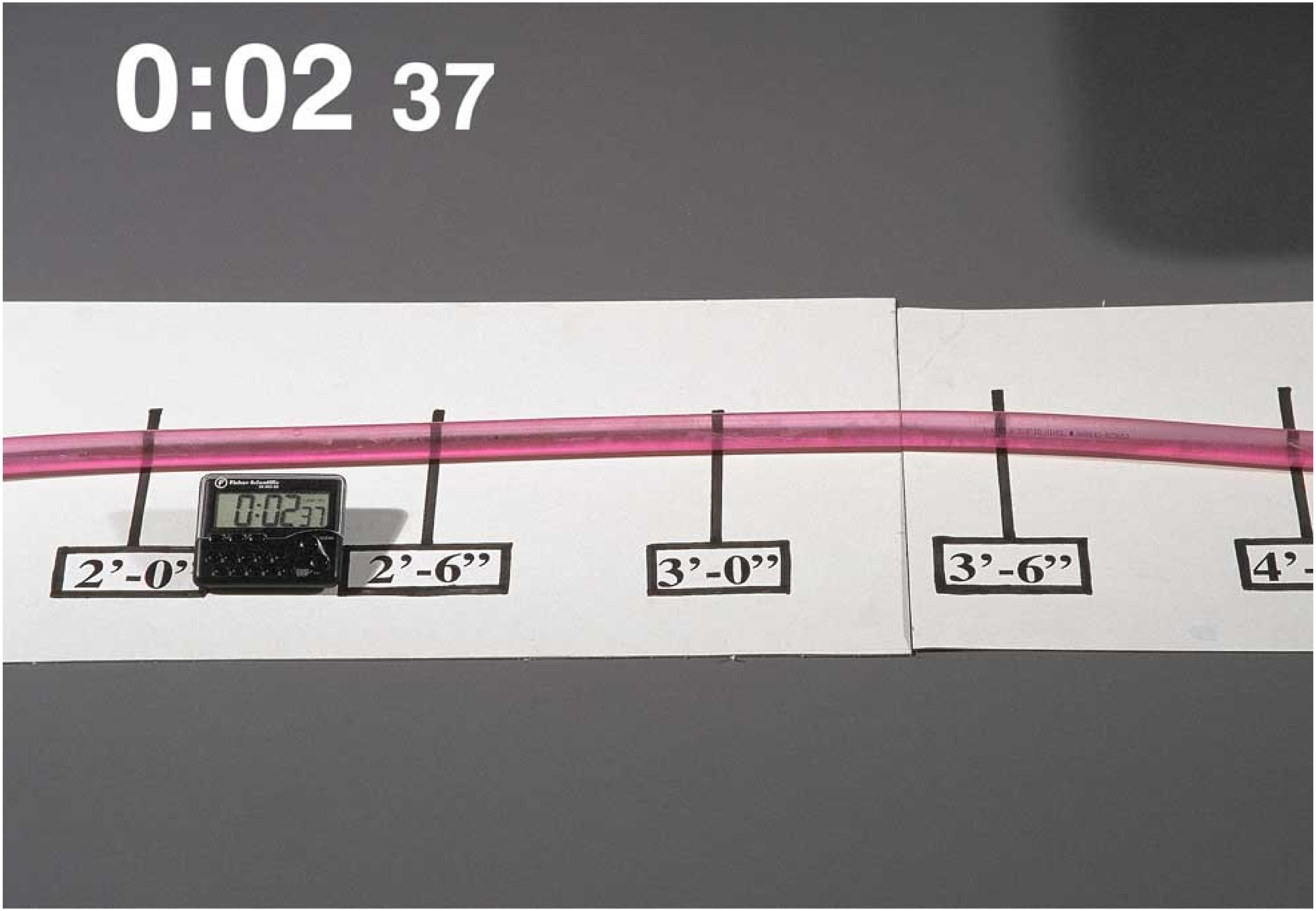

0:00 17
6”
1’-0”
1’-6”
2’-0

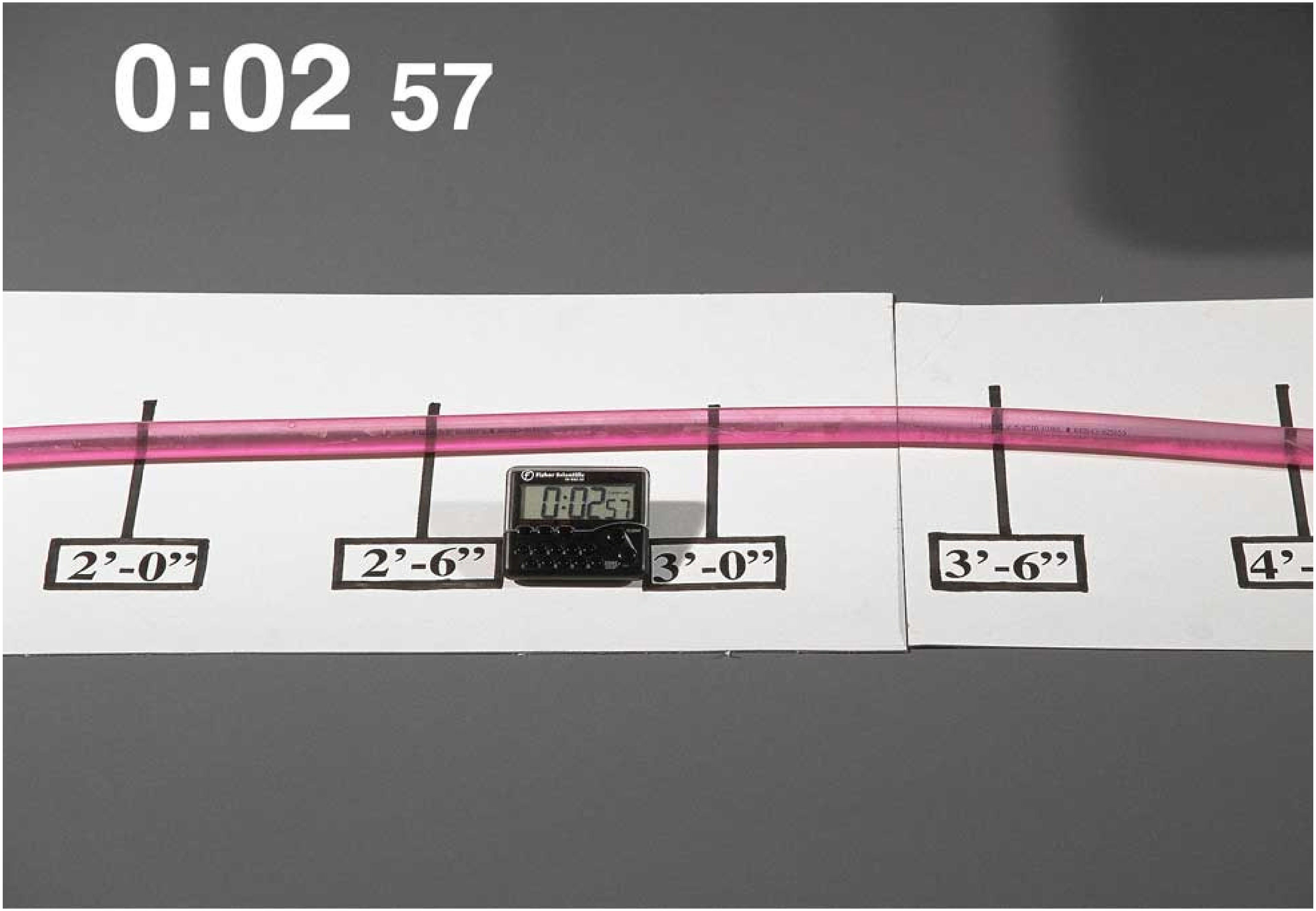

0:00 59
6”
1’-0”
1’-6”
2’-0”

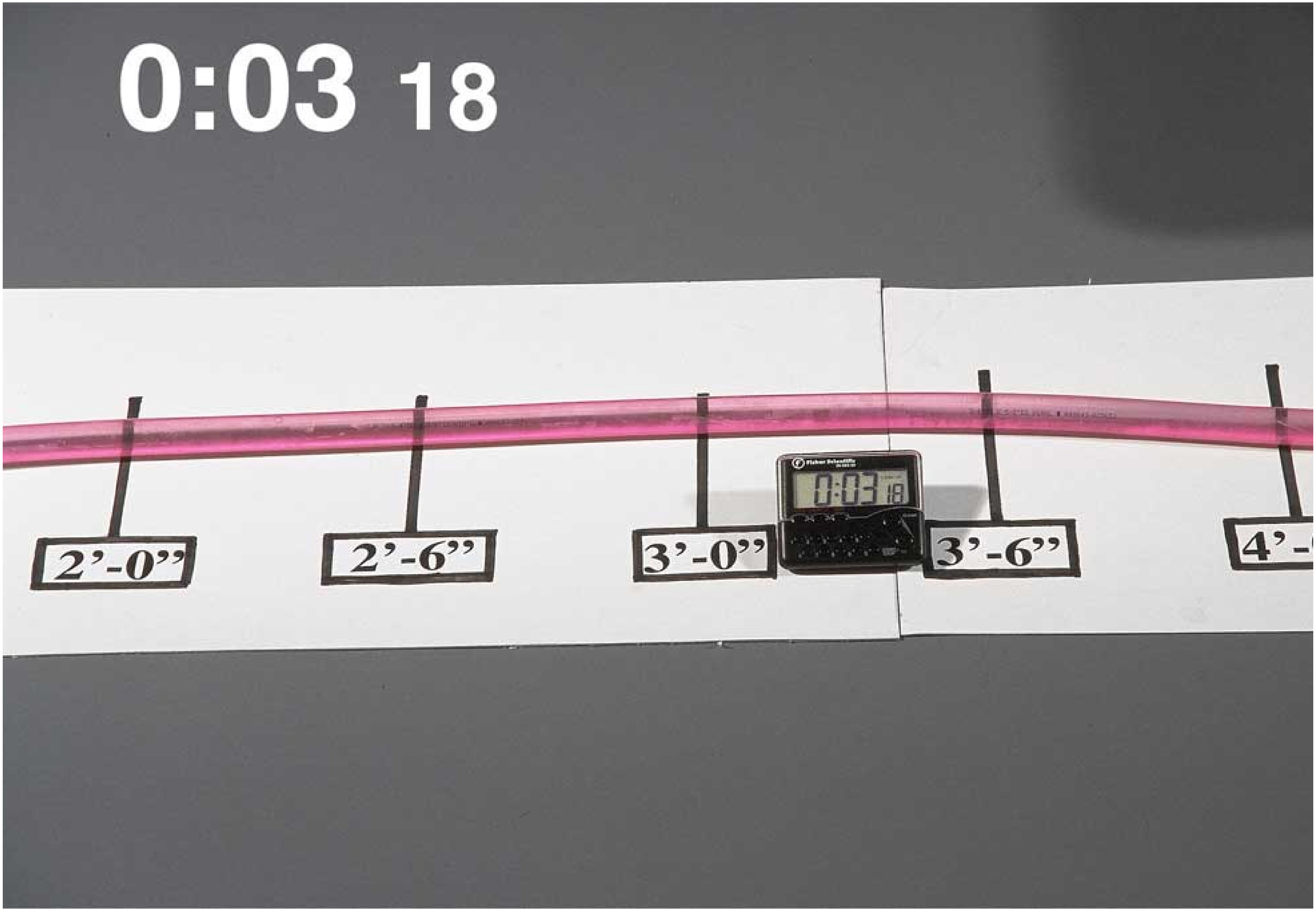

0:01 50
6”
1’-0”
1’-6”
2’-0”

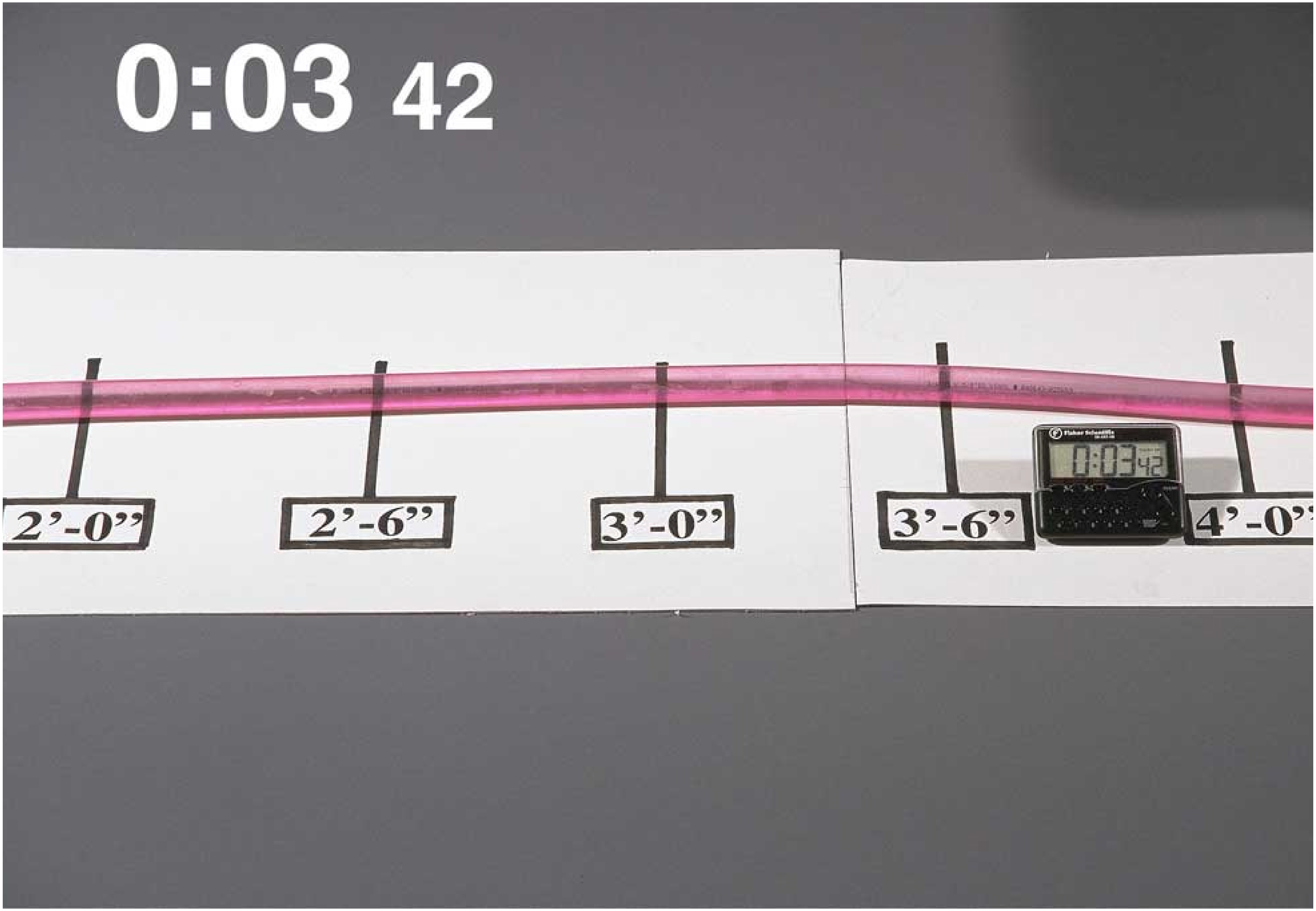
0:02 10

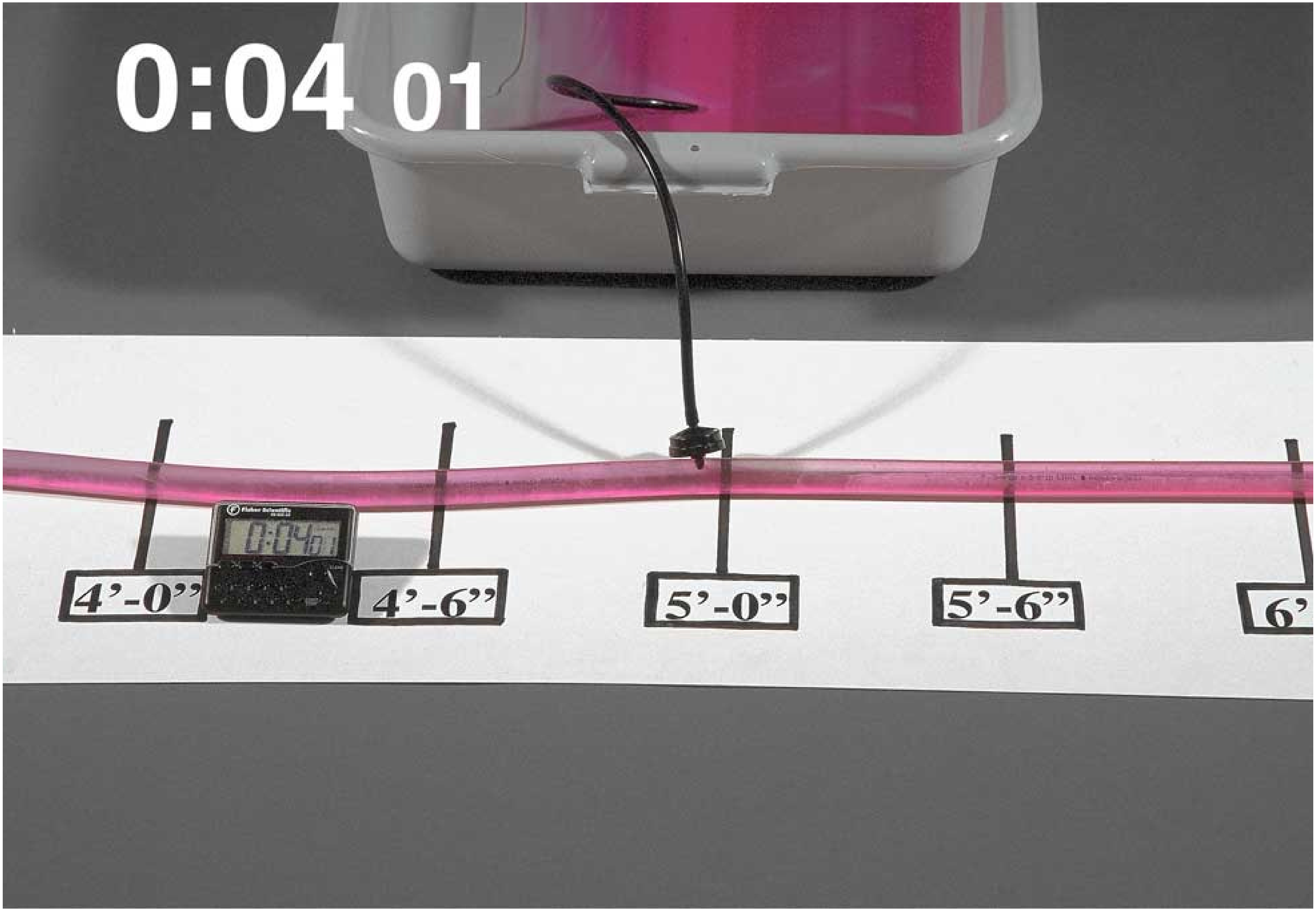



0:02 37
2’-6’’
3’-0’’
3’-6’’

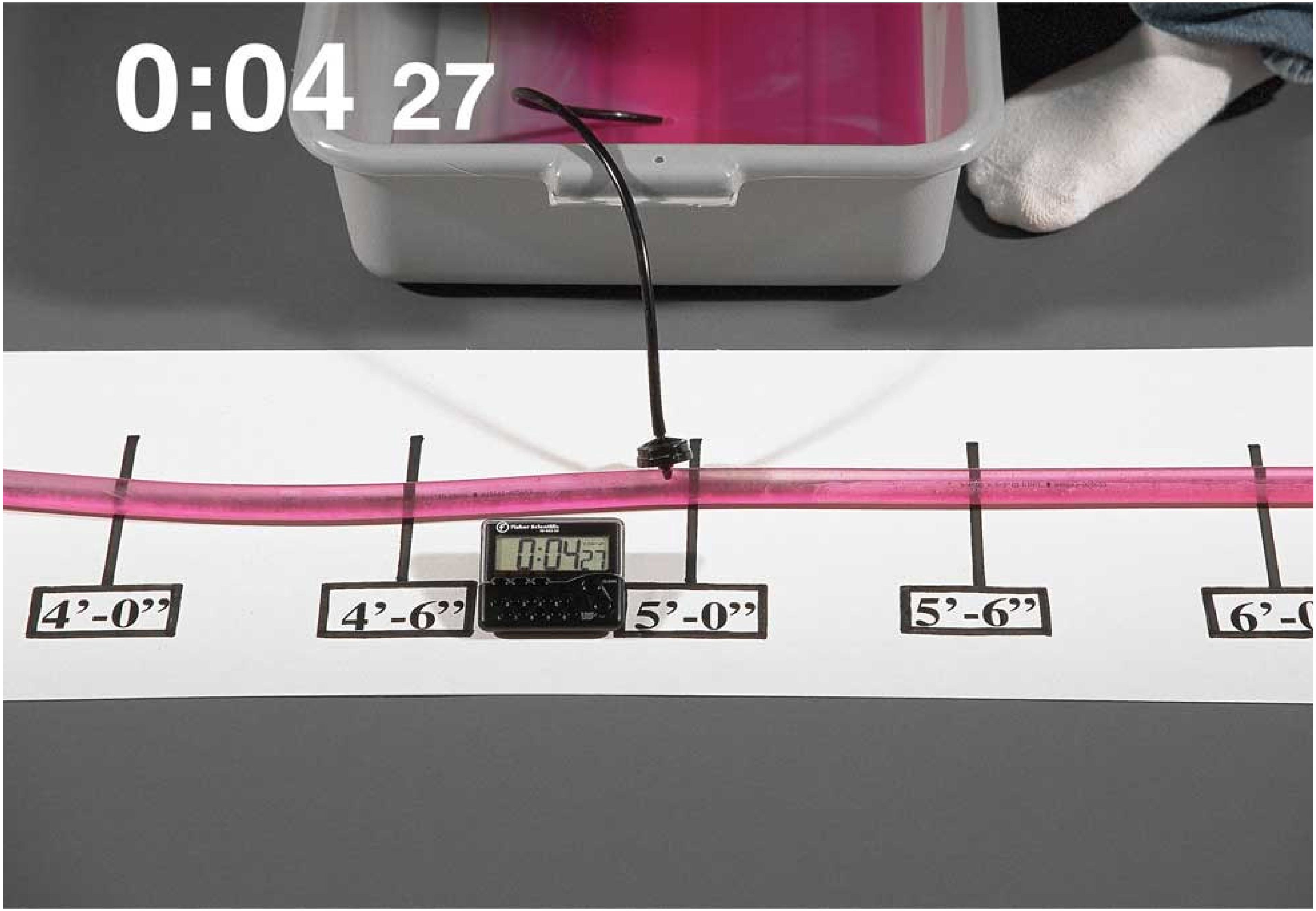

0:02 57
2'-0"
2'-6"
3'-0"
3'-6"
4'-
0:02 57

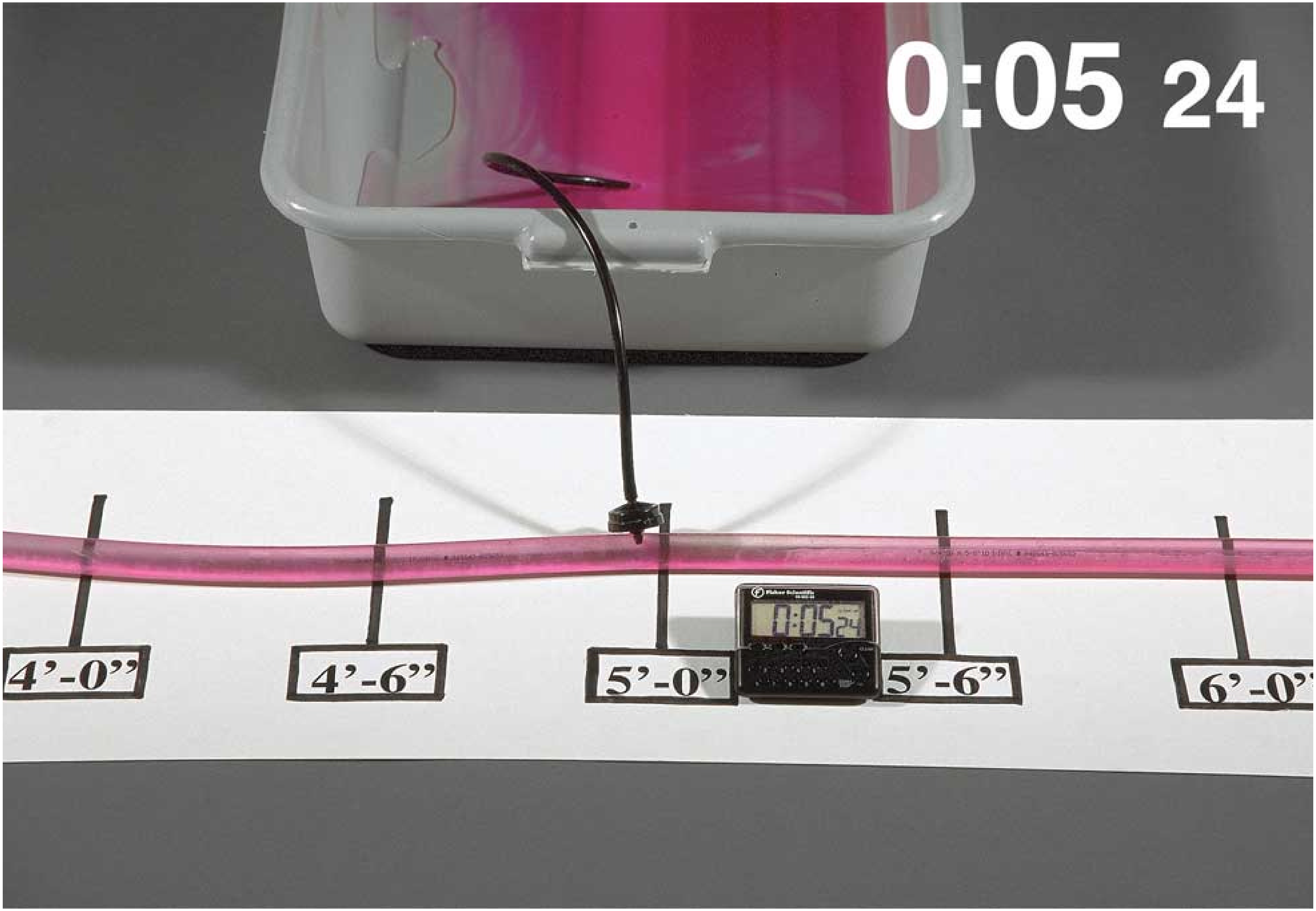

0:03 18
2'-0"
2'-6"
3'-0"
3'-6"

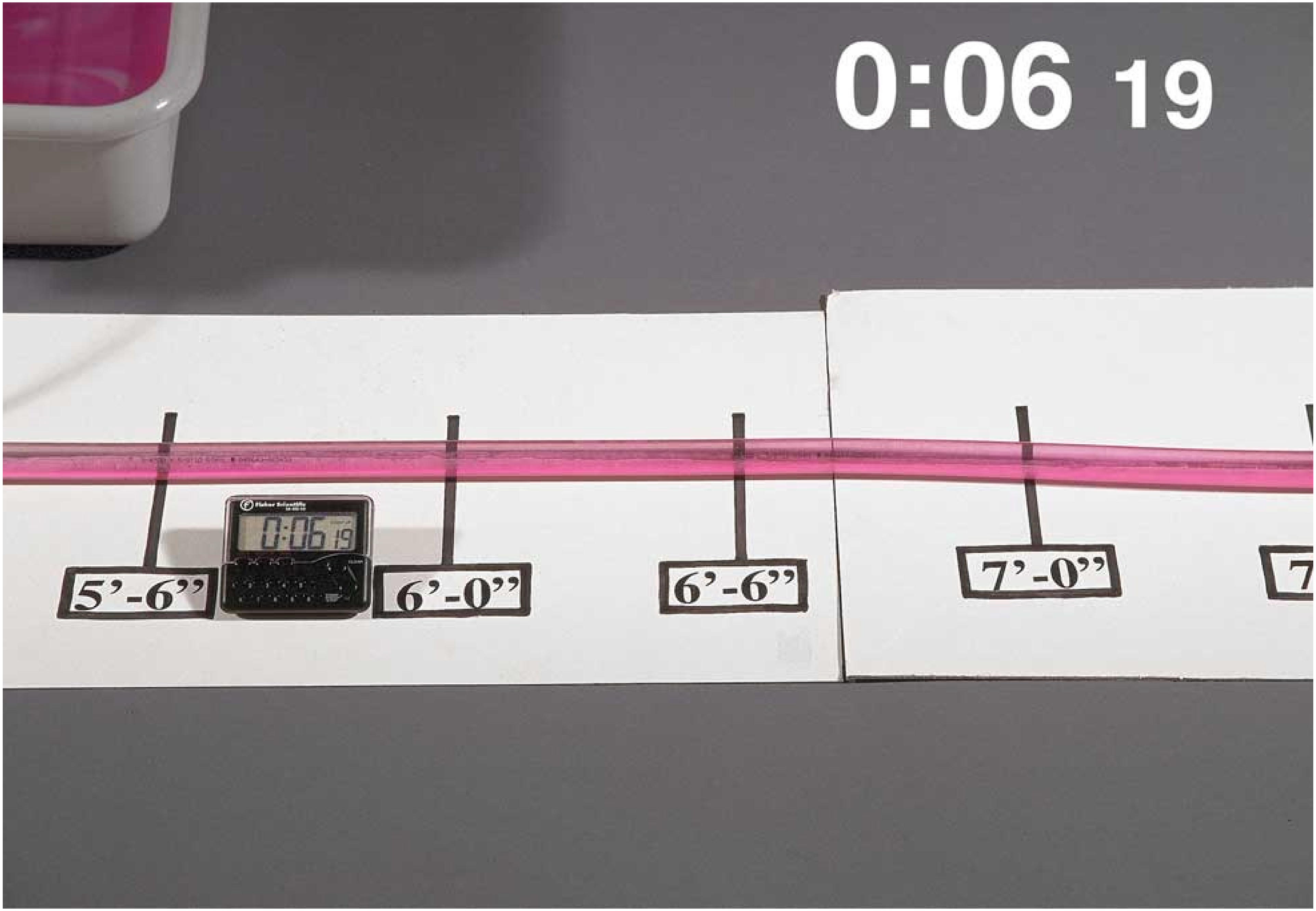

0:03 42
2'-0"
2'-6"
3'-0"
3'-6"
4'-0"

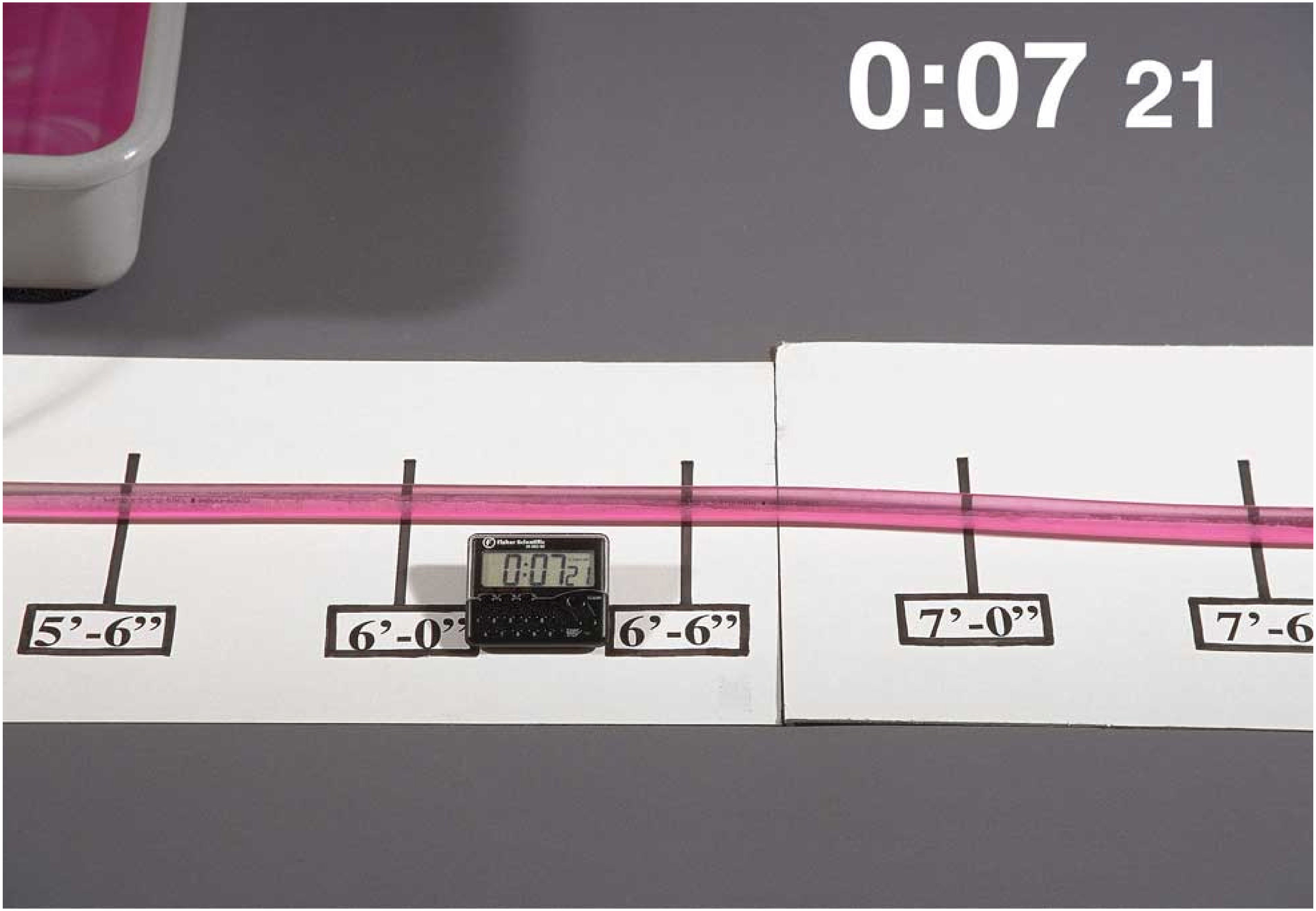


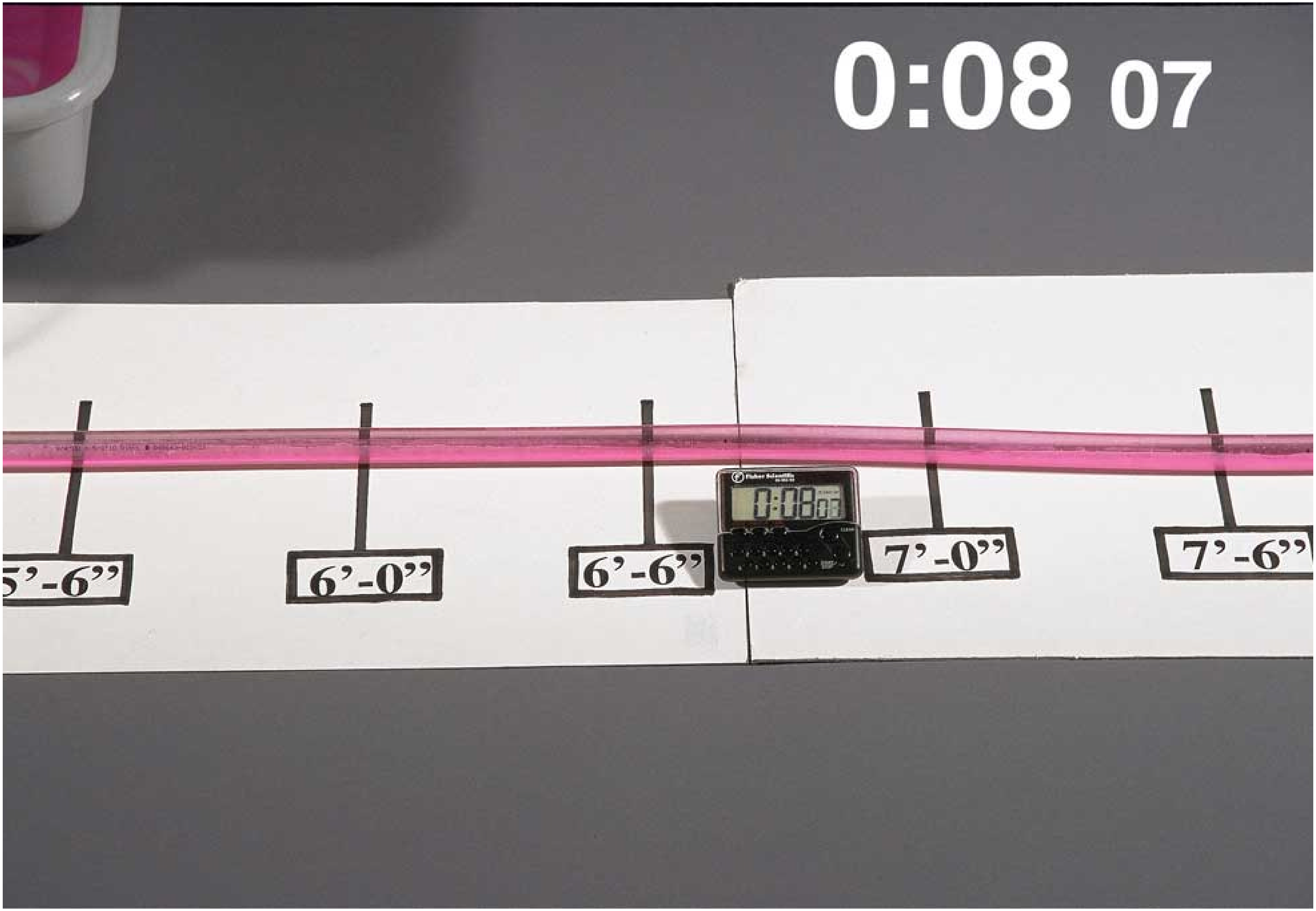
0:04 01
4'-0"
4'-6"
5'-0"
5'-6"
6'

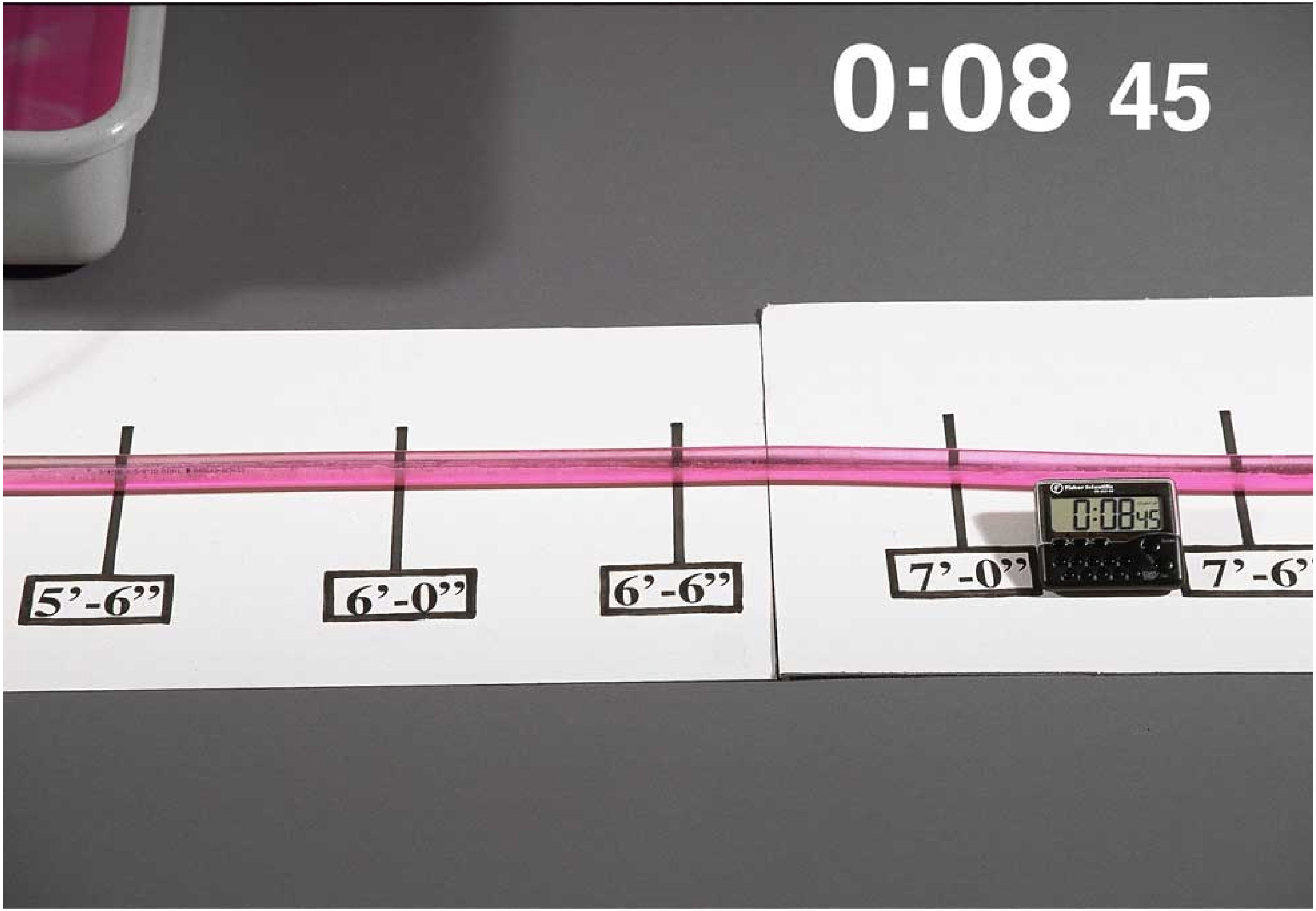

0:04 27
4'-0"
4'-6"
5'-0"
5'-6"
6'-0
0:04 27

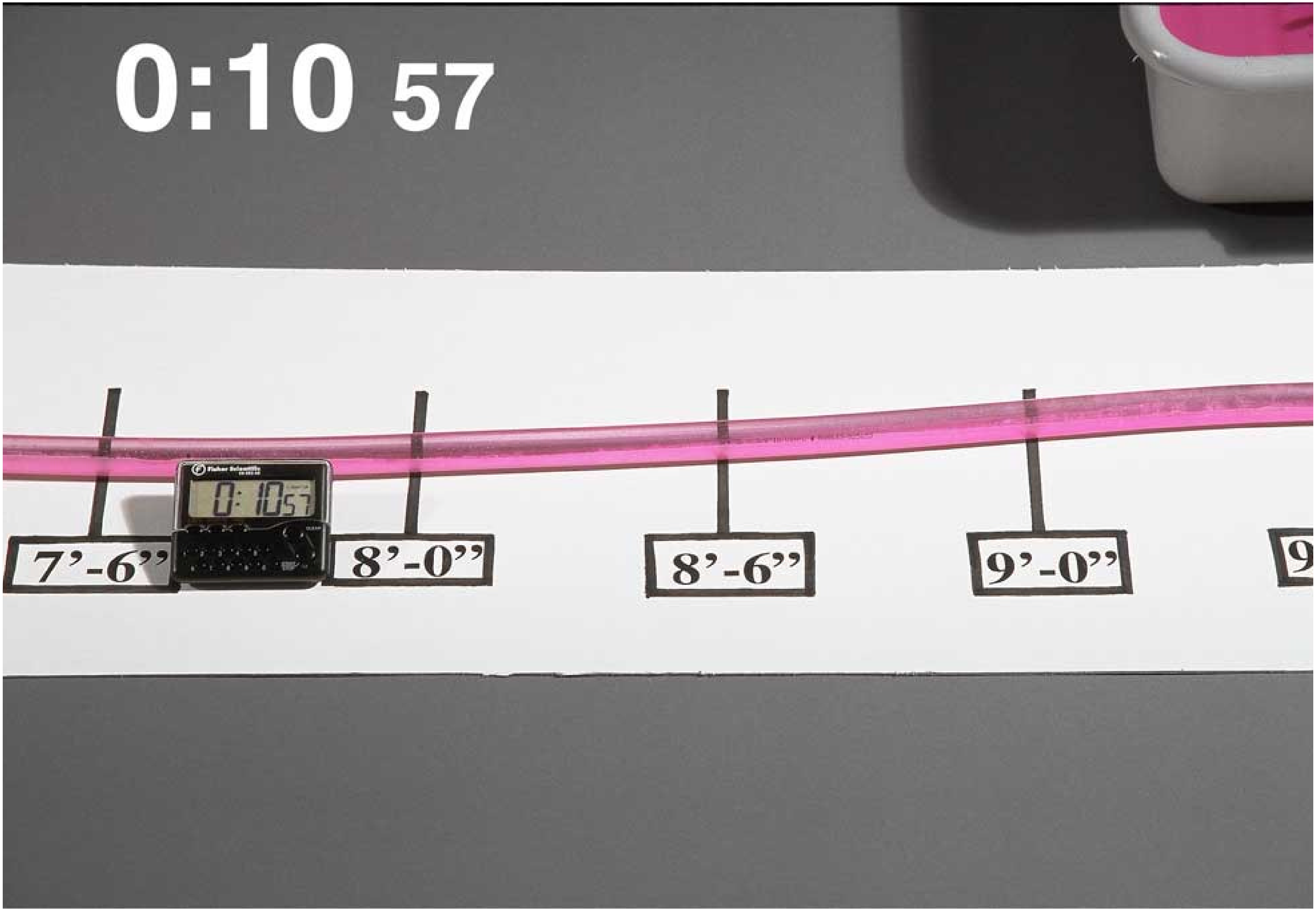

0:05 24
4'-0"
4'-6"
5'-0"
5'-6"
6'-0"

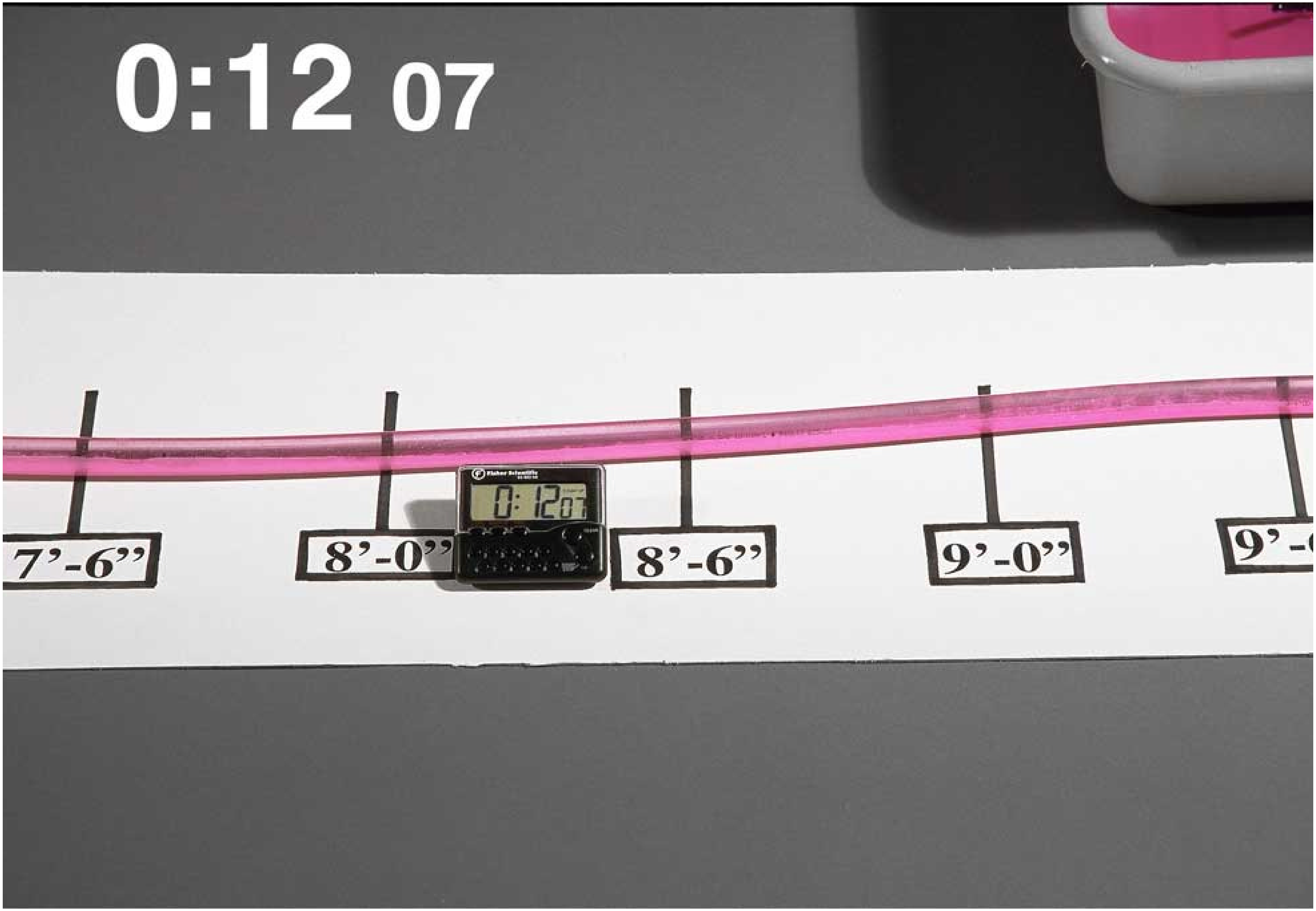

0:06 19
5'-6"
6'-0"
6'-6"
7'-0"

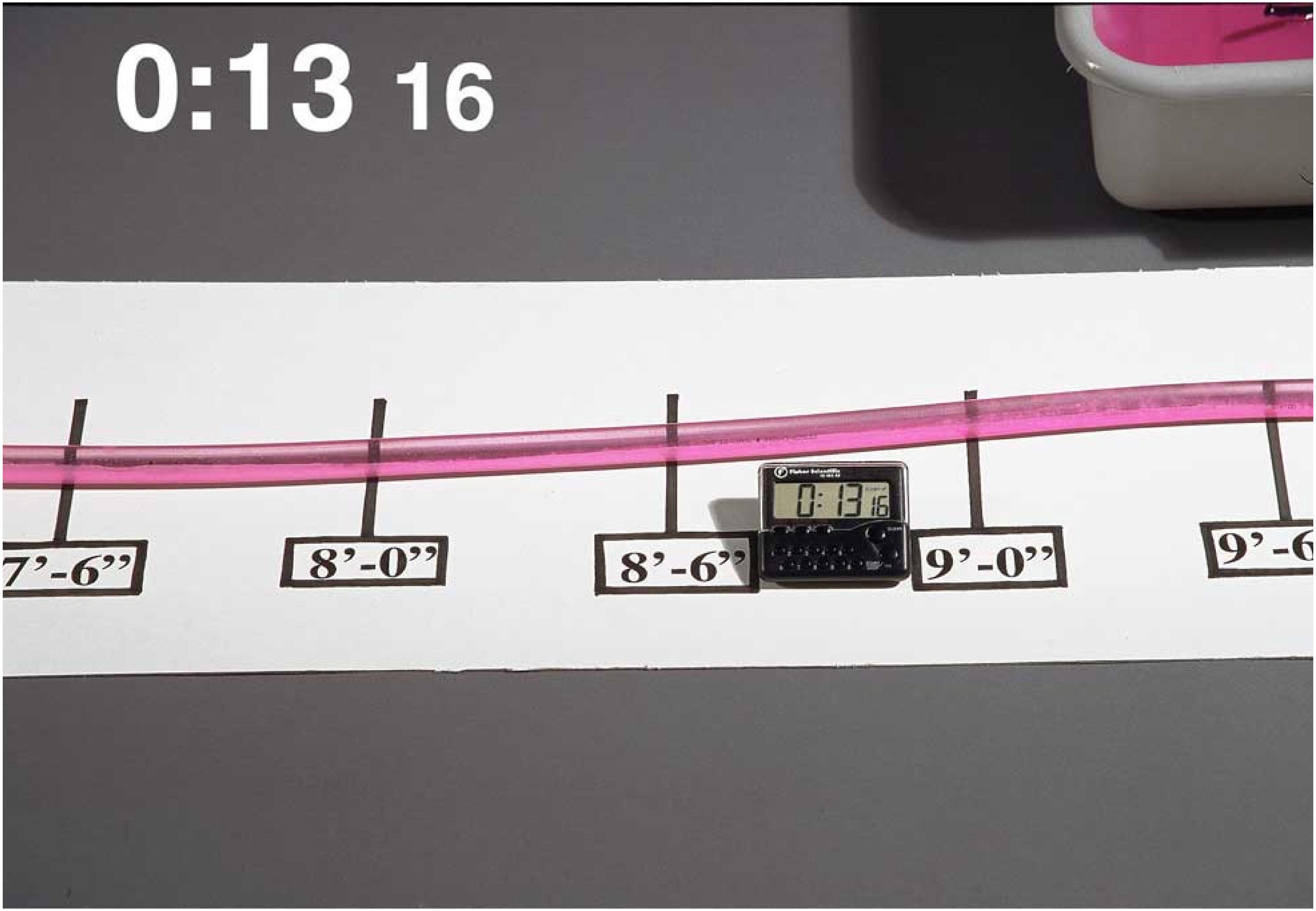

0:07 21
5'-6"
6'-0"
6'-6"
7'-0"
7'-6
0:07 21

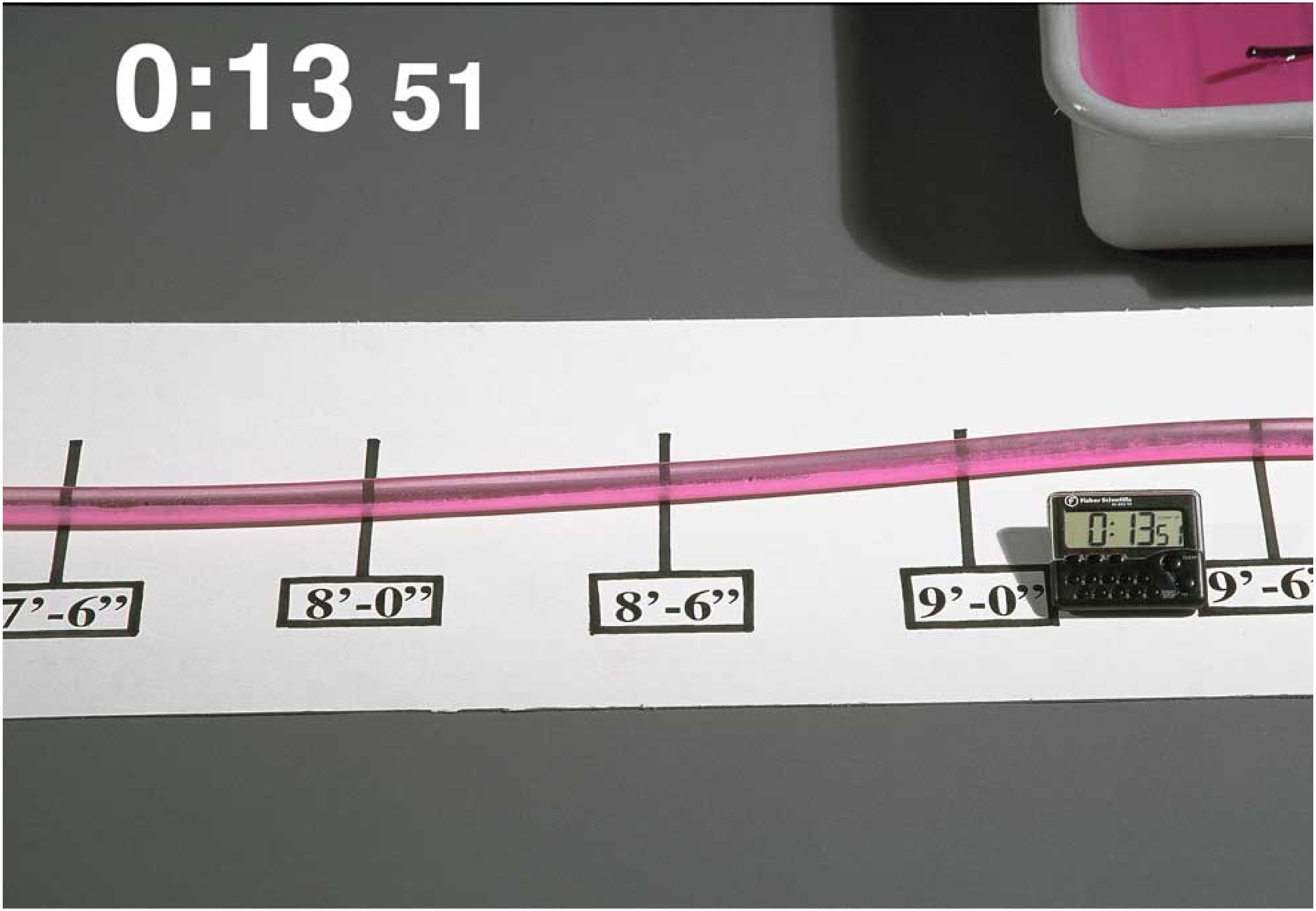

0:08 07
5'-6"
6'-0"
6'-6"
7'-0"
7'-6"

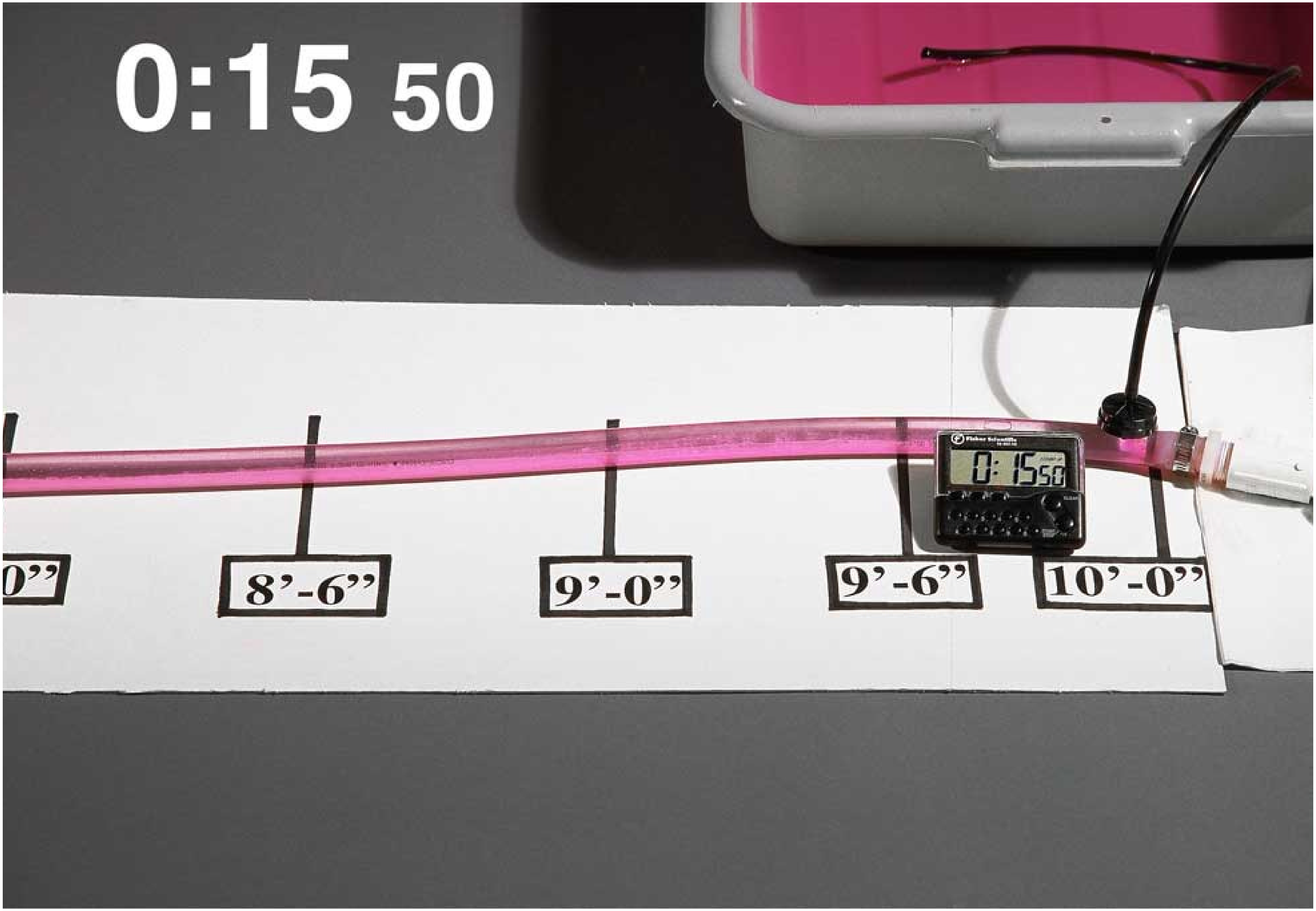

0:08 45
5'-6"
6'-0"
6'-6"
7'-0"
7'-6"
0:08 45

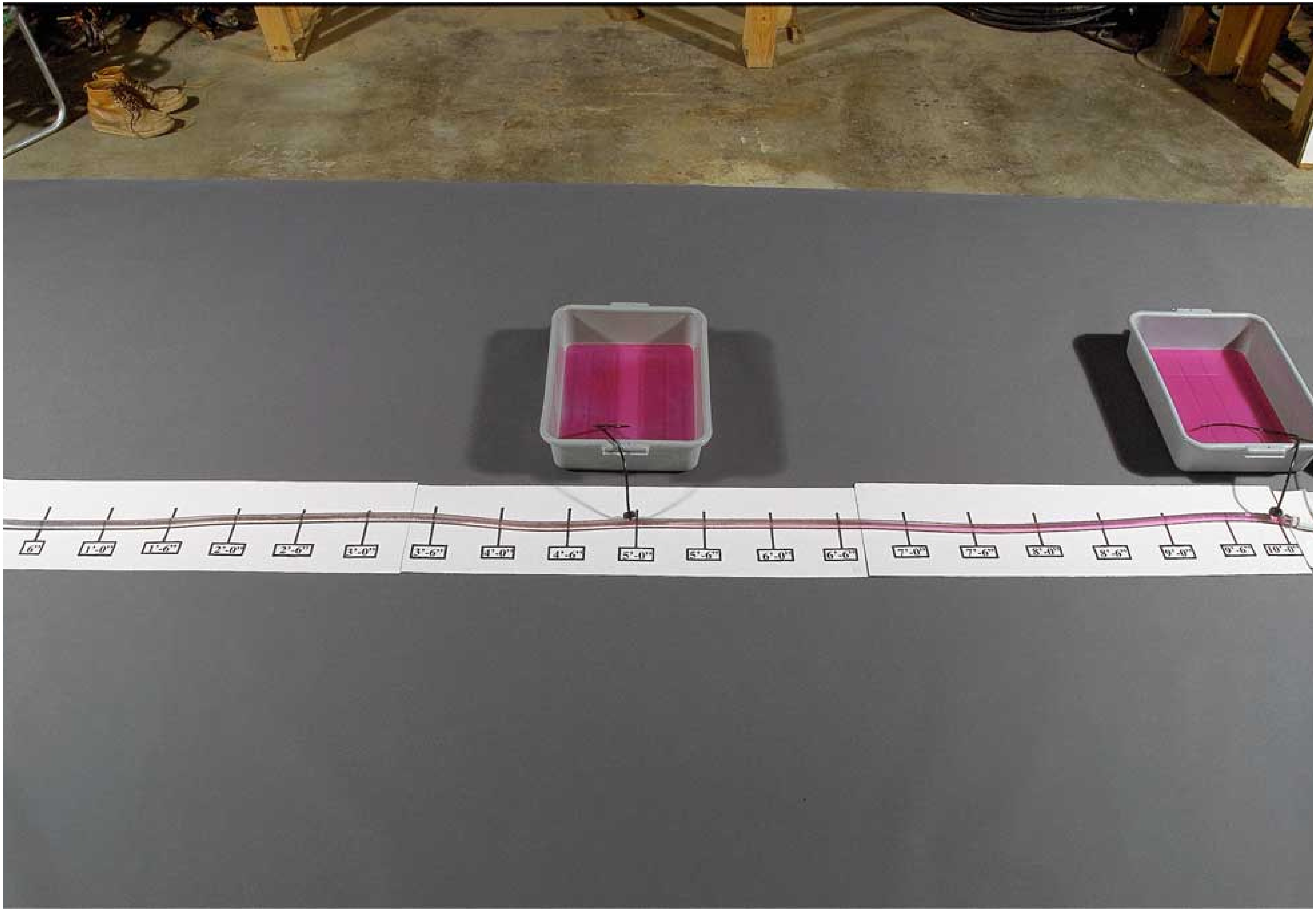

0:10 57
7'-6"
8'-0"
8'-6"
9'-0"
0:10 57


0:12 07
7'-6"
8'-0"
8'-6"
9'-0"
0:12 07
Fisher Scientific


0:13 16
7’-6”
8’-0”
8’-6”
9’-0”


0:13 51
8’-0”
8’-6”
9’-0”


0:15 50
8'-6"
9'-0"
9'-6"
10'-0"


6"
1'-0"
1'-6"
2'-0"
2'-6"
3'-0"
3'-6"
4'-0"
4'-6"
5'-0"
5'-6"
6'-0"
6'-6"
7'-0"
7'-6"
8'-0"
8'-6"
9'-0"
9'-6"
10'-0"

Uniform Chemigation

It takes at least as long for most of the chemical to clear from the drip lateral as it took it to initially move through the lateral.

To takes a long time for all the chemical to clear out of the drip lateral.

Uniform Chemigation

We also need to account for the time it takes for the injected chemical to move through the underground pipelines.

How do we do this?

Uniform Chemigation

The easiest way to determine travel times of chemicals (and water) through a drip system:

- Inject chlorine (at about 10 - 20 ppm) into the drip system and follow its movement through the drip system.
- It is easy to spot when chlorine reaches any point by testing the water with a pool/spa test kit.

Uniform Chemigation

What happens during chemigation in a commercial scale vineyard or orchard?

The following table shows the characteristics (pipeline length and drip lateral lengths) and water/chemical travel times for 6 commercial systems.

Water / chemical travel times through the pipelines and drip lateral lines for the vineyard and orchard field sites evaluated.

Site	Mainline and Submain		Lateral Line		Total Travel
	Travel Time (min.)	Length (m)	Travel Time (min.)	Length (m)	Time (min)
1	22	300	10	55	32
2	30	450	10	105	40
3	65	1500	10	105	75
4	15	425	30	190	45
5	8	215	25	190	33
6	17	250	28	185	45

Chemigation Uniformity in Drip Irrigation Systems

- **Trees & vines** - injections should last at least 1 hour, and at least 1 hour (longer is better) of clean water irrigation should follow it.

- **Row crop drip** - injections should be at least 2 hours in length, and there should be at least 2 hours (longer is better) of clean water irrigation following injection.

Uniform Chemigation

In summary:

- There is no standard total travel time through a drip system. The travel times ranged from 30 to 75 minutes.

- You need to test (using the chlorine travel time test) the drip system you're concerned with. You only need to do this once - then you know the travel time through the drip system.

Uniform Chemigation

To get uniform chemigation, you need to have the injection period be long enough to move the chemical through the entire drip system.

and

You need to have a post-injection period of clean irrigation water.

Uniform Chemigation

What if you don’t have the post-injection period of clean water irrigation?

Uniform Chemigation

The following table shows the uniformity of chemigation for a 150-meter drip lateral with 4 lph drip emitters every 1.5 meter.

It takes 25 minutes for water/chemical to move through the drip lateral.

Chemigation uniformity in a drip lateral (150-meter long with 4 liter per hour drip emitters installed at 1.5 m intervals) for various injection time periods and various post-injection clean water irrigations. The water / chemical travel time to reach the end of the drip lateral was 25 minutes.

Injection Time (min)	Post-Injection Irrigation Time (min)	Relative Uniformity
50	50	100
50	0	25
25	25	95
25	0	11
13	25	81
13	0	7

Uniform Chemigation

In summary, for a drip lateral with a 25-minute travel time:

- A 50 min. injection / 50 min. post-injection irrigation period gave excellent chemigation uniformity.
- A 25-min. injection / 25-minute post-injection irrigation period gave very good chemigation uniformity.
- A 25-min. injection / no post-injection irrigation gave a poor chemigation uniformity.
- A short, 13-min. injection / no post-injection irrigation gave very poor uniformity .

Uniform Chemigation

So what should be our best management practice to get a very uniform injection?

Uniform Chemigation

1. The injection period should be at least as long as it takes water / chemical to move from the head to tail-end of the drip system. Twice as long is better.

Uniform Chemigation

2. The post-injection, clean water irrigation period should be at least as long as it takes water / chemical to move from the head to tail-end of the drip system. Twice as long is definitely better.

- It takes a long time to completely remove all the injected chemical from the drip system.