



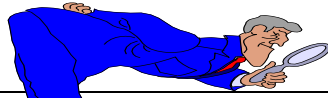
Technical Training

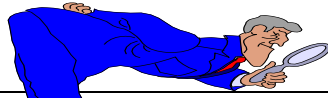
Track & Structures

Track Inspection Training

*Stringline Training*

Section 12



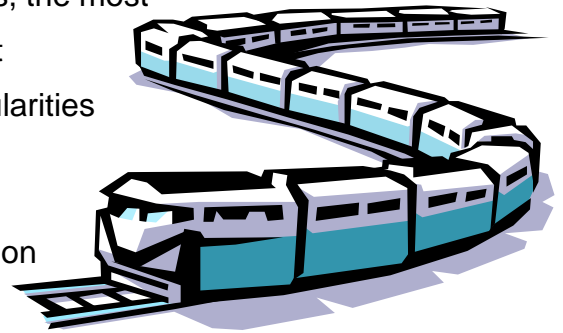


## STRING LINE TRAINING

Many methods have been devised for computing the throws at each station on a curve from string line notes taken on the track.

Some are extremely complicated; some are only approximately correct and give results little better than the existing line.

With the exception of mechanical lining attachments, the most accurate method being used at the present on most railroads and transits for correcting alignment irregularities is the string line method.



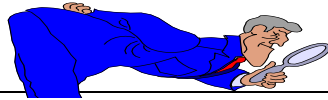
Although nearly all, **out-of-face lining** with production units is now done with mechanical liners, there is still a need for an easy method of figuring curve throws for numerous small jobs.

Such occasions could be:

1. To increase side clearances, where close clearances exist.
2. When rail is to be removed and re-laid
3. To establish good alignment, when renewing a hi-rail access.
4. For final alignment when lifting slow orders for irregular line, such as at derailment sites.
5. Or any time raising or lining is not **out-of-face** and production machinery is not used, or is not available.

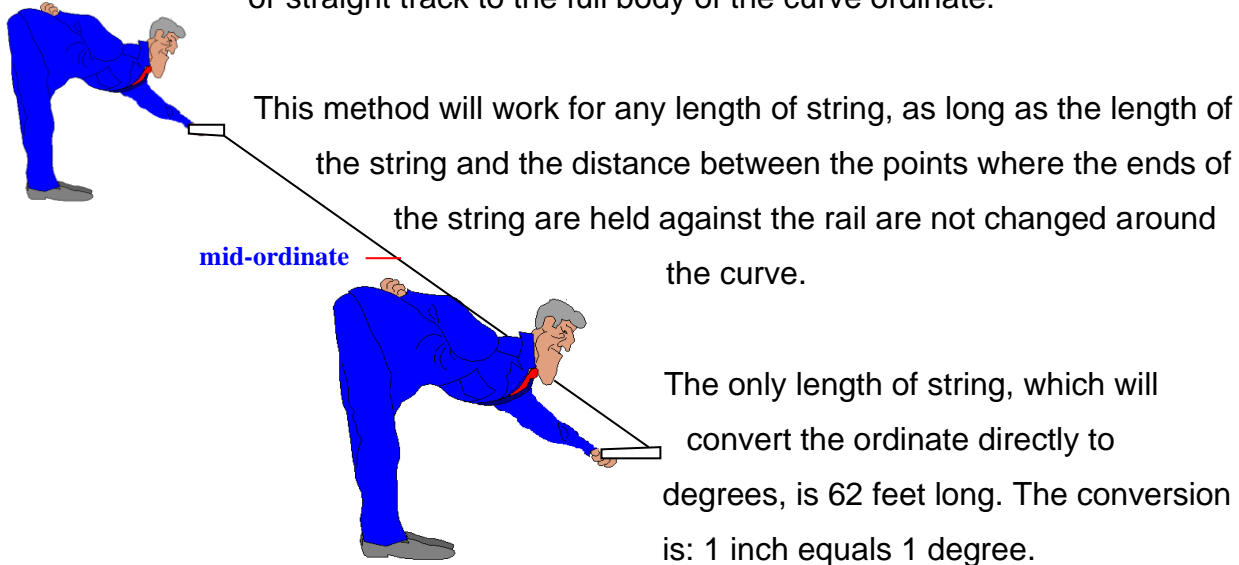
### A. Explanation of Stringlining

Stringlining is based on the principle that a curve of uniform degree is in perfect alignment when the distance between the midpoint of a string stretched between any two points on the gauge side of the outer rail, and the rail itself, is the same at all points.



## Distances

This distance is called the **mid-ordinate**, or simply **ordinate** for this method. The ordinates increase gradually and uniformly in the spiral, from zero at the tangent or straight track to the full body of the curve ordinate.



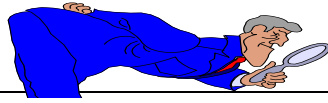
## Cord Length

At **MARTA**, due to the curves being of a much higher degree than on a freight railroad, the cord length used is not 62 foot, but is a **31 foot chord**. With this arrangement, instead of a 62-foot cord, a **31-foot chord** is used and the station lengths are shortened to **15.5 feet**.

When string line measurements are made on a curve, which has not been lined recently, the ordinates will not be uniform in the full body of the curve.

They also will not increase or decrease at a smooth, gradual rate in the spirals, but will vary.

The line of such curves can be improved greatly by throwing the track inwardly where the ordinates are larger than the desired average ordinate and outwardly where the ordinates are smaller than the desired average ordinate.



- Ordinarily you have no way of knowing just how much to shift the track at each point.

### **Stringline Stations**

Station numbers are listed in Column 1; the original ordinates are entered in Column 2, opposite the station where they were measured. Column 3 is for gauge readings and the fourth column is for elevation while the rest will be explained in the calculations, which follow.

Since the method of figuring consists of trial and error, the rest of the columns may be used for further revisions if throws obtained in the first try are too large.

The right hand edge of the paper may be used for such notes as the location of obstacles to be cleared such as other tracks, signal masts, transitions, platforms and points through which the final line must pass such as hi-rail access, turnouts and bridges.

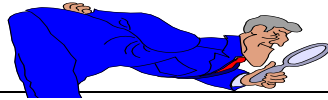
The second step is to plot the measured ordinates on a graph, which provides a complete picture of the existing line conditions.

- Graph paper expressly designed for this curve alignment purpose is available.

### **Elevation**

To match elevation increases to degree of curve increases, the rate of elevation increase must be determined using the actual spiral length or the minimum spiral length whichever is longer.

Because our automatic surfacing equipment increases elevation in  $\frac{1}{4}$ " increments, the rate of increase will be figured using the  $\frac{1}{4}$ " rate of increase per required feet.



*In the example,*

- The actual spiral length is 248' and the minimum is 62'.
- Using the actual spiral length of 248' (which is longer than the minimum), divide the length in feet by the number of  $\frac{1}{4}$ " of elevation to determine the rate per  $\frac{1}{4}$ ".
- 248 divided by 4 (1 inch has four  $\frac{1}{4}$ " ) = 62' and is written as  $\frac{1}{4}$ " in 62'. This rate must be calculated for each spiral individually.

## Conclusion

Of all methods available for lining track, the string line method will give the smoothest curve with the smallest throws.

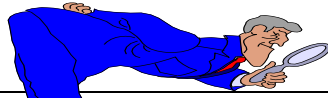
It is as accurate as using a transit, but is more flexible and not nearly as costly. It requires only a string, a ruler, paper and pencil, and a few other simple tools.

Stringlining permits the revised alignment to be shifted to clear obstructions or to pass over the centers of bridges or other fixed points.

It is so flexible that it allows different spirals to be used at the ends of curves if needed or desirable.

ALL railroad personnel know that railroad tracks are composed of tangents connected by curves. Most of them know that the tangents are kept in line easily and that the rails are kept level with each other by means of a tool known as a **level**.

Most of them also know that the real difficulty is to keep the curves in line and the outer rail at a fixed and uniform elevation above the inner rail. This happens, so those transit cars will tilt inward, and thus offset the tendency for them to overturn outward due to centrifugal force while traveling around the curves.



## B. Fundamental Principle Explained

When most of our railroads were built, engineering parties set stakes along the centerlines of the tangents and connected the tangents with curves, usually of fixed degree and radius.

As it was necessary that the rails on tangents be level across the track, and that the outer rails on curves be elevated a sufficient amount to offset the tendency to overturn.

This was a requirement that was obviously impossible to fulfill directly at the points where tangents and curves joined.

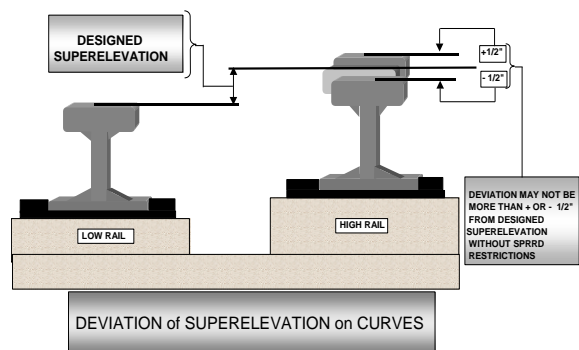
The rails could not be level and have the outer one raised at the same time.

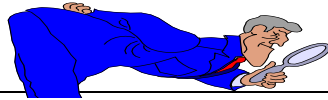
Therefore, it was necessary to insert curves of varying radius between tangents and uniform curves, starting in the tangent and gradually increasing in degree of curvature until it equaled that of the body of the curve.

These **easement curves** are called spirals, and they are now considered an essential part of all curves in mainline tracks.

Track inspection and maintenance personnel know that a curve of uniform degree is in use when the distance between the midpoint of a string stretched between any two points on the gauge side of the outer rail, and the rail itself, is the same at all points.

Near the ends of the curve however, when a spiral is introduced, this distance, called the ordinate, decreases gradually and uniformly to zero when the entire length of the string is on the tangent.





- The foregoing is true, of course, only when the track is in perfect line throughout the curve.

When working complicated situations, it is a good plan for the computer (meaning the person who does the calculations, figuring throws, for stringlining) to be present to see that all side measurements needed are obtained and to give them actual knowledge of the conditions to guide them in computing the throws.

This is particularly true where **compound** or **reversed curves** occur in narrow rock cuts or tunnels, or under overhead structures.

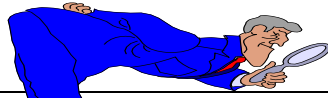
- Under such conditions, side clearances are very important.

The computing person will know from experience where the shift is likely to be large, and he/she can get ample side measurement at these points to assure them self that the throws he/she figures will not be prohibited by insufficient side clearances.

The measurements should start about five to ten stations ahead of the beginning of the existing curve (in tangent track) and extend about the same distance beyond the end of the curve as found (again on tangent track).

- Also, frequently there is a **dogleg** in the tangent, which should be measured and allowed for in the correction.
- If the kink is in the same direction as the curve, it should be measured and recorded exactly as any other ordinate.
- But if it is in the opposite direction it should be measured with an offset string and recorded with a minus sign (-) before it.
- This will cause it to be corrected in the solution, and the track made tangent up to the point of the spiral.

Two persons hold the string against the gauge side of the head of the rail, at the bottom of the curve-worn portion, at two stations, while the third person measures the ordinate at the station half way between them.



If a recorder is present, he/she should check the reading on the rule also, as too much care cannot be taken in getting the original measurements correct.

- An error in reading the ordinate cannot be detected by the computer during computations, but it will be reflected in the final alignment, which will be found by trains, with the result that the track will be knocked out of line again quickly.
- It will cause a sharp or flat place in the curve, two stations long, which will be out of line in the middle by twice the error in reading.

### **C. Stretching the String**

The string should be stretched tightly, but without force enough to break it, and the side of the string next to the rail should always be read, not the center of the string.

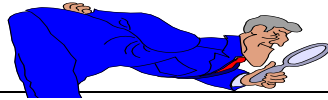
If variations are encountered, a tape must be used to locate the remainder of the stations on the curve. No short stations can be tolerated.

**They must be kept within an inch of uniform length in order to produce satisfactory results.**

The string should be kept at uniform tension and free from any contact with grass or weeds.

- The stringperson must watch to see that it is straight from end to end when the measurement is being taken, as the measurer or recorder at the middle of the string cannot tell if there is a kink in it.

They can tell if the proper tension is being maintained, however, by plucking the string upward after it has come to rest upon his rule, and then checking his reading.



- When the wind is blowing across the track, he/she may have to pluck the string two or three times at each station before he/she is sure he/she has the correct reading.

They should hold the end of their rule against the bottom of the curve-worn portion of the head of the rail, (5/8 inch below the top of the tail) the same as where the string is held.

- This is necessary because the throws for the revised alignment are to be set later by measurement from the same point.

**Accuracy of measurement of the original ordinates is essential to obtain a true curve in the realignment stakes.**

As soon as they have made their reading, the measuring person should so indicate by signal, so that all may move to the next station together.

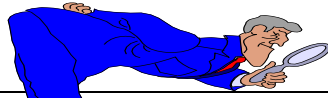
- This is repeated, one station (half the chord length) at a time, until a point, five or ten stations beyond the end of the curve is reached.

The recorder should number the lines on the sheet in advance, and should record each ordinate opposite the proper station number immediately after it has been measured and checked.

- Any delay in doing this may result in confusion or forgetting the figures.

They should note also the locations of any switches, frogs, beginnings and ends of bridges or aerial structures. Any narrow roadbed, signals, piers of overhead structures, track or hi-rail accesses or anything else that will prevent the lining of the track, or that will have to be moved before the track can be lined toward it.

Usually it is sufficient to estimate the locations of such obstacles to the nearest station. However, a surveyor's marker or station marker, or other fixed point of known location, should be tied in to the curve with a tape measurement so that proper record of the curve can be made.



Side measurement to each obstruction is taken with a tape on a return trip over the curve, the recorder indicating to the stringperson each measurement they desire.

- Also gauge readings need to be taken at each station on Direct Fixation.

Clearance from station platforms, adjacent tracks and retaining walls should be measured at each station on spirals and as often as necessary on the body of the curve.

- It is also necessary, on ballasted track, to measure track centers so that re-lining track will not move it too close to the other track. (Track centers are a minimum of 14' 9")

Care must be exercised also to obtain sufficient data to cover any change in location of the point of compound curve, if any, as such points frequently need to be moved ahead or back a few stations.

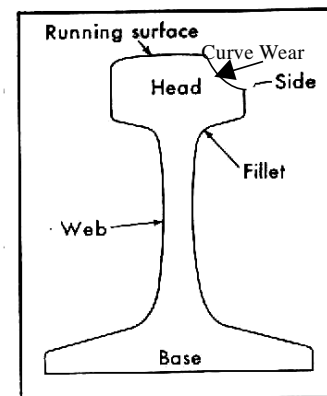
The existing elevation of the outer rail should be measured at every station on spirals and as often as needed elsewhere.

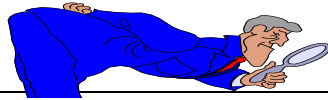
- Record the elevation tags at the station they are close to and confirm with crosslevel.

Any unusual curve wear on rails should also be noted, and the elevation measured at these points to see if the wear is caused by line or surface variations.

- It is good practice to obtain all information that may be useful while on the ground to avoid any delay later.

Excessive wear of the outer rail may indicate too much speed for the elevation, while a hammered condition of the inner rail indicates too much elevation for the average speed.





Of course, the service life of the rail must be taken into consideration also, but the above mentioned conditions frequently are the best indication of any change needed.

On grades, the average speeds over double or multiple tracks may be estimated closely, but on single tracks some compromise must be adopted as the speeds in one direction will vary considerably from those in the opposite direction.

While a long curve on a grade might have different speeds at each end, it is not advisable to vary the amount of elevation of the outer rail unless there is a distinct change of degree of curve also.

#### **D. The Spiral**

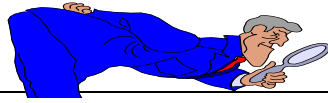
After the station numbers and the original measured ordinates, are recorded on the data sheet, inspection of the ordinate column will show that some of the ordinates at the beginning of the curve will be increasing in value.

- These are on the spiral or easement curve that connects the tangent with the body of the regular curve.
- The length of the spiral depends on the distance necessary to obtain the full elevation required for the degree of the curve and the speed of the trains, which will operate over it.

All transits have fixed rules for the amount of elevation for various speeds on different degrees of curvature up to a maximum amount, usually six inches.

- **At MARTA maximum elevation is 6".**

The minimum length of spiral should not be less than 1.2 times the authorized speed in miles per hour, multiplied by the number of inches of elevation used in the regular portion of the curve.

**Example:**

$$60 \text{ mph} \times 1.2 = 72 \times 6 \text{ inch elevation} = 432 \text{ feet}$$

However, this length should not be less than 40 ft. per inch of rise, (40 ft. x 6 in. = 240 ft.) nor usually more than 80 ft. per inch (80 ft. x 6 in. = 480 ft.)

The first because at anything less than 40 ft. per inch, the rise is quite noticeable to those riding in trains.

And the latter because most transits use gradation marks on their track level boards for each  $\frac{1}{4}$ -in. increase in elevation, and  $\frac{1}{4}$ -in. per rail is about the practical limit for the trackperson to see with their level board.

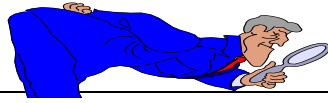
If smaller rates of rise are necessary on account of speeds higher than 65 mph., adjustable levels should be provided and the trackperson required using them at each point where the elevation increases by  $\frac{1}{4}$  in.

There are many possible spirals, but only one type is suitable for track work and that is a spiral, which increases in degree of curvature, from tangent to the degree of the regular curve, at a uniform rate.

- This means that the middle ordinates of the chords in the spiral increase as the distance from the beginning of the spiral increases, up to the value of the ordinates in the regular curve.

As the elevation of the outer rail also increases uniformly from level at the start to full elevation at the point where the spiral joins the circular curve, the tendency to overturn is exactly balanced throughout such a spiral.

- A perfect spiral has ordinates increasing as it progresses toward the body of the curve.



## E. Adjusting Reverse Curves

Particular attention is given to passing the point of reverse curvature and the introduction of suitable spirals at this point, connecting the two simple curves with the least distortion of the simple curves themselves.

With a complete understanding of the solution of such problems, the string liner will be in a position to solve any curve that is likely to be encountered anywhere in track.

Up until now, all the instructions have applied to simple or compound curves – that is, curves in one direction, although they may be composed of parts with different radii.

In rough, hilly terrain, or when following the course of streams, it often happens that a curve in one direction will be followed by a curve in the opposite direction without any intervening tangent. These are known as **reverse curves**.

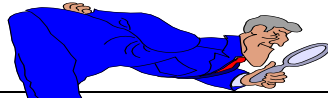
In the case of simple, one-way curves, the trackperson could extend half of the spiral at each end out on the tangent, but with reverse curves there was no tangent that could be used, so the distortion was necessarily very abrupt.

- As a result, the reversing point had to be protected by slowing down trains, and the increase in degree of the adjoining curves generally required a speed restriction also.

The reverse curves were necessary in the first place because of physical conditions, which usually still exist.

- The route may be in deep rock cuts or on side hills where the change in line to avoid the short spirals would be too costly or impracticable.

However, by use of string-lining methods, the best possible alignment can be found, utilizing every inch of available throw to the best advantage.



## F. Measuring the Curve

In measuring up a reverse curve, the station numbering should be carried through continuously.

- When the ordinates have become zero or as near as possible to zero, three or more stations are carried across the track to the other rail and the work carried on as before.

After the last ordinate on one rail is recorded, a line should be drawn across the notes and **marked P.R.S. (Point of Reversed Spirals)** as it is essential to know just when the ordinates changed to the opposite rail.

In the case of simple curves or compound curves, the final figures in each column at the end of the curves must be zero.

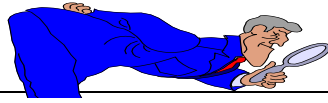
- The zero in the sums column means that the central angle, and no more, has been used, and, the zero in the half-throws column means that the final station is exactly on the tangent.

Since the central angle is entirely used, the direction of the final tangent is parallel to that from which the original notes were taken, and since the final station falls on that tangent, the solution is a correct realignment of the curve.

With reverse curves following each other without intervening tangent, the above will apply only to the final station in a series of curves.

- The direction of the common tangent at each reverse point may, and probably will, be changed, and there may be a throw in either direction at each such point also.

The amount of change and the amount of throw may be varied at will to make the revised curves fit the local conditions and to obtain the best length and rate of spirals possible.



## G. Seek Best Possible Results

The person who computes can well afford to spend several hours in studying such curves, trying time after time to make such slight alterations to his solution as will bring about the best possible results.

- It is obvious that the best results could never be obtained by the use of a transit in rough terrain where intersection of the tangents is not possible and the moving of fixed obstacles is impracticable or too expensive.

Every effort must be made to obtain spirals of suitable length, to make the body of the curve as uniform as may be possible. You also need to keep the degree of curve at a minimum, while keeping the throws inside the maximum limit to clear all fixed obstructions and to pass over the centers of bridges and through all other fixed locations.

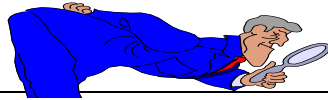
No curve should be staked until the person computing is satisfied that he/she has obtained the best possible solution and that it meets the above requirements at every station.

- Needless to state, this requires patience and perseverance, as each curve is a problem by itself and can be solved only by repeated trial and correction.
- The work, however, is very fascinating, and the computer has a feeling of real satisfaction with the solution of each problem.

## H. Length of Spiral

Once the superelevation has been established, the third step is to determine the length of easement curve.

- The information necessary is the superelevation and the maximum train speed.



Once a track person becomes familiar with the track charts they can read off the values rapidly and with confidence.

- The charts, to be of value, must be of such size that they may be used conveniently in the field.

The clipboard, used by most inspectors, is large enough to give charts, which may be read with sufficient accuracy, yet small enough to be carried in the field without difficulty.

## **I. Materials Required to Stringline:**

### **Needed Material**

- Two String line Paddles
- Sixty two (62) feet of stringline chord
- String line Reader
- Carpenters ruler
- One Hundred (100) foot Tape measure
- Paint Ball Markers
- Track Charts
- Paper and Pen to record readings

### **Additional Items;**

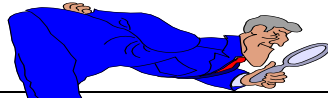
- Gloves
- Flashlight
- Lumber Crayon,
- Extra Cord
- Something to cut the Cord,

## **J. Marking Stringline Stations;**

### **Starting Stringlining;**

In order to properly mark the string line stations you must know where the

**Tangent to Spiral (T.S.)** starts.



- In all measurements made on the track, work from Five Points Station out.
  - a) This means that your first number will start at the end of the curve that is closest to Five Points.
  - b) All other numbers will then increase or get larger as you go away from Five Points.

Once T.S. has been determined, go a minimum of ten (10) stations into the Tangent marking string line stations.

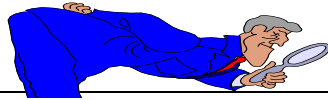
- This will ensure that there is a smooth transition from the Spiral to the Tangent.
- Stations are marked fifteen and a half feet (15 ½) apart.
- This will make for a thirty one-foot (31) chord length.
- Use a Paint ball marker to mark stations and station numbers.
- A line on the field side of the ball of the rail to mark the station.
- Put the station number on the gauge side of the rail at the base.

**It is best to use your Tangent to Spiral as a station location, and then go ten stations into tangent and then to number the rest of the curve.**

### **Where to set stations**

Starting with station 5 or 10 exactly on T.S.

- This puts 5 to 10 stations on the Tangent in order to have the proper run-in to the Spiral.
- This will help to eliminate what is commonly referred to as a **DOGLEG**. A DogLeg is a misalignment of the track where the Tangent and the Spiral meet.
- Putting the mark on the Tangent to Spiral spot helps to set the location of the curve for the computer program that is used to figure the throws for that curve.
- Getting the exact location of everything on the track is also important.



- Mark the stations with a Paint Ball Marker with a slash on the outside top part of the ball of the rail. Also write the station number on the base of the rail.
- Continue to mark stations throughout the remainder of the curve.
- There is no set number of stations.
- The length of the curve will determine the number of stations.
- Start with zero (0) and work your way up.

### String line Data Sheet

Mark the Data Sheet when these areas are reached;

- 1) Tangent to Spiral (TS),
- 2) Spiral to Curve (SC),
- 3) Curve to Spiral (CS)
- 4) Spiral to Tangent (ST)

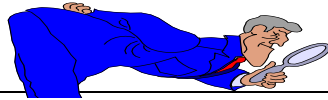
**If T.S. starts at station # 10 then at station #10 on the String line Data Sheet put the letters T.S. If S.C. begins at station #25 then mark that station with S.C. Continue with this for C.S. and with S.T.**

Any obstacles or Survey Markers you come across in this curve, write down its location (such as SR 172+90 a Hi-Rail Access at Oakland City Station) at the string line station it is near.

Write down the location (such as SR 169+30 the abutment at the south end of the West End aerial structure) when the station is at or near an abutment.

Note how far away from that station in feet that marker or obstruction is.

Any transition from one type of track structure to another also needs to be noted. (DF to Ballast or Slab Track to Aerial Structure)



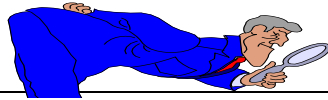
## K. Taking String Line Readings

### When Taking Stringline Readings

- (a) When taking string line readings it's important that the measurements are taken consistently at the same spot on the ball of the rail.
- (b) That point is 5/8 inch below the top of the rail.
- (c) This is accomplished with the String line Reader.
- (d) It is a crosslevel with a metal tape measure attached to the foot
- (e) Never let the string touch the ruler
- (f) The string is to be on top of the ruler
- (g) Put it as close to the ruler as possible, but again, do not to touch the ruler.
- (h) In order to keep the string from touching, your paddle holders will need to adjust the location of their paddles, up or down on the ball of the rail.
- (i) Start at station one (1) and continue to the end of your stations.
- (j) Making sure that you write down all the readings.
- (k) All readings are in sixteenths of inches.
- (l) String line paddles keep the string one (1) inch from the Rail
- (m) The one (1) inch mark on the ruler is your zero point.
- (n) All measurements over an inch are plus numbers
- (o) Everything below an inch is negative numbers.

### Negative Readings

- a) If your ruler reads  $\frac{3}{4}$  of an inch then that equals to a negative four (-4).
  - We count in sixteenths of an inch
- b) Do not start counting at the end of the ruler
  - Start at the one (1) inch mark and count backwards.
- c) The count is negative four (-4) sixteenths back from the one (1) inch mark of the ruler.
  - Remember everything below the one (1) inch mark is a negative number.



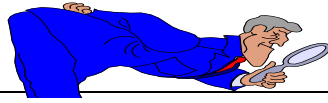
## Positive Readings

If everything below the one (1) inch mark on the ruler are negative then everything over one (1) inch are positive numbers.

- a) If the reading is 1  $\frac{1}{4}$  inches, then your reading will be a plus four (+4).
  - Because 1- $\frac{1}{4}$  inches is plus four (+4) sixteenth of an inch above the one (1) inch mark.
  - Remember the 1-inch mark on the ruler is the zero point for stringlining.
  - The paddles keep the string 1-inch away from the rail.
- b) The readings that you take will vary throughout the curve.
- c) Sometimes making large jumps, plus or minus.
  - This is to be expected.
- d) The track will have bulges and flat spots throughout the curve.
- e) That is why we are taking these readings, so that we can make the curve as smooth as possible.

## Starting Stringlining

- a) When starting the String line readings, put the first paddle on station zero (0)
- b) The second paddle will be on station number two (2), taking the reading on station number one (1).
- c) Once each station has been read, such as station number one (1) move the paddles ahead one station each.
- d) Now the paddles will be on stations one (1) and three (3)
- e) Take readings on station two (2).
- f) Continue this moving ahead, one station at a time until the entire curve is completed.
  - Always take your time in reading each station.
  - The more accurate the readings the better the curve will line.



## L. Figuring String Line Throws

### When Figuring Stringline throws

That for every throw, positive or negative,  $\frac{1}{2}$  of that throw will be added or subtracted from the station right before and right after that number.

Having three readings in a row and they are, 7, 4, and 8, and wanting to correct the alignment in this area, add 2 to the reading that is a 4.

- This will make the 4 a 6 (because  $4+2=6$ ).

Now that the reading has changed the 4 reading to a 6, subtract  $\frac{1}{2}$  the throw number from the 7 and also  $\frac{1}{2}$  the throw number from the 8 ( $7-1=6$  and  $8-1=7$ ).

- For  $\frac{1}{2}$  the throw of 2 is 1.

In making just one (1) throw it will have effected the readings on each side of it.

- Now the new readings will be 6, 6 & 7.
- This is a smooth piece of track.

No readings should be more than a two (2) sixteenth of an inch different.

What was done is to take readings that were  $\frac{3}{16}$  and  $\frac{4}{16}$  of an inch off and realigned it that it's only now  $\frac{1}{16}$  of an inch off. Well within our limits.

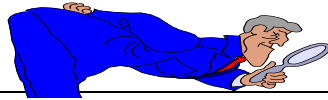
### Positive Throws

#### *Always remember*

- **Throws must be made in even numbers, 2,4,6,8 etc.**
- **Never in odd numbers, such as 1,3,5,7 etc.**

As seen from the readings above we go from 7 to 4 to 8 to 4 to 7. The alignment is not good, with changes occurring at each station too great to leave.

- Two throws are needed in order to smooth the alignment.



### **This is what happened.**

The 4 needed to be raised,  
Adding Plus Two (+2) the 4 becomes a 6

### **As stated before**

If adding to one number, then subtract  $\frac{1}{2}$  that throw number from the number above, and the number below that number.

- When that is done to the 7 it becomes a 6 and the 8 becomes a 7.

### **Now go to the other 4**

Adding +2 to that number, It becomes a 6.

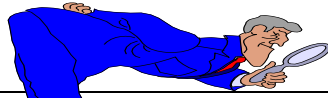
As before subtract  $\frac{1}{2}$  the throw number (1) from the 7, making it a 6, then subtract  $\frac{1}{2}$  the throw number (1) from the 7 to make it a 6.

Why do we subtract or add  $\frac{1}{2}$  the number from the numbers above and below the station thrown?

- When you move the track in one area you change the reference point for the other stations that are above and below it.
- Since the string line paddles will be set on the stations that will be moved, if it's moved in or moved out, that will change the reference point for measuring each station on each side of your throw.

### **Negative Throws**

Above was how to make positive throws, now take a look at making negative throws.



Stations	readings	throws ( )	new readings
1	5	→ +1	=6
2	8	(-2)	= 6
3	4	↙ 1 = 5 ↘ +1	=6
4	8	(-2)	=6
5	5	↘ +1	=6

**Always remember,**

- Throws must be made in even numbers, 2, 4, 6, 8 etc.
- Never in odd numbers, such as 1,3,5,7 etc.
- Even numbers are easy to read on a tape measure.
  - It is impossible to throw just 1/16 of an inch.
  - It's so small, just holding the paddles different can make that much change in the readings.

From the readings on the previous page, the changes are from 5 to 8 to 4 to 8 to 5.

**This alignment is not good**

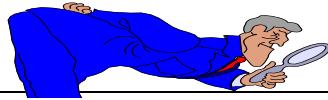
With changes occurring at each station too great to leave. Two (2) throws are needed in order to smooth the alignment.

- The 8 needs to be lowered, subtract 2 from the 8.
- Then the 5 becomes a 6.

**As stated before**

When subtracting one throw number you must add ½ that throw number (1) from the number above, and the number below.

- When that is done the 5 becomes a 6.
- The 4 becomes a 5.



### Now for the other 8

Subtract 2 from that number and it becomes a 6.

- As before add  $\frac{1}{2}$  that throw number to the 5, making it a 6.
- Then add  $\frac{1}{2}$  of that throw number to the 5 to make it a 6.

These rules apply to any set of numbers you have.

The throws were small. Any throws that we make, will need to be worked out on a sheet of paper.

Or given to your foreman to put into the computer.

- The computer will work out the necessary throws.

**Its important to give the foreman all the information needed to line the track.**