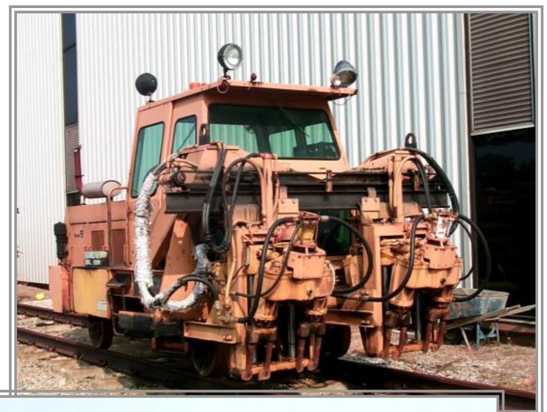
Track and Structures

Track Maintenance Training



Track Geometry

Module

TRACK SURFACE

Metropolitan Atlanta Rapid Transit Authority

Infrastructure Training

Table of Content

Introduction

Track Structure training provides a review of MARTA maintenance and railroad standards. At the end of this course, students will be able to describe basic Track Surface and surface related problems and corrections in accordance with MARTA Maintenance Procedures.

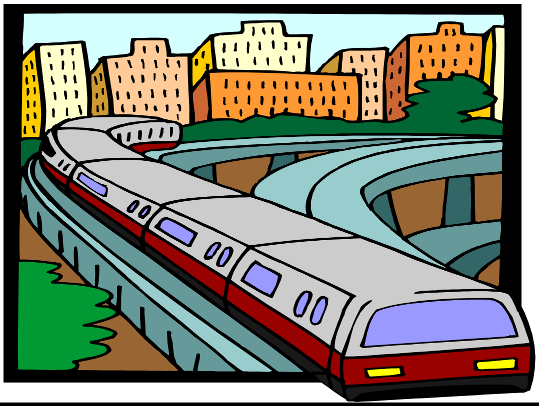
Requirements

> Test scores must be 80% or higher on all written evaluations. Only one retest will be allowed on any written evaluation without additional training. All MARTA Track and Structures personnel must demonstrate knowledge of MARTA Track Structures.

Each student will be asked to complete a class/instructor evaluation at the end of the class.

Learning Objectives

> **Class Objective**
>
> Demonstrate the ability to correctly describe surface defects and corrective methods. Demonstrate ability to use MARTA and FRA track safety standards.



Section Objectives

1. Describe effects of poor track surface.

2. Describe MARTA & FRA standards for track surface.

3. Describe track rises & run-offs and their effects on track surface.

4. Demonstrate the ability to take and read cross level on tangent, spiral and curves.

5. Demonstrate ability to figure run-offs on MARTA curves.

6. Describe twist and its effects on trains.

7. Demonstrate ability to mark elevation in the spirals of a curve.

8. Demonstrate ability to spot surface defects.

9. Describe how to correct surface defects using the manual tamping method.

10. Demonstrate ability to correctly use the spot board and surfacing laser.

Track Surface

Introduction to Track Surface

In another module, attention was directed to those parts of track geometry involving the horizontal location, measurement, and maintenance of track.

This module will examine the vertical placement of track.

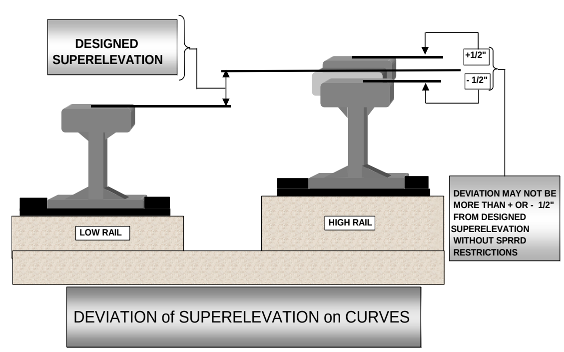
Where matters of track alignment and gauge are involved, the point of reference is always on the inside edge of the railhead, at a point **five-eighths inch below the top of the rail**.

The point of reference concerning track surface is always on **the top of the railhead.**

Ideally, the tops of the railheads should always provide a smooth uniform surface, free of humps or dips.

- In addition, the tops of the two rails should have a definite vertical relationship to each other.

The tops of the two rails on tangents should be level with each other.



On curves, where the speed and degree of curvature are great enough to justify it, the outer rail should be elevated somewhat above the inner rail.

The loads which are placed upon a track structure by modern rolling stock can be very large.

They can be so great that the underlying structure is not always able to sustain them without a partial breakdown in supporting ability.

One of the large items in any railroad's maintenance budget consists of those funds which are expended in order to maintain adequate track surface.

Millions of dollars are spent each year because the need for good track surface is well recognized by knowledgeable railroaders.

- Its importance can best be understood through a knowledge of the consequences of poor track surface.

A. Effects of Poor Track Surface

The most serious result of poor track surface is the derailment of transit cars or the locomotives.

- This can range from minor derailments, where little or no damage is sustained, to major catastrophes.

1. Derailments

Defects in track surface can be the sole cause of a derailment, or they can contribute to a combination cause of a derailment.

Derailments are not the only problem created by poor track surface. Harm to passengers, damage to equipment or excessive wear on equipment represent part of the problem.

- Usually, it is very difficult to trace some specific damage or wear to a particular point where track conditions are substandard. Nevertheless, expenses due to such damage are very real.

Another result of poor track surface is accelerated deterioration of the track structure itself.

Surface defects can lead to rail damage, shortened tie life, and fouling of the ballast. It is believed by many that over a long period of time good track costs less to maintain than poor track.

2. Speed Restrictions

Speed restrictions (slow order) are a very real part of the cost of poor track surface. This can be in the form of delayed trips, increased crew costs, or both. If the resources needed to correct defects are not available, this alternative must be used. Yet, it should be recognized that it could mean substantial increases in transportation costs.

Track surface irregularities are widespread and can lead to serious consequences if ignored. Most Track Maintainers will find a substantial part of their work related to such conditions.

- This work may consist of looking for and determining the seriousness of such conditions.
- It may consist of correcting surface defects.
- Both types of work could be involved, if that is part of the Maintainers responsibilities.

This module will be concerned with the detection of track surface defects, and with the correction of such conditions.

Since it is necessary to be able to recognize a track surface problem in order to correct it, detection of defects will be considered first.

Automated Track Geometry Measurement

At least semi-annually all revenue track is measured by an automated geometry measuring system. The parameters measured include gauge, alignment, crosslevel, profile, and twist. This procedure generates an exception report and a graphical representation of all defects which exceed designated thresholds.

These defects are then manually verified for accuracy and proper track orders are placed as needed.

Profile (surface)

Surface or profile describes the vertical smoothness of the track. Deviations from the desired condition can be observed by sighting the length of the rail with one's eye parallel to the top of the rail. Minor deviation is normal. If the deviation appears abnormal (more than 1 inch) the area should be checked using a 62' chord and accepted stringline methods (see Exhibit # 8).

Flat track should read zero inches. Suspect areas can usually be confirmed by riding a train over the area and noting the ride quality. Refer to MARTA Track Standards (see Exhibit # 15) for appropriate action once the amount of the deviation is determined.

Crosslevel

Crosslevel is the difference in height between the two rails of the track at points directly opposite each other. Design crosslevel on tangent (straight) track and in all turnouts is zero inches and can range up to six (6) inches in curved track. In many curves the outer rail is higher than the inner rail. This difference in height is known as **superelevation** (see Exhibit # 9). The superelevation is indicated on metal tags which are affixed to the ties or direct fixation concrete throughout the spiral (see Exhibit # 10). The tags cease once full elevation is achieved. Crosslevel is checked with a track level when there is evidence of excessive deviation from normal. Crosslevel defects can be readily identified by riding a train through the area and will be felt as a gentle **rolling** or **swaying motion**. Once the amount of deviation is measured refer to the MARTA Track Standards for appropriate action.

Gauge

Gauge is the distance between the two rails of track at points opposite each other and 5/8 inches below the top of the rail head. Gauge measurements should be made in suspect areas. Unusual rail wear can be an indication of tight gauge. Unusual rail wheel tread pattern on top of the rail can indicate wide gauge. Evidence of fastener movement is another sign of potential gauge deviation. It is very important to understand that there are two types of gauge readings.

The normal gauge reading is a **static**, or unloaded reading. The second case is a **dynamic** reading, or a loaded reading. If there is evidence of fastener movement in the suspect area, the amount of movement must be measured and added to the static reading and the total recorded as the dynamic reading. The dynamic reading is the actual condition that the train wheel encounters. Once the amount of the gauge deviation is determined, refer to the MARTA Track Standards for appropriate action.

Alignment

The term alignment refers to the horizontal position of the track. To observe the alignment condition the inspector should stand directly over the top of the rail and sight the rail length. Minor deviation is considered normal, especially in the turnout areas. If the visual inspection indicates an abnormal deviation the area should be stringlined using a 25 foot chord to verify the defect.

Alignment is usually observed as kinks in both rails and should not be confused with gauge defects which usually appears in only one rail. Alignment deviation in tangent track is easy to observe, but is extremely difficult to see deviations in curves. It is important to use the stringline method to identify defects in curves.

Defective alignment can be readily observed when riding a train through the area, and will be felt as a jerking side-to-side motion. Ballasted track to direct fixation track transition areas are known to be particularly prone to alignment defects. Refer to the MARTA Track Standards for appropriate action after the amount of deviation is identified using the chord methods.

Listed on the next page are the MARTA and F.R.A. standards used for track surface. MARTA standards are of a higher quality than the F.R.A.. The F.R.A. standards are the minimum safety standards used anywhere in the country.

B. Runoff at End of Raise

The first set of dimensions refers to the difference in elevation between newly raised track and track which has not been raised.

- Such transitions are commonly referred to as runoffs.

There will be a runoff at the beginning of a stretch of track to be raised.

- A temporary runoff will be made each time the track is cleared for the passage of a train and at the end of each day's work.

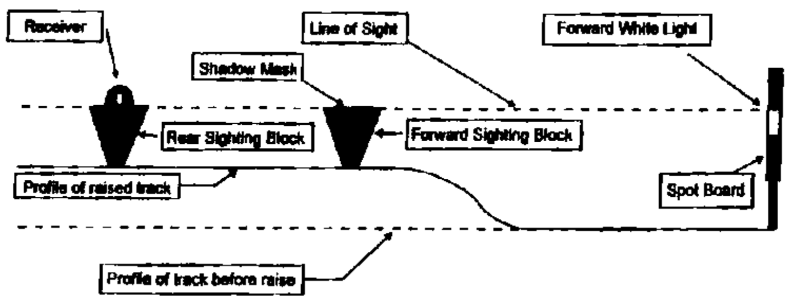
Runoffs will be needed on connecting tracks that are not to be raised.

If some part of the track structure is not to be raised, runoffs will be needed either side of the un-raised section.

Such locations might include:

- Bridges or aerial structures
- Hi-rail accesses
- Crossovers
- Track under overhead bridges
- Through station platforms.

Finally, a runoff will be needed at the end of the raised portion of track. Runoffs are usually of the same length on each rail.



If a runoff is too short, it will tend to give a vertical bounce to each piece of equipment passing over it. If severe enough, such a bounce can cause broken car springs, breaks in various parts of the trucks or the car body.

A short runoff can also lead to train separations. A sudden change in vertical direction can result in vertical slippage of locked couplers between two cars.

Particularly, in cases where the two couplers were not well matched as to height on level track, such slippage may result in enough vertical movement for the couplers to become free of each other.

- This, of course, results in a separation of the train and an emergency brake application.

Sometimes such incidents only require the train to be re-coupled and started on its way again. In other cases, a severe run-in of the rear portion of the train against the head end might occur and result in a major derailment.

These hazards require that abrupt runoffs be avoided.

There are two conditions which determine the length of runoff required.

- One is the maximum speed of trains operated over the track. This is provided for in the table with different dimensions for each class of track.
- The other condition is the height of the track raise. This must be calculated.

For example:

Suppose that a raise of 3 inches is being made for Class 4 track. The table of Rule §213.63 Track Surface shows that:

- 31 feet of runoff is needed for each 1-1/2 inches of raise.
- Since the raise is 2 times the amount permitted per 31 feet, the length of runoff must be at least 2 times 31 feet, or 62 feet.
- Formula: Class 4 = 1-1/2" so 3 ÷ 1-1/2" = 2", 2 x 31 = 62 ft.
    a) Length and height of runoffs can be checked with a string, a ruler and a tape line.
    b) Place one end of the string on top of the railhead at a point which has been fully raised, but near the runoff.
    c) Lower the other end of the string until the string is just touching the railhead, along the fully raised portion of track.
    d) The point at which the railhead and the string first start to separate is the beginning of **the runoff.**

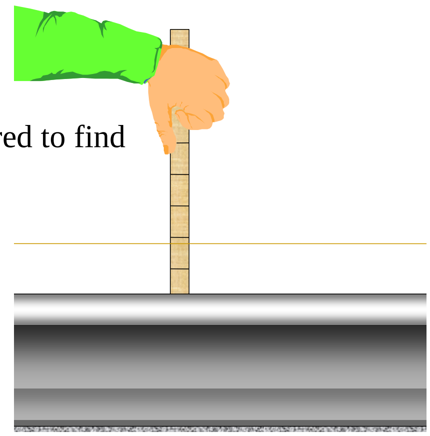
- This point should be marked.

e) Holding the string in the same position, measurements should be taken of the distance between the railhead and the string until the point is located where this distance no longer continues to increase.

f) This is the end of the runoff and should also be marked.

g) The distance between the railhead and the string is the height of the raise.

h) The distance between the beginning and end of the runoff can now be measured to find the length of the runoff.



It is now possible to calculate these dimensions in order to find out the class of track to which the runoff conforms.

For example, suppose that by following the procedure just described you have found the length of the runoff to be 53 feet and the height to be 2-1/8 inches. The runoff per 31 feet **(R)** can be found by using the following formula:

- L - is the total length of runoff
- H - is the height of the raise.
- To simplify calculations, the number 2-1/8" should be converted to a whole fraction which is 17/8

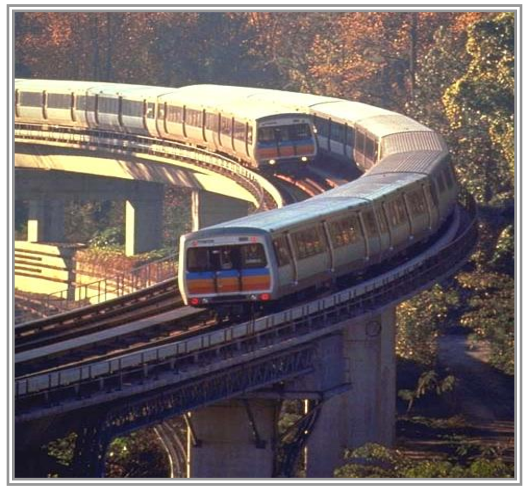
$$R = \frac{31 \times H}{L} \quad \text{or}$$

$$\frac{31}{53} \times \frac{17}{8} = \frac{527}{424} = 1.24 \text{ inches}$$

A runoff of 1-1/4 inches per 31 feet exceeds the allowance of one inch for Class 5 track, but is within the allowance of 1-1/2 inches for Class 4 track. Therefore, the maximum speeds permissible on this runoff are 60 mph for freight trains and 80 mph for passenger trains.

Another situation that must be recognized when making runoffs is the effect of previous runoffs.

Consider a part of the track structure of fixed elevation, such as an bridge or aerial structure. If previous track raises have created runoffs adjacent to the ends of this bridge, no additional track raise can be made within the limits of such runoffs. If a new raise of the track is made, the runoffs will have to be made beyond the old runoffs.



C. Deviation from Uniform Profile

The second standard for track surface, refers to the deviation from a uniform profile on either rail at the mid-ordinate of a 62-foot chord.

It should be recognized that these deviations or irregularities may consist of dips or humps in the rail.

1. Dips in the track

Dips are most common, as most irregularities in surface are caused by a breakdown in underlying support due to the heavy loads imposed on the ballast and roadbed.

There are conditions where the deviation will consist of a hump. Such conditions might develop during cold weather in track subject to frost heaving. A hump might result from a general breakdown of surface on each side of a firmly supported point in the track.

- A hump might also be caused by the *careless jacking of a track.*

The mid-ordinate to the 62-foot chord is measured by placing the string so the center is at the low spot on the railhead *(for dips)* with the ends tightly stretched and held against the top of rail. The distance between the center of the string and the top of rail is then measured.

1. **Humps in the track**

For humps, the same procedure is followed, with the center of the string at the high point. The ends of the string should be placed on blocks of uniform height which are placed on top of the rail. The height of the blocks is allowed for in measuring the mid-ordinate.

In cases where the track is on a level grade or on a uniformly ascending or descending grade, these measurements are relatively simple to make.

It has been seen that in horizontal alignment, curves are used to connect tangents. In vertical alignment, curves are also used to connect changes in grade.

2. **Vertical Curves**

A vertical curve may be in a sag at the bottom of two opposing grades as in Figure 1. It may also connect the tops of two opposing grades in Figure 2. In other cases, the two grades connected may both be ascending or descending, but of different steepness as in Figure 3.

Whenever profile is being checked on vertical curves, the mid-ordinates to the 62-foot chord, should be other than zero. The procedure is to check mid-ordinates at several points within the vertical curve, find the average, then find out how much the mid-ordinate at the point in question varies from the average.

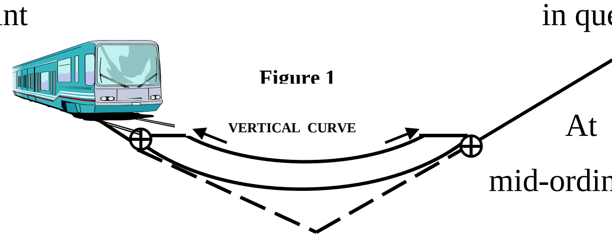


Figure 1

At locations not on vertical curves, the mid-ordinate should be zero.

In such cases, the deviation from uniform profile will be the actual reading of the mid-ordinate. This will apply whether the track is a level, ascending, or descending grade.

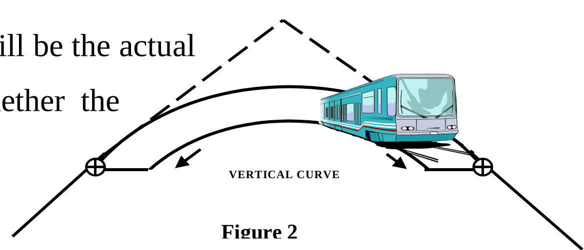


Figure 2

One of these dips or humps may develop on both rails at points approximately opposite each other. Should this happen, moving trains will be affected in much the same way that they are by runoffs.

- The extent of the irregularity and the speed of trains will determine whether the condition is serious.

If such an irregularity in the track surface appears on one rail only, its influence on trains may be quite different.

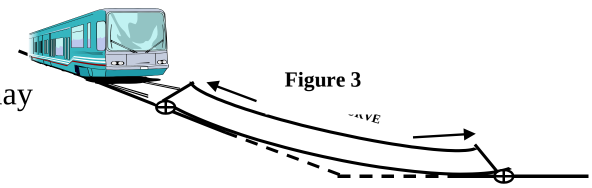


Figure 3

- Such a condition is not nearly as likely to cause a parting of locked couplers.

It may start a rocking action in various types of cars. This can be the source of a different type of hazard.

D. Grades

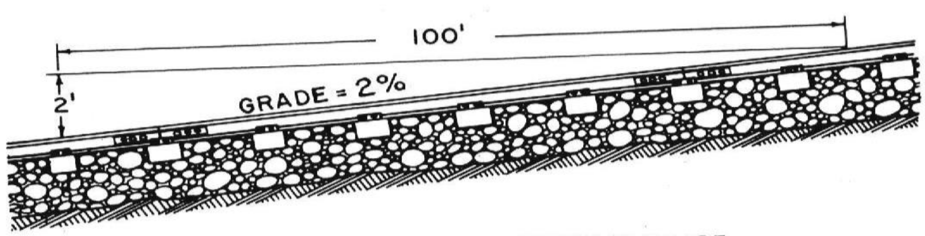
Since the subject of grades has been introduced, it would be well at this point to find out how grades are rated.

A system of measurement is needed because the sternness of the grades on a route can determine how much tonnage a train can haul.

The system which is used to measure grades is based on a length of track 100 foot long. The information needed to determine the grade of a track is the amount of vertical rise in a 100-foot length of track.

• If the track rises two feet in a 100-foot length, it is a two percent grade. (2% grade)

• If it rises 6 inches (0.5 feet), per 100 feet, the grade is 0.5 percent.



DETERMINING PERCENT OF GRADE

E. Cross Level

The remaining standards for track surface are all related to the cross level of the track.

- Cross level is the difference in height between the two rails of a track at points directly opposite each other.

Cross level is usually determined by the use of a cross level or multi-gauge.

To read cross level, the fixed foot is placed on top of the railhead believed to be higher. The adjustable foot is placed on the opposite rail.

The cross level is then adjusted until the bubble is centered with both feet still on the railheads. This is the difference in height of the rails. The scale is normally marked in inches. Fractions can be read to the nearest one-sixteenth inch.

- Sometimes it will be found that the rail assumed to be higher was actually the lower one. In such cases, it will be necessary to reverse the cross level in order to get a reading.

On tangent track, both rails should be the same height. This is zero cross level.

F. Elevation

MARTA and FRA standards specify the amount of superelevation required on curves.

- Superelevation, commonly referred to as elevation, is the cross level on curves which have the outer rail raised above the inner rail.

This amount varies with the degree of curvature and the speed permitted on the track.

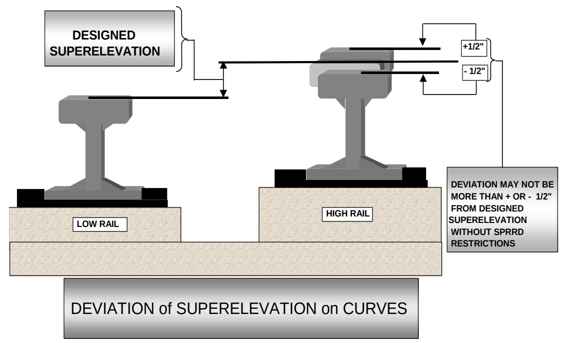
- The FRA specifications for elevation are given in the following table taken from Appendix A of the Track Safety Standards, Subpart A to F, Class of Track 1-5.
- MARTA design standards are set in the **TRACK CHARTS** and can be found for any curve on the system.

A railroad or transit may use this table or it may prefer to use a different one. If a different one is used, it must provide for slower speeds for any combination of degree of curvature and elevation. Higher speeds are not permitted.

G. Effects of Irregular Cross Level

Before proceeding further with the requirements of MARTA or the FRA Standards, it is necessary to have an understanding of the effects of a change in cross level.

- This can best be done by examining some of the things that happen to equipment on track with cross level changes.



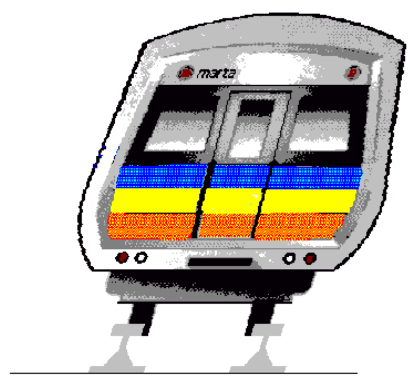
1. Low rail joints

The examples which will be used will be based upon a transit car. The first example will be based upon a low spot on one rail. This low spot will be rather short in length, possibly in the vicinity of one rail joint.

The track is assumed to be tangent.

A cross level indicates this spot to be one inch low. A 62-foot string placed on the rail with the low spot also shows it to be one inch low.

- The transit car is placed on this track with one truck directly over the low spot.



Since the track is not level, the truck is leaning. The side bearings between this truck and the car body have minimum clearance.

- This causes the car body to tilt.

The height of the car is considerably greater than the distance between rails. Because of this, the one inch variation in cross level causes the top of the car to tilt about three inches to one side. (this is a 3 to 1 ratio)

2. Twist

At the same time, the other truck under this car is on level track. That end of the car body is also level.

- This means that the car body is twisted.

The example just described applies to a car that is not moving. Now, consider what happens to the same car when it moves over the same low spot in the track.

As the leading truck moves onto the low spot, the wheels on that rail dip. Since the change in cross level takes place rather abruptly, the tilting of the car body occurs quickly.

- This brings a considerable amount of weight into motion.

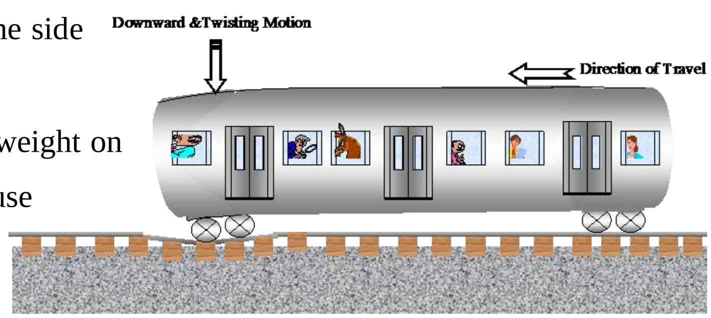
It is now pivoting about the wheels on the rail with the low spot. Some restraining force is needed to stop the roll of the car body.

- This force is in the truck springs.

At the point where the maximum tilt or roll occurs, the top of the car body has moved a greater distance than it did when it was on the same low spot, with the car at rest.

At the same time, the truck springs on the side to which the car rolled are compressed.

- There is greater than normal weight on the rails on this side because they are affected by the compressing of the truck springs.



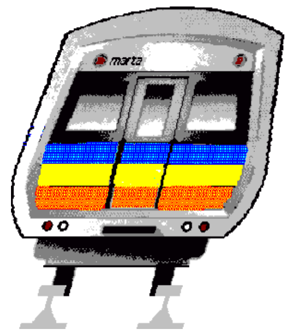
Correspondingly, there is a less than normal weight on the wheels on the opposite rail. All of this happens quite rapidly.

The car is continuing to move. In a fraction of a second, the wheels are coming out of the low spot, back to level track.

- This starts a rolling of the car body in the opposite direction.

This tendency is accelerated by the compressive forces in the car springs. The result is that the car body rolls past the center point in the opposite direction, and reverse forces come into action.

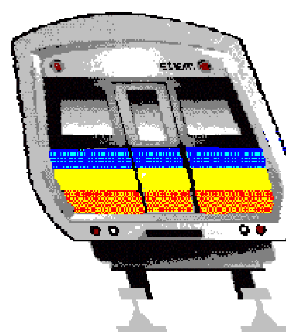
- If this is the only low spot, the car begins to settle down in the vicinity of this track.



While all this has been taking place, the trailing truck has been on level track.

- The car body has undergone a twist in one direction and then quickly twisted in the other direction.

Now the trailing truck of this car approaches the low spot. The entire sequence of events happens again at the other end of the car.



The severity of the car body rolling and of the forces involved depends on several things. They include

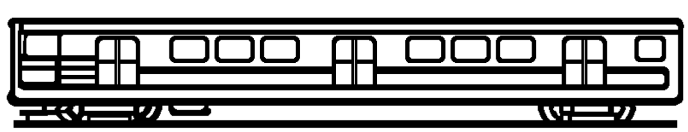
1. The dimensions of the surface defect.
2. The speed at which the car is moving.
3. The dimensions of the car.
4. The weight of the loaded car.

The average height of the car and load are known as the **center of gravity.**

3. Multiple low spots

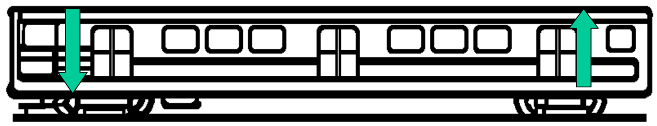
Suppose, that instead of one low spot in the track structure there are two similar low spots. These low spots are on opposite rails.

- The distance between them happens to be about the same as the distance between trucks of the transit car.



As this car moves over this track, at one point in the sequence of events, opposite ends of the car are trying to roll in opposite directions.

Suppose, also, that this car is relatively stiff and cannot twist very much. It is difficult to say which way the car will go.



It will probably be influenced by the way in which it was tending to rock just before the trucks arrived at these two low spots. The manner in which the car is loaded might have some effect. What could happen is that the car is not fully able to bend to the shape of the track surface.

This can result in a loss of contact between the wheels on one of the low spots and the railhead.

- This would be a momentary situation.

If the track is tangent, wheel contact with the railhead will probably be re-established in a fraction of a second, and this incident will not be noticed.

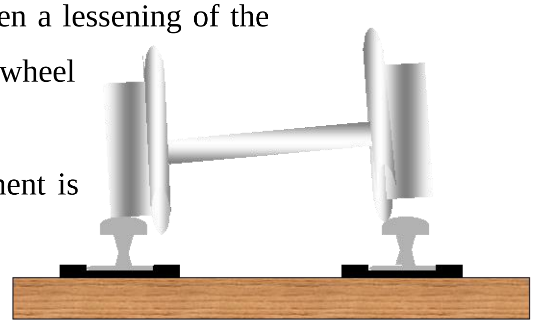
4. Loss of wheel contact

But suppose that this occurs on a curve, and that the loss of contact takes place on the outer rail.

- This rail has been guiding the wheels on a curved route by means of a lateral push against the wheel flanges.

This momentary loss of rail-wheel contact, or even a lessening of the vertical wheel load on the rail, can permit a wheel flange to begin climbing onto the railhead.

- Once this happens, the risk of derailment is very high.



This is only one of the ways in which track surface defects can cause a derailment. Assume that there is a series of low joints or low spots on both rails. Assume that the distance between the trucks on the transit car is about the same length of the rails.

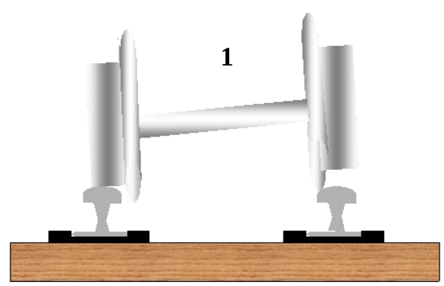
- This means that both trucks will be on low spots on the same rail at the same time.

The entire car body will roll to that side. There will be no twisting of the car body. As the car moved beyond these two low joints, it begins to roll in the opposite direction. Even if there are no more low spots, we know that the car body is going to tend to roll past center.

But as the car moves a half rail length, both trucks come to low spots on the opposite rail. Depending on the design of the car and the speed at which it is moving, the reverse roll from the recovery from the previous situation may occur, just as the car responds to a second set of low spots.

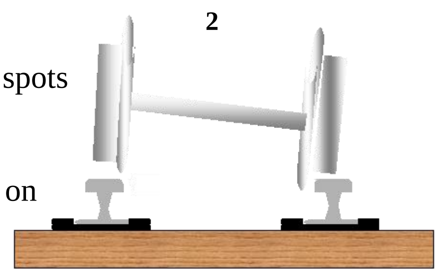
5. Harmonic rocking

1



These two forces combine cause a more violent rolling action. This is called **harmonic rocking.** Given such conditions and a continuing series of low joints, this rocking will continue and probably become more violent. Under such conditions wheel lifts occur in many cases. As in figures 1, 2 and 3.

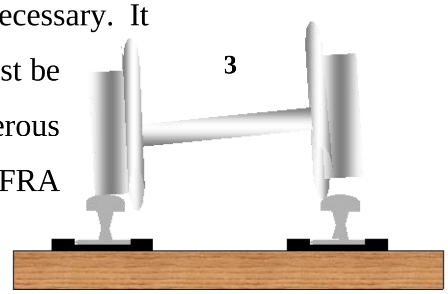
2



They illustrate the rocking a transit car can do between low spots in the track surface.

- Again, there is greater danger on curves than on tangents, but derailment can take place on tangents as well.

The foregoing descriptions illustrate just two of the ways in which changes in cross level can cause derailments. It would be possible to get into more complex situations where derailments can occur, but it is not necessary. It should be evident by now that a great deal of attention must be given to changes in cross level in order to avoid dangerous situations. It is because of this that the MARTA and the FRA has not one, but several sets of standards to cover cross level defects.



H. Runoff of Elevation in Spirals

Attention has already been called to the desirability of the rails being level in relation to each other on tangents.

The need for the outer rail on curves to be elevated above the inner rail in many cases has also been discussed.

- The change from zero elevation to the elevation required for curves has not yet been examined.

It has been shown that abrupt changes in cross level can seriously affect the ability of trains to operate without risk of derailment.

This necessitates a gradual change in cross level at the ends of curves with elevation. In another module, the need for spirals at the ends of curves to meet alignment requirements was discussed.

Spirals are also valuable from the standpoint of track surface. They provide space for a gradual runoff of the elevation which is needed for the body of the curve.

Transits may designate the maximum rate at which elevation can be runoff.

- This is usually based on increments of 31 feet.

This may provide for different allowances for various speed ranges. For instance, a certain transit or railroad may have a standard which says that for speeds up to 50 mph, elevation may be runoff at a rate up to one half inch per 31 feet.

To apply this, you would have to determine the length of the spiral and the elevation of the body of the curve. You may find that the spiral is of the proper length to runoff the elevation at this rate. For example, if the elevation of the curve is 2-1/2 inches and the length of the spiral is 155 feet, the one half inch per 31 feet will work out properly.

1. MARTA spirals

At MARTA runoffs for curves are pre-determined by the MARTA engineers when the system was built. Looking in the track charts you will find how long each spiral is for every curve. Divide the **Length of Spiral (Ls)** by the number of ¼ inch increments in elevation.

Let us say that the Length of Spiral is 453 feet, there is 4-1/2 inches of elevation in the curve. There are 4, ¼ inches in every inch.

Then the math is easy. 453 (feet) divided by 18 (There are 18, ¼" in 4-1/2" of elevation) = 25.1 feet of runoff per quarter inch of elevation.

1t is more likely that the length of the spiral will be either more or less than needed to fit the increments of runoff. Such conditions are covered by the following statement from the FRA Standards Subpart A-F, Class of Track 1-5:

2. § 213.59 Elevation of curved track; runoff. (F.R.A.)

(a) If a curve is elevated, the full elevation shall be provided throughout the curve, unless physical conditions do not permit. If elevation runoff occurs in a curve, the actual minimum elevation shall be used in computing the maximum allowable operating speed for that curve under §213.57(b).

(b) Elevation runoff shall be at a uniform rate, within the limits of track surface deviation prescribed in §213.63, and it shall extend at least the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.

3. Spiral lengths

If the spiral is longer than the minimum needed for a complete runoff, the increments per 31 feet are to be reduced so that the full spiral is used for the elevation runoff.

- Uniform increments are also required.
- Avoid using one half inch increments for part of the spiral and one fourth inch increments per 31 feet for the balance of the spiral.
- Average it out.

If the spiral is not long enough to accommodate the runoff at the specified rate, then the elevation runoff must be started from the point where full curvature begins. The increments are to be reduced through the length of the spiral and extended onto the tangent until the zero point is reached.

Using the example previously given of one half inch per 31-foot increment, with a maximum elevation in the curve of 2-1/2 inches.

- Suppose the length of the spiral was found to be 110 feet.

It has been seen that 155 feet is needed for this elevation runoff. In this case, the point of zero elevation would be on the tangent 45 feet ahead of the beginning of the spiral.

I. Variation in Cross Level on Tangents and Curves

Since it is possible to pick many combinations of two points in any 62-foot length of track, a great many differences in cross level can be read.

- What is needed is to find the maximum difference.

This means finding the maximum cross level reading and the minimum cross level reading on a curve. These readings are subtracted in order to find the difference.

- The distance between two points could conceivably be rather close or it could be any distance up to but not including 62 feet.

In the case of tangents, finding the difference could be somewhat confusing. Suppose that you find a situation within the 62-foot limit where the cross level varies from one half inch (with the north rail low), to 1-5/8 inches (with the north rail low). The difference in cross level is 1-1/8 inches (1-5/8" minus 1/2").

Next, assume that you find a situation which varies from one half inch (with the north rail low), to 1-5/8" (with the south rail low). In this case, the difference in cross level is 2-1/8 inches (1-5/8" plus 1/2").

Example 1:

A 5° curve, with a designated elevation of 2-1/2 inches, has an authorized speed of 40 mph. At one point in this curve the elevation is found to be 1-1/2 inches.

- At another point 20 feet away, the elevation is found to be 3-3/4 inches.

You must determine whether this condition conforms to the MARTA and/or FRA standards. First, you should recognize from the speed limit that this is Class 3 track. The permitted deviation from designated elevation is 1-3/4 inches.

- The first point has a deviation of 1 inch (2-1/2" minus 1-1/2").
- The second point has a deviation of 1-1/4 inches (3-3/4" minus 2-1/2").

These are both within the allowable deviation from designated elevation.

- However, these points are less than 62 feet apart, and the difference in cross level must be considered.
- The difference is 2-1/4 inches (3-3/4" minus 1-1/2").

The maximum permitted for Class 3 track is 1-3/4 inches. Class 3 speeds are not permitted. Actually, this exceeds the 2-inch limit for Class 2 track. Speed must be reduced to Class 1 limits until the condition is corrected.

Example 2:

A certain Class 4 track has a 3° 30' curve with 3 inches of elevation. Cross level readings taken at successive 39-foot intervals are as follows:

3"	2"
2-5/8"	2-1/2"
2-1/8"	3-1/8"
1-3/8"	

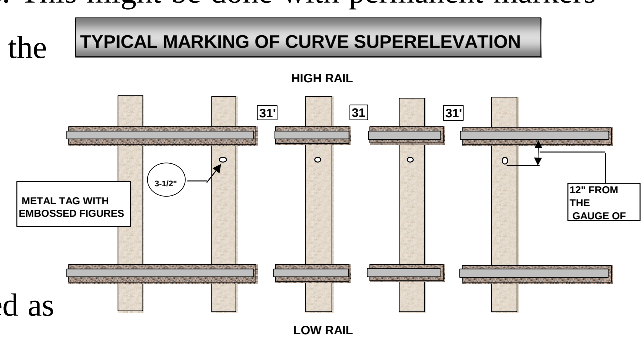
All of these readings are within the allowable 1-1/4 inch between two points, less than 62 feet apart. However, the l-3/8 inch reading is 1-5/8 inches less than the designated 3-inch elevation.

- This exceeds the permitted deviation from designated elevation of 1-1/ 4 inches.

Speed must be reduced to Class 3 limits which permit a deviation of 1-3/4 inches, until the condition is corrected.

J. Marking Spirals and Elevation

It is the practice on some railroads or transits to mark the location of each end of each spiral, at least in the more important tracks. This might be done with permanent markers permanently embedded in the ballast or in the second pour.



In other cases the identification might be in the form of markings on the rail web. This procedure would have to be considered as somewhat temporary.

Another procedure, sometimes employed, is to affix metal tags to the ties closest to these points. These tags can have the advantage of identifying the amount of elevation required at that particular point.

This procedure can also be used to indicate the proper elevation at each 31-foot interval within the spiral.

K. Inspecting Track for Surface Defects

Many Track Maintainers have responsibilities for locating track defects within an assigned territory. Usually, the territory assigned is extensive enough to make it impracticable to make the necessary measurements and calculations to positively identify all track surface irregularities without using the engineering signs that are located every 100 to 300 feet wayside.

The experienced Track Maintainers relies on various observations and on knowledge of the territory. When a condition looks questionable, stop and check it with a cross level and, if necessary, with a string.

- Occasionally, a train ride over your territory can help in feeling any rough spots. These points can then be checked later on the ground.

Time may be set aside for walking inspections. This affords an opportunity to get down and sight the rail, looking for irregularities.

- Suspicious spots can then be measured to establish the severity of the defect..

The Track Foreman may know of conditions within the territory that requires a close check at regular intervals.

For example:

- It may be an unstable roadbed condition.
- A stretch of track with a troublesome rail joint condition may need watching.
- Another area may have a history of frost heaving in cold weather.
- Also keep an eye on a muddy ballast situation and its effects on surface.

Knowing that the surface is more likely to cause problems on curves than tangents, arrange to make a detailed cross level check of one or two curves, each time a walking inspection is made.

- Since the spirals are the most critical points, give these areas the most careful inspection.

Experience is an important factor in a pattern of inspection such as the one just described. This does not mean that it takes many years to acquire such experience. Someone with a desire to learn and a willingness to work at it, can become a competent inspector of surface defects in a reasonably short amount of time.

Close observations paired with frequent measurements will develop reasonable judgment as to the surface irregularities that may need further attention.

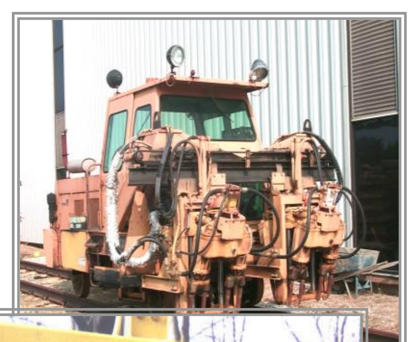
L. Correcting Surface Defects

The most common procedure for correcting defects in track surface is that of tamping. There are many ways in which a track can be tamped, but they all involve at least three essential operations:

1 . Jacking of one or both rails
2. Some means of referencing, to establish the desired location of the rails
3. Tamping or compacting ballast under the ties made loose by the rail jacking operation

1. Spot Tamping

One type of tamping procedure that is widely used is known as spot tamping. Spot tamping involves jacking the track just enough to remove a specific surface irregularity. Ties are then tamped through the portion of the track that has been jacked.



Spot tamping has several advantages.

- One of these is flexibility.

A spot-tamping operation may proceed with the intention of removing all noticeable irregularities in a stretch of track. The method may also be used only to correct those defects that are considered more critical. If the latter method is used more track can be covered in a day's work.

- Both methods have their place in maintenance operations.

There will probably be times when you, as a Track Maintainers will have to decide which one is proper for the circumstances. On other occasions, this may be a matter of policy, of which you will be informed by a supervisor.

Another advantage of spot tamping is that little or no additional ballast is needed to perform this type of tamping. This contributes to the economy of this type of work.

- It also minimizes the advance preparations, when the need to correct surface defects develops. The fact that this type of tamping usually requires less manpower and less equipment than other types of tamping, it also adds to its economy.

2. Spot surfacing track on a curve by hand

1. Pick out the low joint or spot by eye and mark the **grade rail** at two points that appear to be at proper elevation on either side of low spot.
2. The area between the two marks is the area to be raised. This could be possibly two to ten ties in length.
3. Place the track jack on field side of grade rail at low spot, sighting the top of the rail, raise the low rail with the jack until low spot is at the proper profile, then jack the track one or two notches higher. Next with cross level check the amount of elevation of the high rail and determine the required amount of elevation for this particular curve. If the high rail needs to be raised, place the track jack on field side of the high rail and jack to the required elevation. Tangent track requires zero cross level and again the cross level must be used.

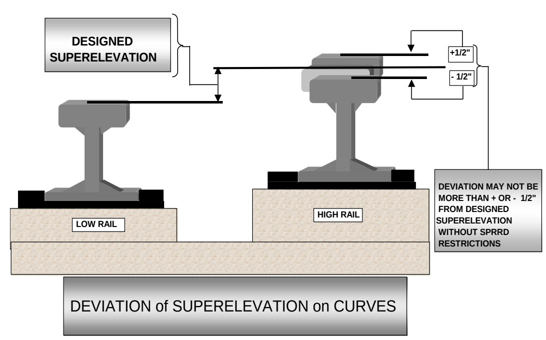
4. Clean out the ballast from edge of tie, and clean off any ballast between the tie plate and tie and/or the tie plate and the rail.
5. Nip up the tie(s) with a lining bar.
6. Tamp both ends of the tie(s) inside and outside of the rails. Ballast should be tamped solidly under rail bearing area of the tie.
7. If the low spot and area of tamping is in or near a joint, after tamping, tighten all the bolts in the joint.
8. All ties should be tamped in area marked on rail in Step #1 and all loose spikes driven or clips replaced where necessary.
9. Always check the gauge in area spot surfaced. If the gauge is wide or tight, corrective action must be taken.

Out of face raises are usually two (2) to three (3) inches. Raises in excess of three (3) inches will not be made unless authorized by the Director or Manager of Track & Structures.

The advantages of out of face surfacing are a better tie and ballast condition. This results in improved drainage and therefore, the surface will last longer.

3. Cross Level

Cross level is the difference in height between the two rails directly opposite each other. On tangent track, both rails should be the same height or zero cross level.



In the full body of curves it should correspond with the curve characteristics chart **(Track Charts)** for the elevation required.

In the spirals, it should correspond to the gradual increase or decrease in curvature throughout the spiral. To check cross level, the use of a cross level or cross level is required. To do this, set the cross level on the top of the rails, the end with the vertical scale on the low rail.

Adjust the cross level until the bubble indicates zero or centered with the bubble scale. Then, read the vertical scale for the amount of superelevation. The scale graduates in 1/16 inch increments.

MARTA and FRA states the difference in cross level between any two points less than sixty-two feet apart on tangents and curves between spirals may not be more than: Class I – 3 inches. Class II – 2 ¼ inches. Class III – 2 inches. Class IV – 1 ¾ inches. Class V – 1 ½ inches.

Since it is possible to pick many combinations of two points in any sixty-two feet, a great many differences in cross level can be read. What must be done is to find the maximum difference.

- That is finding the maximum cross level reading and the minimum cross level reading on a curve.

These readings are subtracted in order to find the difference. The distances between can range up to sixty-two feet.

M. HAND TAMPER (Electric) (JITTER BUGS)

Hand Electric Tie Tampers perform in an entirely different manner than other equipment used in track tamping operations, and for that reason this section has been prepared with the hope that the users of this type of equipment will carefully read and apply the suggestions contained herein.

The blow of the Electric Hand Tie Tamper is not percussive, or in one direction only, as is usual in other mechanical picks or tampers.

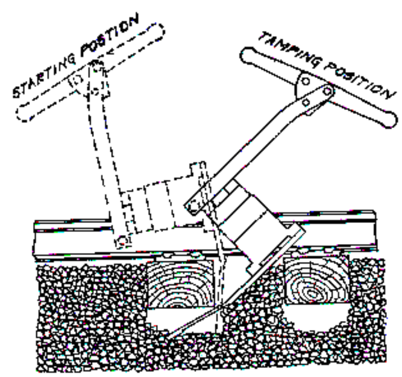
1. How they work

The reason for this is that the actuating element of the Hand Tie Tamper is an electric vibratory motor having a rotor shaft with a heavy unbalanced weigh mounted thereon, creating an impact force of 4500 vibrations per minute (VPM).

The heavy vibrations produced by the motor are controlled and directed through a tamping blade and tip of correct shape and size for the work to be done, which in turn transmits the vibratory blows to the ballast.
Since the vibratory action is produced by an unbalanced weight mounted on a shaft revolving at high speed, a very powerful forward and downward blow is obtained.

This is the tamping blow. Because the primary blow is produced by a revolving unbalanced element instead of a piston or reciprocating hammer, two secondary vibratory actions are produced. Their direction is in a horizontal plane at right angles to each other when the tamper is held in the starting position as outline in Figure 1.

Figure 1



In Figure 2, Arrow A represents the tamping blow, Arrow B the sideways vibratory action, and Arrow C the fluttering or fanning action of the blade which is in a horizontal direction when the Tamper is held in the Starting Position. Although almost vertical when the machine is held as drawn in Figure 2.

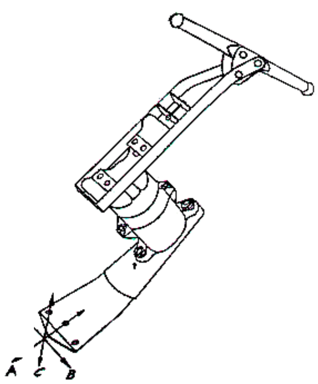


Figure 2

The two horizontal vibratory actions of the blade play a very important role that of keeping the surrounding ballast constantly in motion, feeding it to the end of the tamping blade so that the material is compacted progressively.

- They also prevent ballast particles underneath the tie from wedging, which would prohibit the forward or tamping blow from firmly consolidating them against already compacted or tamped ballast.

Thus, you can see that in constantly conveying ballast to the tip of the tamping blade, the two lesser vibratory actions account appreciably for the remarkable speed and efficiency of the Electric Hand Tamper.

To get the best results, the tamper should be handled sot that the tip or end of the blade goes down through the ballast alongside the tie. Then it works entirely underneath to the opposite side of the tie immediately below the rail in the first insertion, to ensure a free opening for the passage of ballast during subsequent tamping.

The tools is swung around or moved back and forth sideways to make an unobstructed opening for the new ballast which is to be tamped firmly underneath the tie.

- The method of making the first insertion is clearly illustrated in Figure 1.

As soon as the blade has passed underneath the tie, it should be withdrawn slightly to permit loose material to be worked forward by the two secondary vibratory actions.

This should be repeating until the entire space underneath has been filled by firmly compacted ballast integrally consolidated with the surrounding ballast.

- Should the ballast be wet or very angular and not have a tendency to flow, it may be necessary to withdraw the tamping blade entirely, allowing more ballast to flow underneath.
- But in doing so care should be exercised to prevent clogging of the opening by too much material before the tamping operation is completed.

When the tool **kicks back** and becomes difficult to hold, it is an indication that the ballast is tamped and that the Tamper should be moved to another location.

After the first insertion has been made directly under the rail, the tamping blade is moved out progressively to the end of the tie, or, in towards the center of the track, for the required distance.

- The tamping action is not confined to the ballast directly in front of the tip of the blade, but will extend radically to a considerable distance area adjacent to the point of contact with the ballast.

Riding the handle of the tamping tool retards its action. The motor should be permitted to vibrate freely for maximum power and length of stroke.

2. Penetrating fouled ballast

Penetration in fouled or badly cemented ballast is made much easier by inclining the handle of the tamper forward and away from the operator, as in Figure 3, at about the angle illustrated in of Figure 3.

- At this angle, the corner of the blade will quickly slice through or dig into the ballast.

Insertion should be made close to and alongside the tie as illustrated by of Figure 3.

Figure 3-A

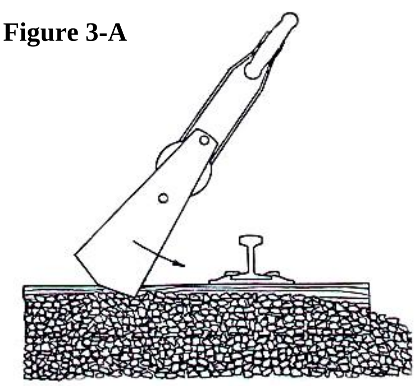
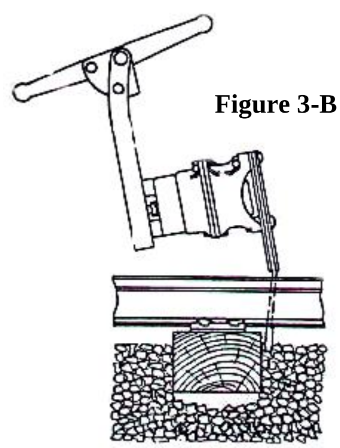


Figure 3-B



Striking proof and illustration of the efficiency of the Electric Hand Tamper can be obtained by removing a tie that has just been tamped.

- In rock ballast, for instance, it will be seen that the action of the Electric Hand Tamper has caused particles of ballast to fit together, making for a perfect bearing that assures uniform and smooth riding track.

The flat faces or surfaces of the ballast have been brought in close contact with the underside of the tie, so that the whole resembles mortar-less masonry.

Such results are impossible of achievement with tampers of the percussive blow type. Due largely to the fact that a percussive blow tamper has positive action in one direction only.

Its function thus limited to forcing a comparatively small amount of ballast under the tie until it is wedged between the tie and the ballast below

This wedging almost invariably takes place before the particle of ballast reaches the material on the other side of the tie from being tamped, so that considerable space underneath is not filled.

Therefore, a percussive tamper is not able to place the amount of ballast under the tie that is possible with the Hand Tamper.

The crib should be fairly full of ballast when Electric Hand Tampers are employed

- So that the material will fall in on the blades and be carried by the vibration to tamping position without completely withdrawing the tamping tool.

It is not necessary to dig out in order to insert the tamping blade under the edge of the tie.

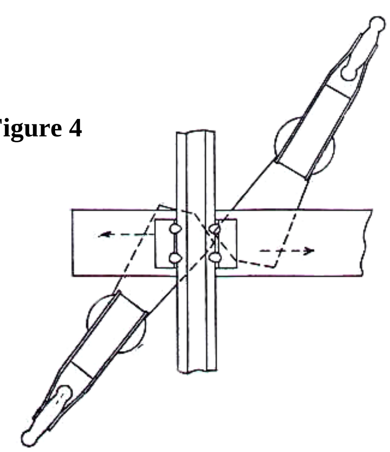
If the operator will place the blade alongside the tie at an angle, allowing the sideways vibratory action of the blade to force the tip under, as previously mentioned and illustrated in Figure 3A.

3. Cross tamping

Cross tamping (4 face) is the most effective method.

- It is done by starting with tampers diagonally opposite under the rail.
- The one outside the rail moving out progressively to the end of the tie, and the

Figure 4



tamper inside the rail moving toward the center of the tie for a distance of 12 to 18 inches, as illustrated in Figure 4.

In this system, ballast is solidly placed against the undisturbed old shoulder on the opposite side of the tie being tamped, thus preventing the tamping tool from forcing the ballast through into the adjacent crib.

Particular attention must be given to the selection and use of the proper blade and tip for the work, or character and kind of ballast.

Electric Hand Tie Tampers will successfully and economically tamp any kind of ballast encountered, when equipped with the proper blade.

- These blades and their uses are illustrated and explained further on in this section.

The vibratory motor of the Tamper will run in either direction. And the motor lead connector should be plugged into the **wye** cable lead, as explained under the heading **Tamping Blades**, so that the blade of each machine will have a tendency to travel or work toward the rail whether the machine is on the inside or outside.

4. Track surfacing methods

It is important that the proper blade with a tip of correct thickness be used in order to obtain best results.

- As explained in the succeeding pages, blades and tips are provided for every kind of ballast.

While the size of the ballast is the principal governing factor in the selection of blades, the amount of lift or raise given the track is of nearly equal importance.

- Wider blades and thicker tips may be used where the raise is 3 inches or more.

Cross tamping (4 face) is the most satisfactory method where Hand Tampers are used.

- By this method, the ballast is tamped against the old shoulder on the opposite side of the tie, filling up and building the tip bed there from until the space underneath the tie is completely filled, making it unnecessary as well as undesirable to tamp the opposite space.

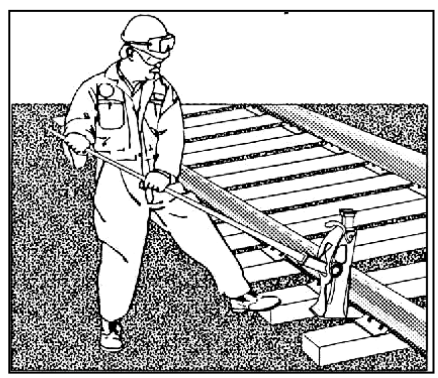
5. Multiple Jack Method

The work of tamping is made a great deal easier and much more uniform by using eight or more jacks to raise the track..

Tie renewals may also be made at the same time, thus avoiding additional raises or lifts.

The number of jacks used is determined by the quantity of ties to be renewed and the size of the gang.

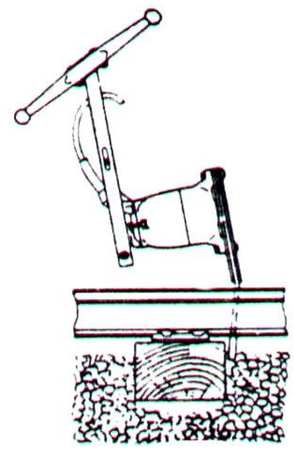
- It has been found that eight is the minimum for satisfactory operation, even in small gangs.
- Where eight or more jacks are used they should be spaced about 4 ties apart.
- The lead pair are operated as equalizers to take out any sags or humps in the rail.
- The second pair of jacks are the raising jacks, and the section of rail carried by them should be brought to the predetermined height.



Jacks are left in the track until tamped off by the Tampers, the rear ones then being carried forward to become the first pair.

- Not only is the work made easier because the ties do not have to be double tamped, but a much more uniform surface can be held, with settling compensation for or corrected by the jacks when left in during the tamping operation.

A run-off is quickly prepared when the Multiple Jack Method is employed by simply shoveling a small amount of ballast underneath each tie and dropping the jacks.



Subsequent picking up permits the Tampers to proceed normally, all ties having been uniformly tamped.

It has not been found practical to hand tamp joints or jack ties ahead of the Tampers as the work is never uniform and there is a tendency for the track to settle at these points.

6. Tamping Blades

Electric Hand Tie Tampers are successfully and economically used in any kind of ballast material.

The various types of blades are described on the following pages.

- They are equipped with renewable tips attached to the blade by cold rivets, which may be renewed without removing the blade from the Tamper or sending it into the shop.

Tamping tips should be renewed when they become thin and rounded, and tend to pass through the ballast.

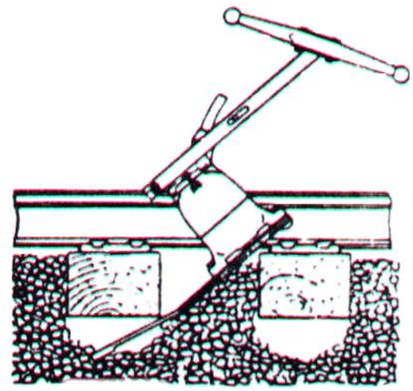
The sideways travel of the tamping blade in one direction is caused by the direction in which the unbalanced weight revolves in the tamper motor.

When it is necessary to have the Tamper operate the opposite way, the direction may be reversed by simply disconnecting the plug connector on the motor lead from the wye connector and turning the motor plug half over before reconnecting.

- This puts the electric current through the Tamper motor in an opposite direction, thereby causing the motor to run likewise.

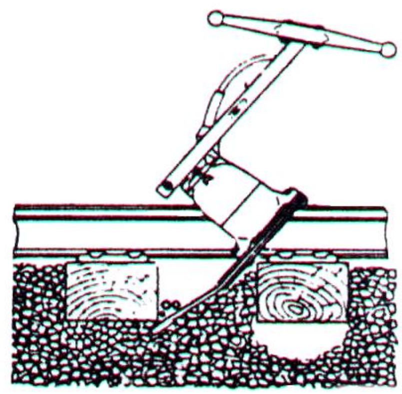
7. Cross tie tamping in three easy steps:

1. Penetration to the void under the tie is quick, the tamper is tipped to a vertical position, and powerful side and chopping actions combine to drive the step-cut blade into position.
2. The under-tie void is enlarged by tipping the tamper away from the tie. Simultaneously moving the blade from side to side, while vibratory action puts the ballast into motion. The under-tie void is then ready for ballast insertion.



Additional back and forth movement of the tamper lets powerful high frequency vibration place in motion ballast under the tie, consolidating the material to proper density.

The operator then **walks** the vibrating tamper to the next tie with no lifting.



N. Skin Lifts

A tamping procedure which attained considerable popularity with the development of the modern tamping machines is usually referred to as the **skin lift.**

This procedure involves making a general raise of the track. In the process, irregularities in surface are removed.

The general raise is usually one inch or less.

This amount will be greater in the areas in which low spots exist. General raises of the track structure, regardless of the amount of raise, are frequently called **out-of-face raises.**

One of the principal advantages of the skin lift is that every tie is tamped.

- This permits uniform compaction of ballast under each tie.
- If settlement occurs under traffic, it should be relatively uniform.

This contrasts with the situation that exists in track that has been spot tamped. Some ties will be on an undisturbed bed, and some will be on newly tamped ballast with different compaction, following a spot-tamping job. It is entirely possible that there may be a few loose ties if the wrong locations were selected to begin and end tamping.

Unless there is an excess of ballast in the track, it is usually necessary to provide additional ballast in advance of a skin lift.

- A light application of ballast will be sufficient, if the need is to maintain a similar ballast section to the one that existed prior to the raise.

To obtain maximum efficiency, equipment capable of shaping and leveling the ballast section should be used in this type of tamping operation. Correction of alignment is usually done when skin-lift tamping.

This may be done by a tamper with track-lining capabilities, or by a separate lining machine. In many cases, two tampers are used in this operation. The lead tamper may have jacking and surface referencing equipment.
If so, this machine will bring the track to proper surface, tamping every other tie. The second tamper will then tamp the alternate ties.

The need for additional ballast, and the additional equipment and manpower required, increases the cost of a skin lift over spot tamping.

- The advantages of a skin lift over spot tamping are quality, uniformity, and usually longer lasting results.

O. Higher Raises

Prior to the development of tamping machines with the capability of effectively compacting ballast with only a small opening under the tie, most out-of-face track raises involved a more substantial lift.

The popularity of the skin-lift has reduced the frequency where such higher raises are made.

- There are still times when a raise of several inches is desirable.

When ballast becomes fouled with foreign material and drainage is impaired, a general track raise that will result in clean ballast under the ties will help considerably. The restored track surface will last longer because of improved drainage around the ties.

Raises of this type require considerably more ballast than skin lifts. Tamping productivity will be somewhat less than that which is attainable with skin lifts. This is because of the greater volume of ballast that must be compacted under each tie.

Equipment and manpower requirements for such an operation are usually similar to those used in skin-lift tamping. Factors which increase costs are the additional ballast and the additional time it takes to tamp track.

1. Surfacing Track With the Plasser 08-32

The 08-32-4S is a fully automatic tamping machine. It uses the latest technologies to surface, line, crosslevel and tamp tangents, curves and switches.

Through the use of an on board computer and Plasser American Corporation's AGGS program the 08-32 can be a useful tool in the upkeep and maintenance of track structure.

Equipped with the AGGS computer program the 08-32 can also be fitted with a separate gauge measuring buggy for measuring and recording of track gauge.

The tamping is carried out with split double tie tamping units that are traversable and each may be lowered independently to allow for tamping around objects in the track giving the most complete job possible and prevent center binding of the ties.

Probably the most important factor in producing good track is the correct amount of lift for the conditions of the track and the amount of ballast.

- If the track is lifted too high for the ballast, the places with insufficient ballast will settle the most under traffic, leaving a low spot or sag.
- If the lift is not enough for the irregularity of the surface of the track being tamped, the surface behind the machine will not be completely satisfactory.

A good way to determine this is to watch the lift indicator lights or gauges; they should indicate when the machine is moved forward to the next tie every time. If it is noticed that one or both of the lights or gauges fail to light up for several ties, the lift definitely is not enough and should be slowly increased.

Some types of ballast are extremely hard to penetrate, and if there is a noticeable increase in the time it takes the tamping units to reach full tamping depth, the lift should be increased slowly.

In most conditions a lift of 1¼" to 1¾" is ideal, and usually one insertion per tie with one second of squeeze time will properly compact the ballast under the tie.

- If the tamping tools squeeze against down ties and they fail to come up, then another insertion should be made.
- For lifts of 2", two insertions may be necessary. Minimum lift should be greater than any crosslevel errors in front of the machine.

The top of the blade of the tamping tool must always be just below the bottom of the tie (approximately ½") when tamping.

- It is preferred that the ballast be removed from each side of a full or new tie, in order to visually check the depth of the tamping tools at insertion.

The **zero** of the depth code switch is considered to be when the top of the tamping tool blade is ½" below the top of the rail, to allow for the clearance specified in the previous paragraph.

All Plasser equipment always had the main lift by a spindle on the lead buggy that adjusted the front of the lift cable.

- Because such a spindle adjusted the leading reference point, the ratio for raising the track was '1 to1' (a 2" required lift would call for a 2" displacement of the spindle,).

Remember, all cab lift entries are referenced to the curve buggy, which is the lead buggy under the front of the machine. Lift can also be guided by an on board computer generated signal (AGGS).

For cab lift, it will only be necessary to turn the automatic lift switch on, set the zero point controls as outlined in the following zeroing procedure and manipulate the lift preset code switches.

Should work be interrupted temporarily, a short run-out may be made.

- This should only be allowed if the speed of traffic is slow, and preferably, a low lift is being made.

The last tie tamped should be marked, and when it is reached simply turn off the lift, line, and crosslevel systems.

- The remaining ties in the ramp to the undisturbed track should be tamped, with the rollers and hooks open.

The following procedure will give an example of how the cab lift controls can be used to remove a long sag in the track.

Assume that a low spot is coming up in front of the machine, estimated to be 2 inches lower than the rest of the track structure. This point is "B". From the beginning of the sag (point "A") to point "B" is 100 ties.

- The sag bottoms out and at point "C" starts back up to point "D", in 50 ties, where it is back in grade. We are lifting 1 ¼" before we get to the sag.
- When the curve buggy reaches the beginning of the sag (point "A"), with the lift preset code switch already set on 125.
- Start increasing the lift preset at a rate of "002" per tie (2 inch lift change over 100 ties).
- This change should be complete when the curve buggy reaches point "B", the lowest spot.
- If the sag stays bottomed out keep the new lift setting until the curve buggy reaches point "C".
- When the curve buggy reaches point "C" start decreasing the lift "004" per tie (2 inch lift change over 50 ties).
- When the lift preset code switch is back on "125" continue tamping until the rear buggy is sufficiently past the sag.

If conditions warrant it, the operator will need to change to double insertion to maintain the lift and crosslevel.

The first step in marking off a curve is to locate and identify the two points associated with each spiral, a term associated with the line of a curve.

- Zero elevation will coincide with the "TS" (tangent spiral) point and the full elevation will coincide with the "SC" (spiral curve) point.
- Elevation changes will be made over the length of the spiral at a consistent rate.

The usual procedure when marking off a spiral for elevation is to identify and mark stations, which almost always are in ¼" increments.

- These stations provide checkpoints for a machine tamping the curve and the crew responsible for checking the curve geometry at a later date.

There are two ways to control crosslevel changes, manually and through the AGGS computer.

- For manual operation, turn the crosslevel reference switch to the grade rail (low rail) position, and manipulate the crosslevel preset code switch to read the elevation value. When tamping a spiral, manipulate the crosslevel preset code switch at a linear rate.
- The reference point for elevation is always the lining buggy.

Anytime a machine is first set-up for tamping, a check should be made that the lining indicator is at, or close to, a zero reading.

- Should the indicator not be close to center, make sure that the lining buggy fork is on the lining cable and that all buggies are shifted to the proper rail.
- Also, insure that the curve buggy spindle is at the zero mark, if no work warranting movement is in progress..

Should a line swing exist or engineering stake work is in progress, the indicator may not be close to center, and this should be explained to the operator.

P. Manual Tamping

Before the development of mechanical tampers, the manual tamping of ties required a tremendous amount of labor. Because modern tamping machines are highly productive, their use is widespread. Yet, there will continue to be frequent situations in which manual methods will be used to surface the track.

Sometimes, there is a need for a small spot-surfacing job that does not justify moving a tamping machine a considerable distance to correct. In other situations, the urgency of the condition may require immediate corrective action. High density traffic may preclude the use of on-track equipment for operations such as spot tamping.

This type of tamping requires a jack, lining bar and a fork.

Place the jack in the low spot and slowly jack up the track until the dip has been removed. Once the surface is smooth continue to raise the track another notch or two.

- Since the track will settle considerably once the jack is removed and train traffic resumes, it is advisable to produce a small hump in the track at that area.

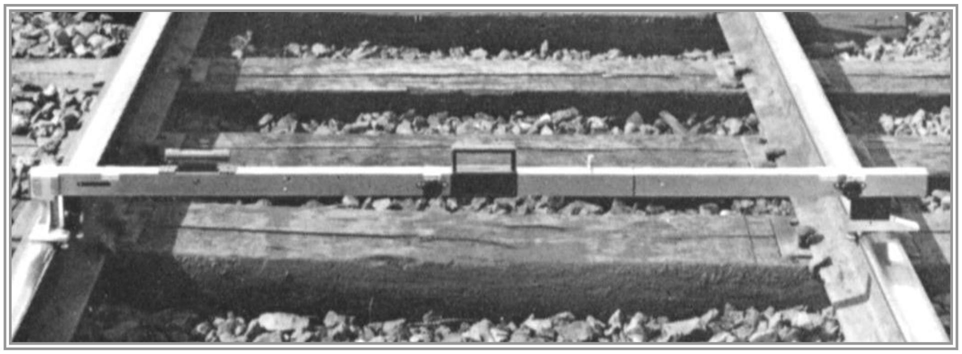
Dig out the ballast on each side of the tie until you can see the bottom of the tie.

- Once the bottom has been reached start packing ballast into the hole that is under the tie with a ballast fork.
- Always remember to push the ballast toward the area under the rail first then fill the rest of the void.
- Once both the inside and outside cribs have been tamped (from both sides of the tie) in this manner move to the next tie and repeat the process.
- When you get to a tie with no void under it, shake the jack loose and check your work.

Q. Grade Rail

Whenever an out-of-face track raise is made, one rail is designated as the grade rail.

<u>Regardless of the means of referencing used, the grade rail is first brought to proper profile.</u>



The other rail is then brought to its proper position by use of a cross level. On curves, the low or inner rail is always the grade rail. A transit or railroad may or may not have a system of designating which rail is to be the grade rail on tangents. In any case, the use of a grade rail should be consistent throughout the length of the tangent.

As with alignment, it is best to use the rail that is under the train operators cab as your grade rail. This rail is also the same one used to line the track. By following this course the same rail is always used in surfacing track.

R. Manual Referencing - General Raise

Before discussing the mechanized methods of surfacing track, a brief explanation of the manual methods of sighting, jacking, and tamping is in order, as a machine is not always available when it is necessary to spot or surface an out-of-face short section of track.

Learning to manually raise track starts with the raising of a single joint or low spot. This area is brought up level and then another notch or two is given on the jack to allow for settlement after it has been tamped and a train has passed over it.

- The manual track raiser then moves on to spotting track and raising out-of-face with or without a spot board.

In spotting track, the cross level is used to check ahead to determine which rail is running high or where the high spots are located. The high rail is then used for the sighting rail, raising from high spot to high spot, providing just enough extra raise to allow for settlement. The cross level is used to bring the lower rail to the proper elevation.

You must learn how much to allow for settlement through practice and follow up checking of your work. The type of ballast and expertise of the people performing the tamping will govern the amount of settlement.

When spotting track, care must be exercised to maintain cross level. Track that is out of cross level will not ride satisfactorily at high speeds and will not retain its line; therefore, learning to maintain the cross level is of extreme importance.

Raising track out-of-face without grade stakes or the use of a spot board requires good eyesight and experience. As each rail is raised, it is used for sighting the next rail ahead. The levelness of the rail raised is projected ahead to the next rail and care must be exercised to avoid letting the track climb or get too high, or letting the rail drop, not allowing enough raise.

In order to carry a true surface for an indefinite distance by eye alone, it is necessary to be the right distance from the jack. This recommended distance is not closer than 1-1/2 to 2-1/2 rail lengths (39 ft. rails).

S. Surfacing tools

1. Spot Board

A more accurate way to produce a good surface by manual sighting is to use the spot board.

- The spot board is a sighting instrument used in manual surfacing operations.

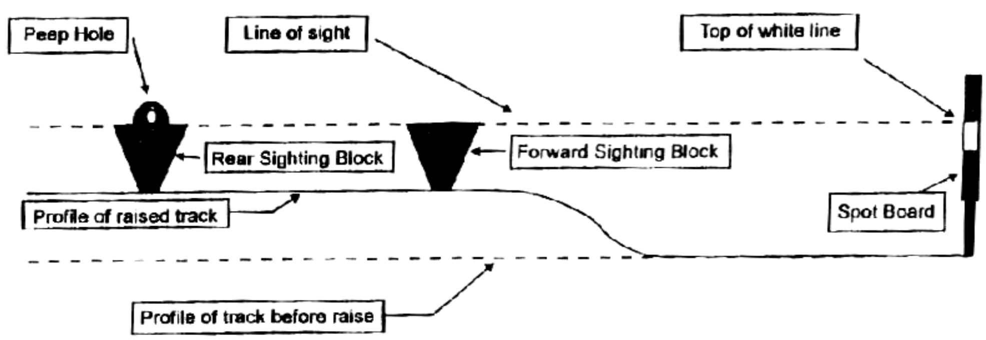
- The spot board increases the accuracy of surfacing operations when the desired new position is determined by eye.

The spot board is placed above and across the track at the proposed height to indicate the new surface and ensure its uniformity. The basic board is made of wood 1-1/8 inch thick, 8 inches wide and 12 foot long and is painted white, with a 2-inch wide dark-colored stripe centered on it and running the entire length.

Two sighting blocks are used with a spot board, which are of such height that when placed on top of the rail and adjacent to the spot board setting flush on the rail, their height will exactly coincide with the top of the dark stripe. The purpose, of course, is to sight across the two blocks to the top of the stripe.

A raise using a spot board should be started from a high point in the track. The spot board is placed ahead a distance of 150 to 250 ft. and is set above the railhead the desired raise that is to be made on the track.

- One sighting block is placed on the railhead at the tie that is to be jacked and tamped, and the person holding the other sighting block in his hand places it on top of the rail over a previously tamped tie.



The distance between the two blocks is approximately 1-1/2 rail lengths. The individual places his eye at the top of the sighting block and has the person with the jack will raise the track until the jack block shows slightly higher than the top of the spot board stripe.

The tie is then tamped and the jack and block moved to the next tie to be raised and tamped- When the raising is within approximately 50 foot of the spot board, the board should be moved and the same procedure repeated.

If when resetting the spot board, the line of sight hits the top of the stripe, raising may proceed. If the line of sight hits above the stripe, the spot board can be raised to it or the raise dropped to fit the board.

- If the spot board is located in a short dip in the track, it would be proper to raise the spot board to improve the general surface of the track.

However, if the spot board were set at a high spot, it would be better to drop the raise to meet the new setting of the board.

- If the line of sight falls below the stripe, the reverse procedure would apply, with possibly a change in grade by sighting to a lower point on the board.

When raising track around a curve, the spot board should be used on the low or inside rail.

- The high or outside rail is then brought to proper superelevation by use of the cross level.

Care should be taken to see that proper elevation is placed on the curve; you should never make any changes in the superelevation without first discussing it with the proper authority.

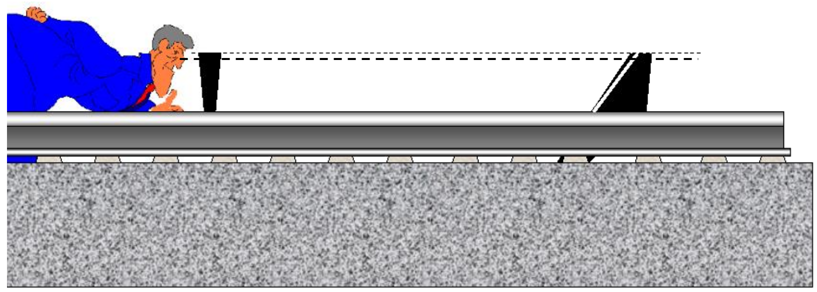
The spot board will provide grades of satisfactory accuracy on level track and on a uniformly ascending or descending grade.

- It also is quite useful in making runoffs at the start or end of a raise.

When working within the limits of vertical curves, the spot board is less accurate.

- If the vertical curve is a sag, raises will tend to be too high within its limits. If the vertical curve is a crest, the raises will tend to be too low.

The spot board may be adjusted either upward or downward to compensate for this tendency. You should sight the track in advance and mark the ends of vertical curves. In this way, you can adjust the spot board at the right points, rather than waiting until your raise gets out of control. The tendency towards such errors can also be lessened by shortening the distance from the point of jacking to the spot board.



2. RAILQUIP Rail-Level

New versatile Laser measuring tool system Rail-Level system.

It uses a laser beam as reference in two planes instead of unreliable steel wires or other equipment twice as expensive.

The Rail-Level system is based on the Laser Level, a product manufactured in large volumes which guaranties a low price and good reliability.

3. Rail-Level AU laser unit

This kit contains an adjustable support for the laser and a magnetic adapter that fits directly on top of the rail.

There is also a support for the horizontal position on the rail. The included target plate has the same type of magnetic adapter as the adjustable support. The target plate measures 14” x 11”. The target plate has a scale in inches for vertical and horizontal directions.

Rail-Level AU target

The center of the target is located on the same line as the laser beam in reference to the mount.

The target plate has a reflective background made of the same reflective material that are used on road signs. The laser unit is pointed towards the target plate. As soon as the beam hits the target plate it will become clearly visible.

- The reflex from the target can be seen from distances over 300 feet.
- The center of the target is marked with a black dot.

When the laser beam is correctly adjusted to the center the reflex will disappear.

Rail-Level AU function

a) The laser unit is mounted on top of the rail to be measured, approximately 30 feet ahead of the area to be measured or repaired.

b) The target plate is positioned on the same rail approximately 30 feet behind the area to be measured or repaired.

c) The laser unit is adjusted towards the center of the target plate by the adjustment screws.

d) The target plate is then moved to the positions where measurements needs to be done.

e) The position of the laser spot on the target is then measured in sideways and in height at the same time. This way you can measure each individual points position in reference to the laser beam.

Laser Level AU Contains:

- 1 Laser Level 300
- 1 Penta-prism
- 1 adjustable support
- 1 adapter with magnets
- 1 target plate (reflective back-ground)
- 1 target adapter with magnet
- All packed in a heavy duty case.

3. Rail-Level INS

Rail-Level INS is especially for people doing railroad inspection but it can also be used for many other applications by all type of personnel.

Applications

- Straight measurements vertical & horizontal.
- Measuring angularity on turnout switch tongue.
- Other measurements such as platforms, etc.

Advantages

Defects on the rail that earlier only could be noticed can now very easily be measured. With the help of this very simple but accurate measuring-device it is possible to measure straightness over a distance more then 300 feet single-handed.

- In a very convenient way it is possible to measure exactly if the rail is within or without its straightness tolerance.

Function 1

The Laser Level with its magnetic holder in front and its adjustment unit on the rear end is positioned 30 feet before the position is to be measured. The magnetic holder has a sideways reference stud that must be tight to the rail.

The target plate is positioned on top of the rail 30 feet away from the position to be measured. The reflective side must be turned towards the Laser Level.

Function 2

The laser is then adjusted towards the target plate. When the laser beam hits the target plate you will get a strong reflex. The beam is then adjusted against the black dot on the target plate. When the laser beam hits the back dot the reflex will disappear.

- Now you know that the system is aligned and ready for use.

Turn the target plate with the scale facing the Laser Level. Move the plate with the scale facing the Laser Level. Move the target plate to different locations along the rail and measure the vertical and horizontal error.

The Rail-Level INS generates a perfectly straight laser beam that can be used up to 300 feet in daylight. The Laser Level have built in horizontal and vertical vials.

- It is powered by 4 AA size batteries that will last for 35-40 hours.

This kit also contains a 90 degree penta prism that can be attached at the front end of the Laser Level. The prism can be attached at the front end of the Laser Level. This prism can be used to measure for example the position of the turnout switch tongue or anywhere else where a straight angle is required.

Advantages

- Versatile
- Easy to use
- Accurate
- Vertical and horizontal position at the same time.
- Affordable

T. Mechanical Referencing

1. General Raise

The use of machinery to raise track requires that the track raiser or person in charge have the same talents as the person who uses the spot board. These skills must, of course, be learned and developed through practice; in addition to understanding the techniques involved, you must also understand the capabilities of the machine utilized.

The principles used in the operation of grade-referencing equipment on tamping equipment are very similar to a spot-board operation.

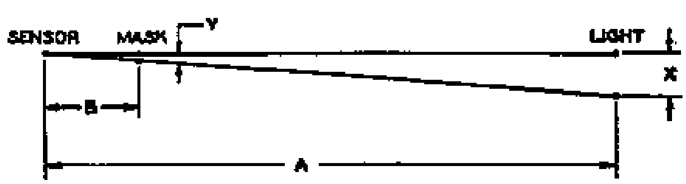
- Each manufacturer issues instructions covering the operation of his equipment.

Regardless of the device used, one rail is set up as the grade rail, and the other rail is brought to position by cross leveling.

- They all have similar tendencies on uniform grades, on runoffs and on vertical curves.

In most cases, the front reference point, corresponding to the spot board, moves constantly. Therefore, this reference point is sometimes on high spots and sometimes on low spots. This can introduce small errors. These are similar to those described in module about alignment, when lining equipment is used.

- Usually such errors are small enough to be negligible.



$Y = \frac{B}{A} \cdot X$

EFFECT OF TRACK ERRORS AT THE LIGHT

With the development of the mechanical tamper it became evident that the track foreman or maintainer needed a new way to speed up his work to realize the full capacity of the new tampers.

- To accelerate the raising of track, the first development was a tamping power jack.

These machines eliminated the need for many hand jacks, as they could raise the track and tamp one tie at each jacking point to hold the raise for the tampers.

Since the actual sighting for the raise by the tamping jack was still performed by the eye, the foreman still found it difficult to stay ahead of the tampers.

Further improvements were thus made in the tamping jack by adding a wire surfacing device; the wire placed on the foreman's or track maintainers line of sight.

- By putting the spot board and peep sight on wheels and using the power tamping jack for motive power, the track raising operation became mechanized.

Further development in equipment has resulted in machines in which a **moving spot board, peep sight,** located at the tie being tamped, and a **foreman's or track maintainers eye,** located behind the tie being tamped, are all built in the piece of equipment identified as a tamper.

- Most out-of-face surfacing or track raising jobs are now being performed with this equipment.

The spot board is a point of reference at a fixed distance in front of the tamper and is connected to it. This front reference point usually carries a light source, although with some systems it secures the front end of a wire that is also tied into reference points on the tamper.

The **peep sight** is located in the area of the tie being tamped and is actually a shadow-board or mask in the case of alight source system or a point of contact with the wire in a wire system.

The **foreman's eye** is in reality a receiver or bank of photocells in the case of alight source system or a rear tie point for the wire system, and is located approximately 10 to 15 feet behind the tie being tamped.

In all cases, with the machine adjusted for zero lift, all three points, which are referred directly to the top of the rail, are at the same height above the rail.

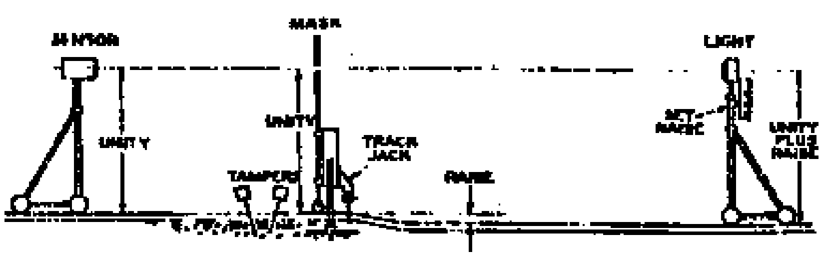
By either raising the front reference point or by lowering the measuring point **(peep sight area)** a raise can be made to the track.

2. Mechanical Surfacing

If the shadow-board or mask were lowered one-eighth inch and the rail is jacked until the shadow-board prevents the light from entering the receiver, the track will be raised one-eighth inch.

However, as the machine proceeds, further jacking the rail and tamping ties as it travels, the rear reference point (receiver) will be raised as it rides on the lifted track. This will cause an additional raise to be made.

- This procedure continues to take place in smaller increments, until after approximately 250 ft., a nominal one inch of raise will be made to the track.



The amount of raise operated by a fixed amount of change from **"0"** position of either the shadow-board or mask by raising the front reference point, is dependent on the distances between the three units:

1. front reference
2. measuring reference
3. rear reference.

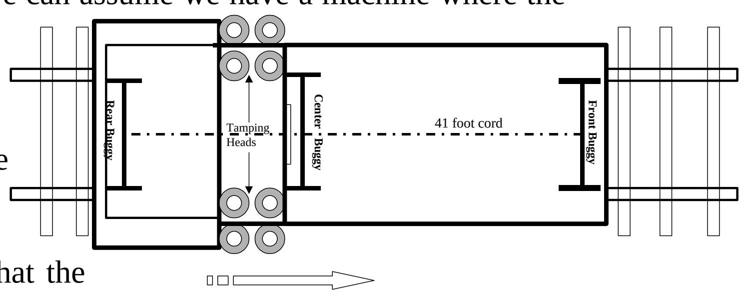
Manufacturers of the various machines deal with the specifics in their instruction manuals.

The actual raising of the track is done hydraulically, using rail clamps and hydraulic jack cylinders built on the tamping machine.

It is important to remember that the track behind the machine will be an exact reproduction of the surface grade rail in front of the machine; however, the error left in the track is directly dependent on the distance between the various measuring points.

- This is due to the fact that the front reference travels through the track error. The farther the front (spot board) is from the tie being tamped, the smaller the error remaining in the track. For maximum correction, jacking must take place at every tie.
- It should be noted here that cross level errors are always corrected, providing enough raise is being made to the surface rail, so that the cross level can be lifted to the level position.

To explain the above in more detail, we can assume we have a machine where the front reference point is 100 ft. in front of the tie being tamped and the rear reference point is 10 ft. behind the tie being tamped.



Plasser 08-32

- It should be remembered that the center point (the tie being tamped) is where the raise takes place.

With a machine of this type, if the front reference point traverses through a one-inch low spot, 100 ft. back at the tie being tamped, a low spot of one-eleventh of one-inch will be left in the surface of the track.

As the machine raises and tamps through the one-inch low spot the front reference has traversed, all of the low spot will be raised out of the track.

All raised track, whether hand tamped or machine tamped, will settle under train traffic. Therefore, allowance should be made when raising to compensate for the settlement.

- Machine tamped track will not settle the same amount its track that has been tamped by hand.

However, experience will soon determine the amount of over raise that should be provided to allow for settlement. It should be noted that the type of ballast, the type of machine and the condition of the tamping tools, along with the manufacturer's recommended machine adjustments, have an effect on the amount of settlement.

Of course, there must be sufficient ballast available for the amount of raise being made.

- Lack of ballast will result in improper tamping and, consequently, settlement of track.
- The number of insertions made by the tamper will also affect the degree of compaction.

With most machines on the market, when lifts in excess of 2-1/2 inches are made, double tamping is recommended.

- It should be remembered that a single insertion will put a fixed amount of ballast under the tie and when the void caused by raising the track is greater than the amount delivered by one insertion, double tamping is required.
- If in doubt, dig out a tie to check the tamping pattern under the rail.

When surfacing out-of-face, it is extremely important that proper cross level be maintained.

- Some of the tampers require the cross level to be maintained manually by the operator.

These machines are provided with a cross level indicator and the operator merely en-gauges the necessary valve to raise the cross level rail.
It is best if the two rails are raised together and when the surface rail reaches its raised position, small corrections are made by the operator to the cross level rail.

In cases where the cross level is handled automatically by the tamping machine, it is best to tamp and raise every tie or every second tie. A second tamper, a **pup,** can follow and tamp those ties skipped by the front machine.

It should be noted that with either type of the above machines, when it is necessary to make a runoff to clear for trains or complete a day's work, the settings of the machine should be recorded and when coming back to that work point the same settings must be put into the machine to prevent leaving a low spot or a hump at that location.

When surfacing into fixed objects such as hi-rail access, turnout and aerial structure, the as hi-rail access or turnout may or may not be scheduled for reworking and, therefore, a good surface is necessary into and out of these areas.

Special care is required to assure the track is not pulled too high. If the track is too high, two alternatives may be considered to correct the condition:

- Lowering the track approaches to the crossing
- Raising the crossing

In the case of a bridge or aerial structures, shimming would be required, and in most cases, this would be prohibitive. Pulling the track slightly higher to allow for settlement will prevent low spots at the ends of fixed objects; however, low spots can be spot tamped quite easily to correct any under compensation for settlement.

Where there are many fixed objects in a short distance, it may be advisable to have grade stakes set to assure a uniform surface through the area.

3. Lining to Grade Stakes

On new construction, grade stakes are usually set; this will require that you be familiar with the equipment for this type of work. There are two methods of raising to stakes, and in both cases, the front reference point of the surfacing system must be adjustable for height.

At each stake, the difference in elevation between the stake and the top of the rail must be marked down so the information is available when you are positioned at the front reference point.

- If it is possible to have the front reference point stationary while the machine raises and tamps (such as a light beam system), then the front reference would be positioned at a stake and the light source adjusted up from the normal "0" position by an amount equal to the difference in height between the stake and top of rail.

The machine would then work toward the front reference point raising and tamping the track. Of course, the adjustments on the machine would be for "0" lift. After tamping a suitable distance, the front reference would be moved to the next stake and the height of the light source adjusted to the new setting and the machine would again raise and tamp the track while the reference point remains stationary.

4. Track Shims

Considerable attention has been given to the correction of surface defects by means of tamping procedures.

- This is the way most surface problems are eliminated.

There are times when this is not practical. Such situations occur when surface defects must be corrected in a track with **Direct Fixation Fasteners**.

One type of condition in which this happens is a conventional low spot in the track. It is either undetected or, for some reason, uncorrected.

- It is determined to be serious enough to warrant prompt correction.

In such cases, flat metal shims are installed between the fastener and the second pour or the fastener and the tie. The procedure is to remove all hold down bolts, lags or spikes through the low area and to jack the rail so as to correct the defect.

Shims of different thickness will probably be needed in order to bring all fasteners firmly against the rail. It may be necessary to use bolts of extra length to keep the rail firmly secured to the second pour.

- Shims may also correct cross level defects..

A surface problem that sometimes develops in frozen track is the so-called **frost heave.**

- This may be a spot where the track raises above the proper grade.

It may return to its proper position when thawing occurs. This does not eliminate the hump, but it can provide a gradual rise and fall.

Once shims are installed in track, they should be checked at frequent intervals.

Appendix I

Glossary of Terms for Track Surface

The following are terms used in this module :

Alignment

The position of track in the horizontal plane expressed as tangent or curve.

Cross level

The difference in height between the two rails of a track at points directly opposite each other.

Crossover

Two turnouts with track between, connecting two nearby and usually parallel tracks.

Grade

The rise or fall in elevation of railroad track. A rise of one foot in elevation in 100 foot of track is a I % ascending grade. Similarly, a decrease of 0.75 foot or 9 inches in elevation in 100 foot of track is a 0.75% descending grade.

Grade level

A grade with level track (no rise or fall).

Gradient

The rate of inclination of track in relation to the horizontal (also see grade).

Jointed rail

A term applied to fastening or connecting rail ends by means of rail joints, as opposed to welding them. Also called bolted rail or stick rail (slang).

Cross level

A track tool consisting of a spirit (bubble) level installed on a wood or metal bar; it spans the rails of a track to determine the relative elevation between the rails.

Lining bar

A steel track tool five feet long, 1-1/4 inch square at the tip and 18 pounds in weight. It is used to line track, operate track jacks, position ties, etc. It comes in wedge point, diamond point, and pinch point styles.

Out-of-face

Major work over a continuous length as compared to spot maintenance work at unrelated locations.

Railhead

1. The top of the rail in which rolling stock wheels are guided. The railhead also accepts the weight from rolling stock in a very small area at each wheel/rail contact point.
2. The end of a railroad line.

Rail joint

1. The meeting of two separate rails.
2. A device which joins or fastens (but does not weld) two separate rail lengths (not to be confused with jointed rail).

Rail web

The vertical member of a rail that provides bridge or beam strength to carry the rolling stock loads from tie to tie.

Runoff

1. The term applied to that part of precipitation which is carried off from the land upon which it falls.
2. To gradually change superelevation or profile.

Runoff, curve

A bend in the alignment of a track. Opposite of tangent.

Runoff, raise

To ramp and tamp a newly surfaced track down to its un-worked position. Raise is normally expressed in inches of runoff per 31 feet of track. Also called surface **runoff** or **ramp**

Runoff, superelevation

The gradual and uniform transition from level track to superelevation.

Spiral

A form of easement curve in which the change of degree of curve is uniform throughout its length.

Spiral, runoff

A section of track where the superelevation changes (runoff) to transition from zero cross level to full superelevation. Superelevation runoff generally occurs in a spiral curve.

Spiral curve

A curve with a radius that changes gradually to provide a transition between a tangent (infinite radius) and curve (fixed radius), or between curves of different radii.

Spot board

A sighting instrument used in manual surfacing operations. The spot board increases the accuracy of surfacing operations when the desired new position is determined by eye.

Superelevation

The banking of track by raising or superimposing the high rail above the low rail at a curve. The desired speed and curve degree or curve radius determine the amount of superelevation.

Tamper

Any mechanical device that tamps.

Tamper, mechanical

A tamper with multiple heads that simultaneously tamps all load bearing areas under a tie. A majority of modern tampers also have the capability of simultaneously correcting deviations in alignment and surface.

Tamping (spot tamping)

The process of compacting ballast under ties to provide proper load bearing.

Tangent

A track with a straight alignment.

Tangent to curve

The point on a simple curve, looking from left to right while standing between the rails and facing the high rail, where the tangent ends and the spiral curve starts.

Tangent to spiral

The point on a curve, looking from left to right while standing between the rails and facing the high rail, where the tangent ends and the spiral curve starts.

Track (crossover)

Two turnouts with track between, connecting two nearby and usually parallel tracks.

Track (runoff)

The vertical transition of the track from one plane to another at the end of a track raise.

Track jack

A heavy-duty tool designed to lift track vertically or to push track sideways. A high lift jack has a lift capability of approximately 13 inches. A low lift jack or **Baby Jack** has a lift capability of 5 inches.

Track liner

A machine operated on the track that shifts track laterally (to the side) to a desired geometric alignment by use of automatic measuring/calculating equipment.

Uniform riser

A split switch in which the slide plates raise the rail base of the switch rail higher than the rail base of the stock rail from the switch point to the switch heel.

Vertical curve

A curve with its radius in a vertical plane that connects two different grades in the track.

Wheel flange

The tapered projection extending completely around the inner rim of a railway wheel, the function of which, in conjunction with the flange of a mate wheel, is to keep the wheel set on the track by limiting lateral movement of the assembly against the inside surface of either rail.