# Signalling& Telecommunication Engineering

## Lesson 2

## Block Working and Interlocking

### 1.0 Introduction

**1.1** For safety of train working, an interval is kept between two trains. In earlier times, a time interval was kept between two trains following each other on the same line. This system was not considered adequate to ensure safety when the densities of trains as well as their speeds increased. The system now followed, uses a space interval between trains. The entire stretch of a Railway line is divided into sections, and when a train enters a section, it is "blocked" for all other trains. Another train is allowed to enter this section only after the first train has cleared the section. These section are called Block sections, and the system of working is called Block working.

**1.2** Trains are permitted to enter the block section, after receiving permissionto do so. Stations are provided at the two ends of a section and are called block stations. These are provided with signals to control entry in the block sections. In automatic working, entry to such sections are controlled by signals which operate automatically by passage of trains.

**1.3** To control movement of trains between two block stations, they are connected by telephones. In addition, except where train densities are very low, special instruments are provided between the block stations to grant permission for a train to proceed from one station to the other. These instruments are called Block Instruments.

### 2.0 Systems of Block Working

**2.1** The following systems of block working are followed on Indian Railways:

(a) The absolute Block System,

(b) The automatic Block System,

(c) The Following Train System,

(d) The Pilot Guard System,

(e) The Train-staff and Ticket System, or

(f) The One Train Only System.

**2.2** Normally, only the Absolute Block system or the Automatic Block Systems are used. The other systems are used only in special cases, under approved special instructions.

### 3.0 The Absolute Block System

**3.1** In the Absolute Block System, the line is divided into sections, with stations at each end of the section. The stations are called block stations. The portion of the line between the

two block stations is called the "block section." Line Clear" refers to the permission given from a block station to the block station in rear for a train to leave the latter and approach the former, or the permission received by a station from a station in advance for a train to leave the former and proceed towards the latter.

**3.2** In the absolute Block System no train is allowed to leave a block station, unless,-

(a) Line clear has been received from the station in advance, and

(b) On double lines, is clear, not only up to the first stop signal, at the station giving line clear but also for an adequate distance beyond it;

(c) On single lines, line is clear of trains running in the same direction, not only up to the first stop signal at the station giving the line clear, but also for an adequate distance beyond it, and is clear of trains running in the direction towards the block station to which such line clear is given.

**3.3** The adequate distances referred to in paras above, shall not be less than-

(a) 400 meters in the case of two aspect signalling, and

(b) 180 meters in the case of multiple-aspect signalling.

**3.4** Where train densities are very low, simple means of communication like Morse telegraph, or telephones, are considered enough for granting and receiving line clear. On other sections Block Instruments of various types are in use on the Indian Railways.

**3.4.1** On the double line sections, these block instruments are interlocked with the signals in such a manner that the last stop signal of the station, which governs entry into the block section, cannot be taken "OFF", unless line clear has been obtained from the station in advance. A common instrument is used for both the lines on a double line section. The instruments are provided with a visual indication that line clear has been granted or received. When a train enters the block section, the indication changes to "train on line" indicating to the station staff, that a train is in the block section. When the train has cleared the block section, the indication changes to "line close" indicating that there is no train in the block section.

**3.4.2** On single line section, two types of block instruments are in use

Fig 13 (a) TOKEN INSTRUMENT

Fig 13 (b)

Fig 13 (c)

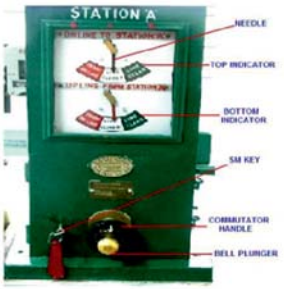



Fig. 13 (d) SGE DOUBLE LINE BLOCK INSTRUMENT

**Fig 13 (b & c) Tokenless Instrument**

(a) Token instruments (Fig 13 a), and

(b) Token less instruments (Fig 13 b & 13 c)

The instruments at the adjoining stations are connected to each other, electrically, and so interlocked that trains cannot be sent by both stations towards each other, at the same time.

On Double line section, SGE Double line block instruments are used (Fig 13 d).

**3.4.2.1** Token instruments are provided with handles which can be turned, to be in any of the three positions. The normal position, called the "line closed" position indicates that there is no train in the block section. The other two positions are designated as "train going to" and "train coming from" position. This releases a metal token at station A (Sending end). This token, usually in the form of a ball, is handed over to the Loco pilot of the train, as a tangible authority to enter the block section. In addition, the last stop signal of the station A is so interlocked, that it cannot be taken "OFF" unless the token instrument at that station is in the "train going to (TGT)" position. When the train reaches station B (Receiving End), the incoming token has to be inserted in the token instrument at station B, to enable B to turn his token instrument handle from Train Coming from (TCF) to line closed position. This enables the handle of the instrument at A to be turned to line closed position to normalize both the token instruments.

**3.4.2.2** Where train densities are higher, token less instruments are provided. These do away with the need to extract a token, and hand it over to the Loco pilot at the sending station, and of taking it from the Loco pilot and inserting it in the lock instrument at the receiving station. This reduces the time when trains cross each other, thus increasing the line capacity of the section.

**3.5** Last vehicle check by axle counter (also called block proving by axle counter).

Checking of last vehicle of the train on most of the sections, except automatic Signalling

sections, is being carried out manually by station operating staff. With increase in traffic density, particularly on double line sections, this manual checking of last vehicle is becoming increasingly difficult which is a potential safety risk. Axle Counter systems are now being used for last vehicle checking & block clearance in some double line sections on the trunk route of IR. The in-count of axles at advance starter signal of sending end station and the out-count at Home signal of receiving end station provides check of complete arrival of train and proves block clearance.

## 4.0 The Automatic Block System

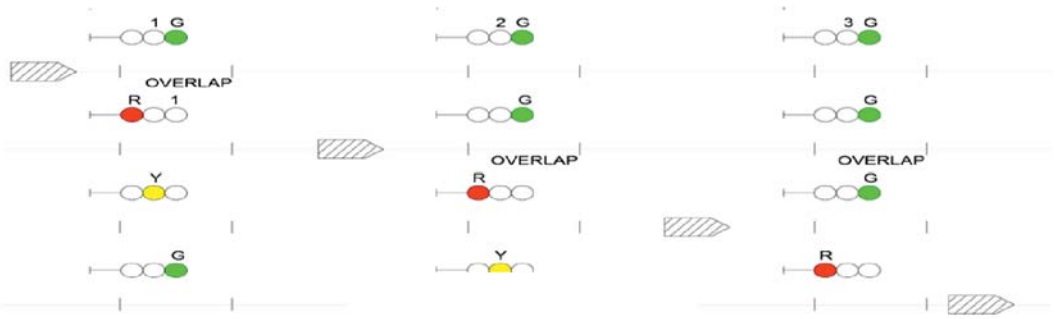



**Fig.14 (a) Double Line Auto Section**

4.1 On Double Line Sections (Fig.14 a):-

(a) The line is required to be provided with continuous track circuiting or axle counters,

(b) The line between two block stations is divided into a series of automatic block signalling sections, the entry to which is governed by a stop signal,

(c) The track circuit or axle counter so controls the stop signals governing entry into an automatic block section that the signal does not assume an "OFF" aspect unless the line is clear not only up to the next stop signal but also for an adequate distance beyond it. The track circuit/axle counter must place the signal to "ON" as soon as the train passes the signal. This adequate distance, normally, must not be less than 120 meters.

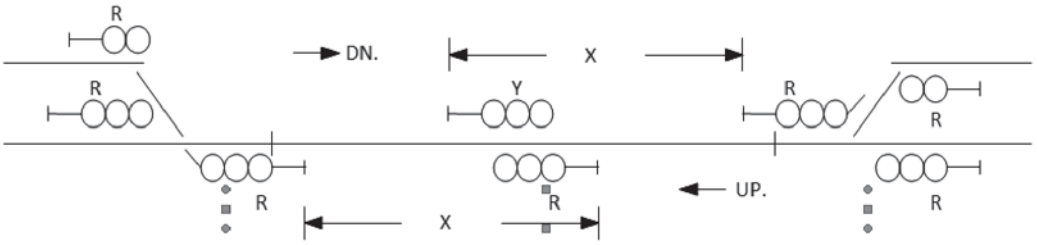



**Fig. 14(b) Automatic Signaling in Single Line Territory**

**4.2** On Single Line sections (Fig 14 b),-

(a) The line is required to be provided with continuous track circuiting, or axle counters,

(b) The line between two block stations is divided into two or more automatic block sections, by providing Stop Signals,

(c) The direction of movement is established by obtaining line clear from the station in advance,

(d) it shall not be possible to obtain line clear unless the line is clear, at the block station granting line clear, not only up to the first stop signal, but for an adequate distance beyond it.

(e) Trains are started from one block station to another, only after the direction of movement is established,

(f) After the direction of movement is established, the movement of trains, into and out of an automatic block section, is controlled by the concerned automatic stop signal, which shall not assume an "OFF" aspect, unless the line is clear up to the next automatic stop signal. Where the next stop single is a manual signal, the line is required to be clear up to an adequate distance beyond the manual signal.

(g) All stop signals against the direction of movement must be at "ON".

(h) The adequate distance is required to be not less than 180 meters.

## 4.3 Passing an automatic stop signal at "ON"

When a Loco pilot comes across an automatic stop signal at "ON", he is required to bring his train to a stop short of the signal and wait for one minute by day, and two minutes by night or poor visibility. If the signal continues to be "ON", the Loco pilot is required to talk to the control, if such telephonic communication is available. If this is not available, he should proceed ahead, after giving the prescribed whistle code and exchanging signals with the guard. He should proceed at a speed not exceeding 10/8 kmph., as far as the line is clear, towards the next stop signal, with great caution, and be prepared to stop short of any obstruction. The Loco pilot must proceed with caution up to the next signal and then be guided further by the aspect of the next signal.

## 4.4 Aspect sequence in automatic territory

On a typical double line automatic signalling section, with 3 aspect signalling the signal aspects shall be as in Fig. 1, as the train proceeds. It may be noted, that a signal assumes a yellow aspect, after one automatic section plus overlap is clear, and assumes a green aspect after two automatic sections plus the overlap are clear.

## 5.0 The Following Trains System

**5.1** In this system, trains are dispatched from one station to the next, following each other in succession, in the same direction, on the same line.

**5.2** This is done only after the station master in advance has agreed to receive the trains, and has given his assurance that no train will be run from his station in the opposite direction on the line till all the trains have arrived at his station.

**5.3** The Loco pilot is required to proceed only after he is given a written authority to proceed.

**5.4** Normally an interval of at least 15minutes is kept between two trains. The trains are required to run at the samespeed, not exceeding 25 kmph. The number of trains in the same direction are normally limited to 4, or not more than one for each 5 km of the distance between the stations.

## 6.0 The Pilot Guard System

**6.1** In this system, a railway servant is deputed to pilot trains. He is called a Pilot Guard. Trains leave a station only under the personal custody of the Pilot guard. The Pilot guard is distinguished by a red dress or badge. Normally the Pilot Guard accompanies each train. However, if it becomes necessary to send two or more trains, one after the other, in the same direction, the Pilot Guard accompanies the last train. He must give personal authority to the preceding trains.

**6.2** The speeds of trains is limited to 25 kmph. An interval of 15 minutes must elapse between two trains.

## 7.0 The Train Staff and Ticket System

**7.1** This system is used only on single line sections. In this system, a train-staff is kept at one station. No train is allowed to start from one station unless the train-staff is at the station. This train staff is handed over to the Loco pilot as the authority to proceed.

**7.2** When two or more trains are to follow each other, the Loco pilot is advised of the time of departure of the previous train, and the stations at which it will stop. Train speeds are restricted to 25 kmph. All trains should run at the same speed, and an interval of at least 15min. must elapse between two trains. In such cases, only the last train-staff is following. The train-staff is inscribed with the names of the two stations between which it permits trains to work.

## 8.0 The One Train Only System

**8.1** This system is used only on short branch line sections, on the single lines only. Only one trains is permitted to run in the section.

**8.2** An authority to proceed is handed over to the Loco pilot of the train, before he is permitted to leave the station.

## 9.0 Interlocking

**9.1** For safe running of trains, it is necessary that the route is correctly set for a train before any movement is made over it. Also it should not be possible to disturb this route till the movement is completed. This requires sequential operation of points, locks signals and

closure of interlocked level crossing to road traffic. The arrangement to do so is called interlocking.

**9.2 Essentials of interlocking**

Lever frames and other apparatus provided for the operation of points, signals, etc. shall be so interlocked and arranged as to comply with the following essentials.

(a) It shall not be possible to take "Off" a running signal, unless all points including isolation are correctly set, all facing points are locked, and all interlocked level crossing gates are closed to road traffic, for the line on which the train will travel, including the overlap.

(b) After the signals has been taken "OFF", it shall not be possible to move any points or lock on the route, including overlap and isolation, nor to release any interlocked gates, until the signal has been put back to "ON" position.

(c) It shall not be possible to take "OFF" at the same time, any two fixed signals which lead to any conflicting movements.

(d) Where possible, points should be so interlocked as to avoid any conflicting movements.

**9.3** Points and signals are worked either from levers, or worked electrically through switches fixed on a panel. Generally, the levers are grouped together in frames, called lever frames, which have an arrangement such that interlocking between levers can be provided in these. Thus two levers can be so interlocked that when one has been pulled, it would lock the other and prevent its operation. Alternately, the interlocking can be such that a lever can be operated only after another lever has been operated.

**9.4** The interlocking can be:

(a) Mechanical, or

(b) Electrical, or

(c) Electromechanical, or

(d) Relay interlocking, or

(e) Solid state, or electronic interlocking.

**9.4.1** Mechanical interlocking is provided using mechanical locks and keys, or directly between the levers in the lever frames. In some cases, particularly where miniature lever frames are used, the interlocking is electrical, using electric lever locks. A combination of the two types is called electromechanical interlocking. In modern signalling, panels are used to control the operation of points and signals. Switches on the panels, operate relays to control the points, signals etc. Here, the interlocking is provided between the relays and is called relay interlocking. With developments in electronics, safe electronic interlocking system have been developed. In these, the control over points, signals etc. is through

switches on a panel, similar to relay interlocking. However, the actual control of movements is done electronically, using solid state components, and specially designed software. The interlocking is achieved in the special software. Hence such interlocking are also called solid state interlocking.

**9.4.2** Relay interlocking and solid state interlocking are provided with full track circuiting. In addition, Solid state interlocking are generally provided with data loggers, devices that record the timings of various events, like taking "OFF" of a signal, or of occupation of a track etc. These assume importance in case of accidents or other unusual events Solid state interlocking enable changes to be made easily to the interlocking when necessary, since these involve only changes to the software.

### 9.4.3Electronic Interlocking System

The Electronic Interlocking System, also called Solid State Interlocking, in signalling is a microprocessor based equipment used for the operation of points, signals, level crossing gates, block working with adjacent station, releasing of crank handle for manual operation of points and other controls like slots etc.

Software used in Electronic Interlocking System is developed in conformity with a software engineering standard issued by standard body such as European Committee for Electro Technical Standardization (CENELEC) with special relevance to safety critical applications. Solid State Interlocking or Electronic Interlocking system is a state of art interlocking technology; that provides flexibility, higher reliability and safety in train operation and is being inducted world over.

## 10.0 Standards Of Interlocking

**10.1** Different standards of interlocking are laid down for Broad Gauge (BG) and MeterGauge (MG) based on requirements of speed and traffic density.

**10.2** The different standards lay down the requirements of point fittings, method of operation of points and signals, type of interlocking, type of signalling, method of block working, requirements of track circuiting, complement of signals, type of point detection, number of distant signals required, and the need for an auxiliary warning system.

**10.3** Broadly then are 4 standards of interlocking

| | | | |
|---|---|---|---|
| (i) | Std I (R) | - | up to 50 kmph of speed |
| (ii) | Std II (R) | - | up to 110 kmph of speed |
| (iii) | Std III (R) | - | up to 140 kmph of speed |
| (iv) | Std IV (R) | - | up to 160 kmph of speed |

## 11.0 Route Holding

**11.1** It is vital for safety of train running that once a route is set and the train has started its movement, the route is not disturbed. This is called "called "Route Holding".

**11.2** The rod operating the lock, in rod operated points, also operates a bar which is fitted generally to the inside of the stock rail. The bar normally lies below the rail top. During operation of the lock, the bar rises to the same level as the rail top, and then again goes back to its normal position. This process repeats when the point is unlocked. This bar is called a lock bar, and serves a very important role. If a train is over the point, the wheel prevents the bar from rising to the top of the rail. This prevents the operation of the lock lever, hence preventing a point that had been locked, from being unlocked, when a vehicle is either moving over the point or standing over it. The length of the lock bar is kept greater than the maximum distance between two axles. This purpose can also be achieved by the use of a track circuit.

**11.3** Normally, a signal is placed as close to a point as possible. With use of lock bars for holding a point, if an attempt

is made to change a point, interlocking would require the putting back of the signal lever, and then unlocking the point by putting back the lock lever before its position can be changed. Keeping this in view, no special arrangementsare required to hold the route, if the distance between the point and the signal is 180 meters or less. Where the distance is more, additional bars are provided (Fig. 2). These are called holding bars.

Alternately, track circuiting is provided for holding the route. The occupation of the track circuit prevents the operation of the lock lever by using electric lever locking arrangements. This is considered a better arrangement than using lock/holding bars.

**11.4** Where points are electrically operated, track circuiting is required to be provided. Occupation of the track circuit pertaining to the concerned point cuts off the electric feed to the point machine, preventing its operation. Where double wire operated points are provided, generally, the route is held by mechanical locks being provided on route levers, the key of which is required to be given to the station master. This is locked in a special key box, or in his slide control frame.

**11.5** In relay interlocking, generally complete track circuiting is provided. The route holding is achieved through these by controlling the concerned relays, and in turn, the feed to the point machines.

## 11.6 Interlocking of level crossing gates

**11.6.1** Important level crossings need to be interlocked with signals, so that the signal permitting movement across the level crossing cannot be taken OFF, unless the level crossing gates have been closed to road traffic and locked. It should not be possible to open the gates till the signal has been replaced to ON.

**11.6.2** When the level crossing is within station limits, it is interlocked with the station signals. Various arrangements exist to provide such interlocking. The simplest arrangement consists of provision of mechanical locks, such that when the gates are closed, a key can be extracted from them. This key is used to unlock the gate control lever, which normally

remains locked. After the gate control is taken OFF, the key gets locked in the signal lever and can be extracted only after putting back the signal lever, which puts the signal to ON. Thus, unless the signal is put back to ON, the level crossing gates cannot be opened.

**11.6.3** Where the level crossing is outside station limits, separate gate signals are provided. These gate signals are provided with "G" markers. The interlocking arrangement can be as described in earlier para, or by direct lever locking. Here, one lever in the lever frame is used to lock the gates after they are closed to road traffic. This lever, in turn, permits the operation of the signal lever.

**11.6.4 Train Actuated Warning Device**

On Indian Railways, a large number of accidents take place at level crossing gates. As at many gate (manned gates not provided with phones and unmanned gates) there is no system to pre-warn the road users of the approaching trains. Train Actuated Warning Device (TAWD) is a system by which road users are warned about approaching trains at level crossings through audio visual signals to the road users.

## 12.0 Signalling, Safety and Line Capacity

**12.1** Signalling is vitally connected with both safety of train working and improvement to line capacity.

**12.2** Signals provide the link between the Loco pilot and the station staff who set the route for the train. The interlocking system ensure that the setting of the route is checked before a signal can be taken OFF. It, thereafter, ensures that the route is held, so that the train runs safely over points and across important level crossing. Track circuits/axle counters are used to detect the presence or absence of vehicles on the track, to ensure that the track is clear, before permitting any movement over the track. Block Instruments are used to ensure that only one train is permitted in the Block section, on the same line. On the suburban sections of Western and Central Railways, an auxiliary warning system has been provided. This system alerts the Loco pilot when he passes a signal at double yellow or yellow, as this requires the Loco pilot to reduce speed. It then monitors the speed and gives an audio as well as a visual alarm if the speed is not reduced to the required extent. If a Loco pilot approaches a red signal automatic brake application takes place, in case the train passes it at higher speed.

**12.3** Signals provide control over movement of trains, and authorizes movement from one station to another, through block instruments. Signalling, therefore, plays a very significant role in the number of trains that can be run on a section. Some important systems that are used to improve line capacity are:

**12.3.1** On Single Line

(a) MultipleaspectSignalling

(b) Token less Block Instruments

(c) Centralized Traffic Control.

**12.3.2** On Double lines

(a) Multipleaspectsignalling,

(b) Intermediate Block Signalling,

(c) Automatic signaling,

(d) Second Distant Signal

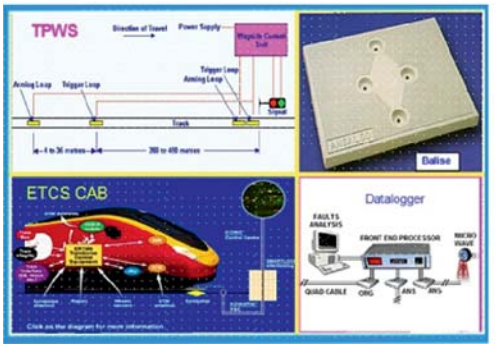
**12.3.3** Multipleaspect signaling, token less block instruments, and automatic signalling have already been explained earlier. In centralized traffic control, operation of trains on an entire section is controlled from a central place. All the stations on the section are provided with complete track circuiting, multipleaspectcolour light signalling, and electric point machines, controlled from panels with relay interlocking. The section between stations is provided with automatic signalling on single line. The section is therefore, broken up into smaller auto sections protected by signals. All the stations can be controlled from a central location, which is provided with a control panel. The position of points, track circuits, signals and interlocked level crossings on the controlled section are displayed on the control panel. Their working can either be controlled centrally, or by the individual stations. With centralized control, the working becomes very efficient, since the complete picture of trains on the entire section is available at one place. This leads to an appreciable improvement in the number of trains that can be run on the section.

**12.3.4** On double lines, trains work directionally, that is, in one direction on one line, and in the other direction on the other line. Thus on each line between two stations, one train can be run. In Intermediate Block Signalling, additional intermediate signals are used on each of the lines, so as to permit two trains to be run on each line. Between the last stop signal of a station and the intermediate signals, the line is provided with track circuiting. The line capacity of the section can thus be substantially increased.

**12.3.5** Increase in speeds of trains can lead to increase in line capacity. Provision of multipleaspectcolour light signalling, has enabled pre-warning to be given to the Loco pilot of the aspect of the next signal. An additional distant signal has been provided on the high speed routes to improve the pre-warning given to the Loco Pilot.

## 12.4 Train Protection Systems:

### 12.4.1 Train Protection and Warning System (Tpws)



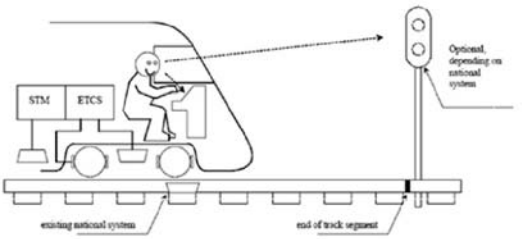




**Fig 15 TPWS**

about 300 signals in each working shift necessitating extreme alertness of motorman. Missing of even one red signal can be disastrous. In other places this may be due to many reasons such as inadequate visibility of approaching signal due to fog, rain, smoke or signals camouflaged by other lights etc. or may be human error. Train Protection and Warning System (TPWS) is a system which provides an appropriate technological aid to the motorman for avoiding accidents due to such error. TPWS gives information of aspects of signals to motorman inside cab and ensures proper speed by alerting motorman and actuate braking if motorman's response is not appropriate.

### 12.4.2 European Train Control System (Etcs)

European Train Control System is the advanced version of TPWS, it is an automatic train control system, which can be used as over lay on an existing signaling system. System provides complete range of functions needed for efficient operation of the railway. Like:

- Automatic speed and brake control
- Cab signaling for Loco pilot's assistance
- Self-diagnostic
- Enforcement of temporary speed restrictions at work sites

ETCS has three levels:

i) ETCS level 1

ii) ETCS level 2

iii) ETCS level 3

### 12.4.3 Anti-Collision Device (ACD)

Anti-Collision Device (ACD) is a 'self-acting' microprocessor based communication equipment when installed on locomotives (along with Auto-Braking Units), guard vans/ SLRs, stations and level crossing gates (both manned as well as un-manned), the resultant 'Net-work' of ACD system prevents 'high speed' collisions in mid-sections, station area and at level crossing gates. In mid-sections ACD detects any 'collision-like' situation in range of 3 Kmwhich Loco pilot cannot detect on his own and applies brakes. There are two types of ACD equipment, namely.

- Mobile ACDs for Locomotives and Guard Vans/SLRs
- Stationary ACDs for Stations, Level Crossing Gates and Repeaters where adequate communication range is not available.

While entering the Station Area, if Loco ACD detects the presence of a train on the main line, it applies brake to bring the train to stand still. If it detects that it is deviating from the main line when the same is not occupied, it automatically regulates its train speed to 30 Kmph, what is maximum permitted over turnouts, thereby reducing the possibility of collision with the other train, either on main line or loop line, respectively.

While traveling in the Mid-Sections, Loco ACDs remain in 'look out' for trains present in the radius of 3 km to handle following potentially dangerous 'Collision-like' situations:

In case Loco ACD detects that any other train has stopped on adjacent track may be due to derailment, Loco failure, cattle run-over, alarm chain-pulling etc., it will automatically regulate the speed of its train till such time it crosses it.

- In case, a train detects an another train approaching it on the same rack, the Loco reducing possibility of 'head-on' collision.
- In case, a train detects an another train moving ahead of it on the same track, and having a separation distance of less than 2 Km, its Loco ACD 'automatically' applies the brakes to regulate the train speed, till such time the separation distance between the two starts 'increasing' again, thereby reducing possibility of 'rear-end' collision.
- In the event of 'train parting' in the mid-section, both Loco and Guard ACDs of the train will radiate 'Auto SOS' signals to prevent the 'rear end' and/or 'side' collisions of their train that might have derailed and infringing the adjacent track.

## 12.5 Train Management System

Train Management system (TMS) provides accurate train information of expected arrival/ departure of trains to the public through VDU monitors and auto announcement systems. It is also an effective system for regulating trains by monitoring their movements and taking timely decision for diversion of trains, induction/withdrawal/reversal of rakes etc., by monitoring the movement of trains on real time basis at a centralized location. At present such a system is working on Churchgate-Virar section.