Reading Material
For Group "A" Foundation Course

Signal & Telecommunication

RAILWAY SIGNALLING AND TELECOMMUNICATION

CONTENTS

Chapter 1
Introduction and History of Railway Signalling

1.1 Introduction :- Signalling may be defined as methods and means adopted to control the movement of trains. The purpose of signalling is threefold.

(1) To ensure safety in train operations.

(2) To improve efficiency of working.

(3) To increase throughput/line capacity of a section.

1.2 Necessity of Signalling :- The necessity of signalling arises mainly because of the flexibility to go around the obstruction not being available in case of trains as compared with the road vehicles. The vehicles are always guided by the rails and the only way to avoid accidents in case of trains is to stop the train short of an obstruction. Hence it becomes necessary to pass on information from track to the train. The information is communicated to the train driver by means of signals. The signals act as a vital link between the track and the train.

There is yet another important difference between rail traffic and road traffic, that relates to the braking distance. In case of trains since the friction between the steel rail and the steel wheel is very less as compared to the pneumatic tyres and rough road surface, **the braking distance required to stop trains is much longer.** Hence, the information regarding an obstruction on the track must be passed on at a sufficiently longer distance in rear of the obstruction to enable the train to be stopped short of the obstruction.

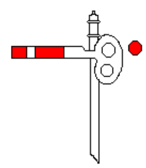
1.3.1 History of Railway Signalling :- The first railway line in the world was opened from Darlington to Stockton in UK in 1825 for goods trains only.

Uniformed men on horses' back called "Bobbies' used to guide the trains. The first passenger train was run between Liverpool and Manchester in 1830. The first passenger train on its inaugural run started off with a fatal accident, running over the

Member of Parliament who inaugurated the train. The signalling adopted for the trains also changed from 'Bobbies' to 'Policeman' posted at a fixed intervals. The Policeman used to display proceed signal by standing erect, and stop signal by 'stand at ease' position.

1.3.2 When the train services increased and night services introduced, policemen were replaced by fixed mechanical signals around 1838. These signals were called **'Semaphore'** signals. Semaphore is a latin word, 'sema' mean sign and 'phore' means to bear. Since these signals bear a sign to the driver of a train, they are called Semaphore signals. The signals conveyed two information to the driver. When the signal arm is horizontal, the information conveyed was stop. When the signal arm is lowered by 45 degree, the information conveyed was 'proceed'. Different forms of semphore signals were tried and it took about 50 years to adopt a standard mechanical signal.

Semaphore Signal at 'On' position



1.3.3 In the early days, there were a number of safety hazards and accidents used to happen at frequent intervals. In fact, accidents like collision of trains were accepted as unavoidable and steps were taken to reduce the impact by hanging large bags of wool at the back of the last coach and also between the coaches.

1.3.4 Since the wheels of a rail vehicle are guided by the rail, to divert a train from one track to another, **points** are used at regular intervals. The point assembly consists of fixed rails called stock rails and movable rails called switch rails. A point is said to be correctly set when the stock rail and the switch rail are housed properly. Improper setting of points would result in a derailment. In the early days, the setting of points had to be ensured by the station staff before lowering signals. The lowering of a signal did not positively ensure setting of points, since the checking was dependent on human element. This hazard was overcome by the introduction of **'interlocking'**, which ensures that signals can be lowered only after the points are set properly. The first interlocking was installed in Bricklayer's arm Junction in England. This interlocking system was considerably improved by 1856.

1.3.5 In the early days, trains were run with definite time interval between the trains. This system of working was called **time interval system**. The time interval used to vary from 5 minutes to 15 minutes depending on the total number of trains run in a section. In this system, the safety is dependent entirely on the vigilance of the drivers of the following trains. If the Train ahead stopped in between stations due to some reason, and the following train driver not vigilant enough, would cause a collision. There used to be a number of such collisions. The only way to avoid such collisions and eliminate this safety hazard was to maintain definite distance between two trains. This system is called **'space interval system'**. The whole length of track is divided into number of small sections called 'block sections' and at any time, there can be only one train in any block section. This system was first started in U.K. in 1856. Introduction of space interval system eliminated, to a great extent, midsection collisions.

1.3.6 There was yet another safety hazard in the early years. This was due to inadequate brakes provided in the trains. The brakes were provided in the engine and the last vehicle. The brakes provided were found to be not adequate enough to stop the train especially when the train was running on a rising gradient. The train used to roll-back and collide with the following trains. The braking system was improved by providing brakes in every vehicle in 1874. This system was called **'continuous braking system'.**

1.3.7 The introduction of lock (interlocking), block (space interval system) and brakes (continuous braking) considerably enhanced the safety of trains.

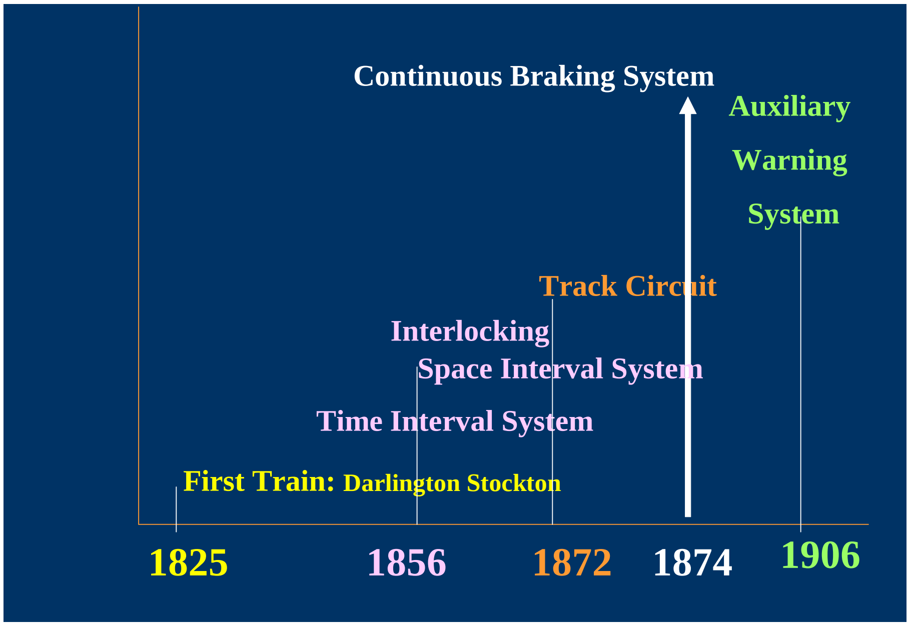
Even though number of accidents, especially collisions, were drastically reduced because of these safety arrangements, collisions could not be totally eliminated because of two main reasons :-

(1) Reception of a train on an occupied line especially at a station (2) Drivers ignoring and passing the signal at danger.

An important safety arrangement called **'track circuit'**, to prevent the reception of a train on an occupied line was first introduced in U.S. in 1872.

A device called Auxiliary Warning System (AWS) was introduced in 1906, which would apply brakes if driver ignores and tries to pass a signal showing danger. This equipment is generally provided only when the speed of the train exceeds 100 kmph.

Development of Rail Signalling: Worldover



Chapter 2
Development of Signalling on Indian Railways

2.1 The first train service was started on Indian Railways in 1853 between Wadi Bunder and Thane, in Mumbai. Even though, semaphore signals were provided at most of the stations, there was no interlocking introduced on Indian Railways.

2.2 Two British Signal Engineers, List and Morse were the first to introduce interlocking in N.W. Railway's 23 stations between Ghaziabad and Peshawar in 1894. They are called 'Fathers of Indian Railway Signalling'.

All other important Company Railways like GIP (Great Indian Peninsular) Railway, BB&CI (Bombay-Baroda Central India) Railway, MSM (Madras-South Maratha) Railway, started introducing interlocking on their important routes.

2.3 There was another important development in 1920. A Signal Engineer of Assam Bengal Railway (present North Frontier Railway) introduced a new system of mechanical signalling called **double wire signalling**, which has many advantages over single wire system which was in use. Many company Railways did not want to adopt this system in spite of many advantages. However, in 1950, the Double wire system became very popular and had to be necessarily used for providing a signalling system known as **'Multiple Aspect Upper Quadrant"** (MAUQ) signals.

2.4 Indian Railways started modernising their signalling system in late 50's. The first modern signalling system called Route Relay Interlocking was introduced for the first time in Indian Railways in 1958. In this system, the operation of a major junction station can be controlled from a single central location, as compared to decentralised mechanical operation from many cabins. Another important landmark in the history of Indian Railway Signalling was the introduction of 'Centralised Traffic Control' (CTC) in North Eastern Railway in 1966 between Gorakhpur Cantonment and Chupra. In this system all the signals located over 175 kms were controlled from Gorakhpur Cantonment. A similar system was introduced in North Frontier Railway between Bongaigaon and Chaunsari in 1968. Both the system were totally imported from U.S.A. An all indigenous CTC was commissioned between Madras Egmore-Tambaram in Southern Railway in 1970. Presently, however, there are no working CTC Installations on Indian Railways.

2.5 Indian Railways introduced for the first time a device called **Axle Counter,** which is used to detect whether a section is occupied or clear, in 1972. This device was imported from West Germany. An indigenous development was taken up by Indian Institute of Technology, Delhi & Research Designs and Standards Organisation, Lucknow alongwithtwo Signal Workshops at Byculla of Central Railway, and Podanur of Southern Railway, in 1973 and completed in 1976. Indigenous axle counters are extensively used on Indian Railways.

2.6 The first Auxiliary Warning System (AWS) was installed in Gaya-Mughulsarai and Howrah-Burdwan sections of Eastern Railways in 1972. However due to large scale thefts of track equipments, the effectiveness of the system could not be evaluated. However, AWS was introduced in the most busy suburban section of Western Railway i.e. between Churchgate-Virar in 1987. This equipment is working quite satisfactorily.

The latest development in signalling is the introduction of computers in interlocking called 'Solid State Interlocking' (SSI). The first SSI was commissioned at Srirangam station (near Trichy Junction) in Southern Railway in 1970.

Another, modern Signalling achievement on Indian Railways has been the commissioning of the Train Management System on Churchgate Virar section of Mumbai Suburban Section. This project, commissioned in 2003, provides live train movements of the entire 60 KM Churchgate Virar Section in the Control Centre at Mumbai Central. Train Timings are automatically logged. Announcements at stations are triggered automatically from the central servers. “Countdown in Minutes” keeps the commuters informed about train arrivals at stations…*in how many minutes the trains shall arrive at the platform.*

Mobile communication has also been provided between Control Centre and the Suburban trains. Train Management System (TMS) is the first modern Project of its kind on Indian Railways.

Anti Collision Device : ACD is a 'state-of-the-art', 'Non-Vital' safety device, developed 'indigenously' by Konkan Railway. When installed on Locomotives and Guards' SLRs/Brake Vans and networked with other 'stationary' ACDs provided at Stations and Level Crossing Gates (both Manned and Un-Manned), it provides an 'electronic' Additional Safety Shield to its users, namely, Drivers, Guards, Station Masters and Gatemen . ACD is

- **A micro-processor based equipment to prevent head-on, side and rear-end collisions at high speed. Also Provides warning at level crossing gates.**
- **Works on Global Positioning System (GPS) and Angular Deviation Count principle.**
- **All ACDs communicate with each other with in 3 kms range.**

ACDs fitted on a Locomotive and Guard's SLR/Brake Van continuously monitor the 'emergency' situations that may lead to 'collision-like' situations, while the train is either stationary or on move. They also detect presence of other train/s, Level Crossing Gate/s, Station/s etc., en-route, in their vicinity, by exchanging information with ACDs fitted on them.

Based on the 'relevant' train working rules programmed in it, the 'Loco ACD' analyses the situation on 'real-time basis and applies brakes 'automatically', either to reduce train speed to a 'pre-determined' level or to a STOP, as the case may be. It releases the control on braking mechanism for the driver, as soon as the task is accomplished.

ACDs exchange 'data' and 'commands' with each other when they are within their 'radio-range' of influence and also accept 'specific' manual inputs, in 'emergencies' or for 'initialisation' purposes·

Chapter 3
Requirements of Signalling and important definitions from General Rules.

3.1 Requirements of Railway Signalling :- Railway Signalling acts as a vital communication link between the track and the moving train, and therefore has to meet the following important requirements : Fail Safe; Reliability; Simplicity & Unambiguity.

3.1.1 Fail Safe : All signalling systems, equipment and components have to be fail safe. Failure of any signalling equipment or component should either result in signal displaying its most restrictive information i.e. danger or impose a restriction on the movement of trains. This is a very vital requirement and hence the use of electronic components and computers, which are inherently not fail safe, was delayed by 20 years till the successful development of fail safe designs with these devices.

3.1.2 Reliability : Reliability of signalling equipment is a very important requirement like any other mechanical or electrical equipment. In one of the busiest suburban sections of the Indian Railways, Mumbai Suburban Section, more than 2000 trains are running every day because of advanced signalling systems. If the reliability of the signalling is not of very high order, this would cause a serious repercussion on rail operations.

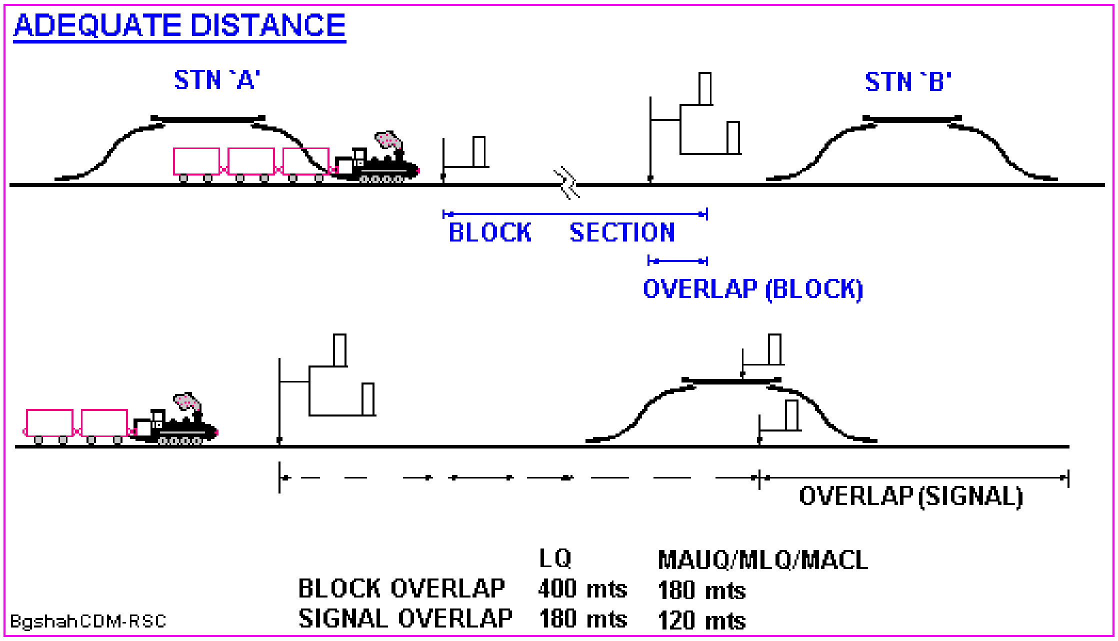
Further, signalling equipments eliminate the dependence on human element to a great extent in train operation. However, in case a signalling equipment or device fails, the safety is dependent entirely on human element and if the staff in charge of train operations, do not exercise proper vigil, there is possibility of occurrence of a serious accident.

3.1.3 Simplicity :- The signalling systems/equipment are installed by signal staff and operated by non-technical staff belonging to operating department. Hence, the operation of these equipment should be simple to be understood by such staff.

3.1.4 Unambiguity :- Safety of trains depends on the information conveyed by a signal. Hence the information conveyed by a particular aspect of a signal should be same every where at all times…with no ambiguity whatsoever. Under no circumstances, should the drivers be required to interpret the information conveyed by a signal on their own.

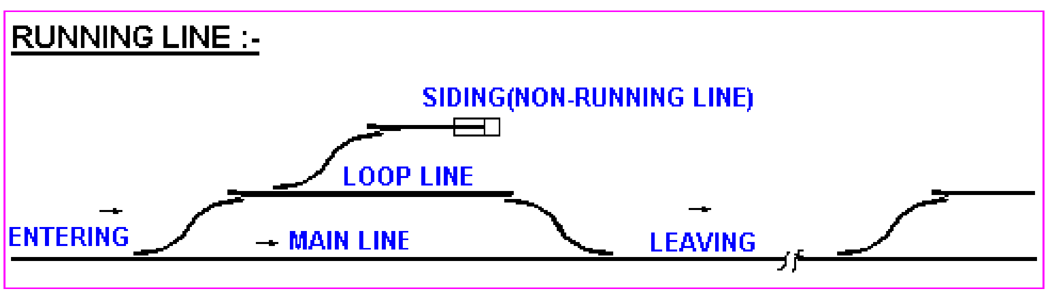
3.2 Important Definitions from General Rules : - The rules to be followed in the operation of trains are given in General Rules and Subsidiary Rules, (revised in 1976). Chapter I of General Rules deals with **Definitions** and Chapter III with **Signals.** Important definitions pertaining to signals are given below :-

3.2.1 Block Section :- The trains are worked with 'Space interval system' or 'Absolute block system' on Indian Railways. The whole length of track is divided into number of small sections of length varying between 6 kms to 15 kms depending on the density of traffic. No train is allowed to enter a block section unless permission has been obtained from the station at the other side. This permission is called Line Clear in Railway Terminology.



3.2.2 Authority to Proceed : - The line clear which is the permission to enter a block section, is obtained by the train operating staff. However this information has to be conveyed to the driver of the train. Authority to proceed is the means adopted to convey this information to a driver. This may be (i) in the form of tangible authority viz. token, which is tied in a pouch and handed over to the driver, (ii) clearing of a signal, called Last Stop Signal (iii) issue of paper line clear, when there is a failure or the movement is not a normal movement (as in the case of running a train in the wrong line due to an accident on the normal line).

3.2.3 Running Line :- The definition of running line is important as most of the main signals are meant for the running lines. Running lines are defined in G.R. as the lines with points or connections and governed by signals, used by a train when (i) entering a station (ii) leaving a station (iii) running through a station (iv) running between stations. If the line is used in any other condition, then that line is not a running line.

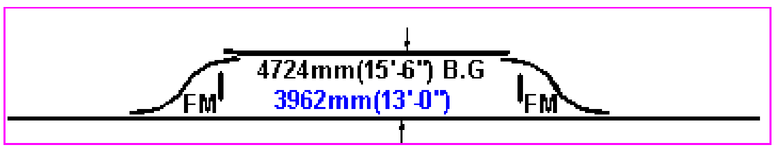


In the above sketch the siding is not a running line, because no train can directly enter or leave or run through the siding.

3.2.4 Running Train :- A train can remain at station or a block section. Normally, in a station a train can cross or take precedence over another train. Hence train standing at a station is not considered as a safety hazard as compared to a train at a block section, which requires more attention. The running train generally refers to a train in the block section. The running train is a train which has started under an authority to proceed and not completed its journey.

3.2.5 Fouling Mark :- The width of rolling stock is fixed on Indian Railways and the overall fixed dimensions of which is given in the schedule of dimensions. When two tracks are running parallel the distance between them should be such that two trains running in these tracks simultaneously do not infringe with each other. Hence a distance of (15' 6") in case of B.G., and (13') in case of M.G., between the adjacent tracks are maintained. When two tracks join each other or cross each other, this distance between the two tracks starts reducing. The point at which the distance starts reducing from a standard distance of (15' -6") - in case of B.G. and - (13') in case of M.G. is very important from safety point of view.

No train standing in any of the two lines is permitted to cross this point, which would infringe the other line and result in an side collision, when there is a movement in this line. A permanent mark (FM or FP) is provided at the track level. This mark is called **Fouling Mark** and is the mark at which infringement to Standard Dimensions occur where two lines meet or cross each other. It is the responsibility of the driver to ensure that the engine is clear of the Fouling Mark and the guard to ensure that the Fouling Mark is cleared by the last vehicle.

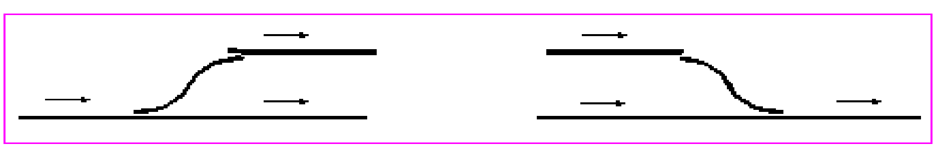


FM : FOULING MARK

3.2.6 Facing and Trailing Points :- Points are used to divert a train from one line to another. Points are classified as facing or trailing depending on the direction of movement of trains over the point.

If the direction of movement is such that the trains get diverted while going over the points, these points are classified as **facing points**. In case of facing points the trains can move to any of two lines. On the other hand, if train approaches a point with two lines converging to one, that point is called a **trailing point.** Facing points are considered more important than trailing because any improper setting of facing points would result in derailment of vehicles moving over the point.

On the contrary, in case of trailing points, even if the points are not set properly, the train is able to pass through the point safely causing damage to the point equipments. This is called 'trail through' or 'bursting of point'.

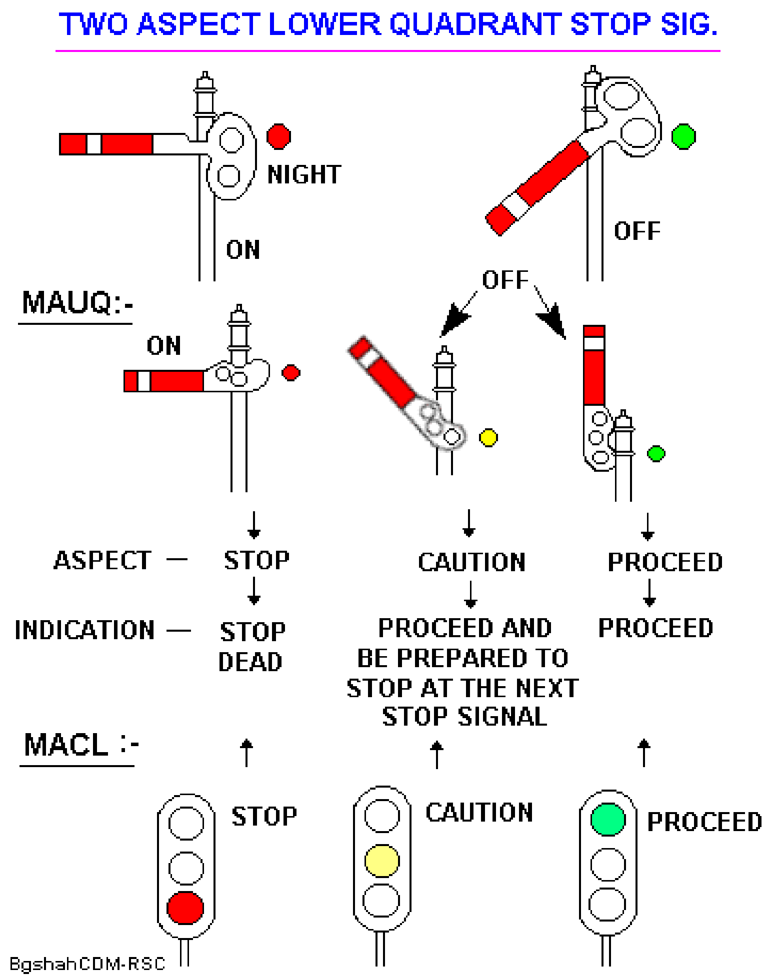


Facing point One Line to Any one of Two Line Diverting Point	Trailing Point Any one of Two Line to One Line Converging Point

3.2.7 Aspect of a Signal : - The physical appearance of a signal as seen by a driver is called the 'aspect of a signal'. The aspect may be a position of the arm (0 degree, 45 or 90 degrees) of a semaphore signal during day time or colour of the roundel (red, yellow or green during night time) or colour of a lens in case of colour light signals, both during day and night.

3.2.8 Indication :- The information the aspect of signal conveys is called the indication. Two types of signals called 'stop signals' and 'permissive signals' are used on Indian Railways. Stop signals can have a maximum of 4 Aspects and Permissive signals 3 Aspects. The various names of aspects and indications of a Stop and Permissive Signals are given below :-

Name of the Aspect	**Indication**	
	Stop Signal	**Permissive Signal**
STOP : RED	**STOP DEAD**	**NOT APPLICABLE**
CAUTION : YELLOW	**BE PREPARED TO STOP AT NEXT SIGNAL**	**BE PREPARED TO STOP AT NEXT SIGNAL**
ATTENTION : DOUBLE YELLOW	**BE PREPARED TO PASS NEXT SIGNAL AT RESTRICTED SPEED**	**BE PREPARED TO PASS NEXT SIGNAL AT RESTRICTED SPEED**
PROCEED : GREEN	**PROCEED**	**PROCEED**


TWO ASPECT LOWER QUADRANT STOP SIG.
NIGHT
ON
OFF
MAUQ:-
ON
OFF
ASPECT —
STOP
CAUTION
PROCEED
INDICATION —
STOP DEAD
PROCEED AND BE PREPARED TO STOP AT THE NEXT STOP SIGNAL
PROCEED
MACL :-
STOP
CAUTION
PROCEED
BgshahCDM-RSC

<u>Types of Signals :-</u>

1. Fixed Signals
2. Hand Signals
3. Detonator Signals
4. Flashing Hand Signal Lamp or Flag

<u>Fixed Signals :-</u>

1. Running Signals
2. Subsidiary Signals

<u>Running Signals</u>

a. Stop Signals

b. Permissive Signals

a. **<u>Stop Signals</u>**

	LQ	**MAUQ / MACLS**
Reception	Outer (FSS), Home	Home (FSS)
Despatch	Starter, Advanced Starter	Starter, Advanced Starter

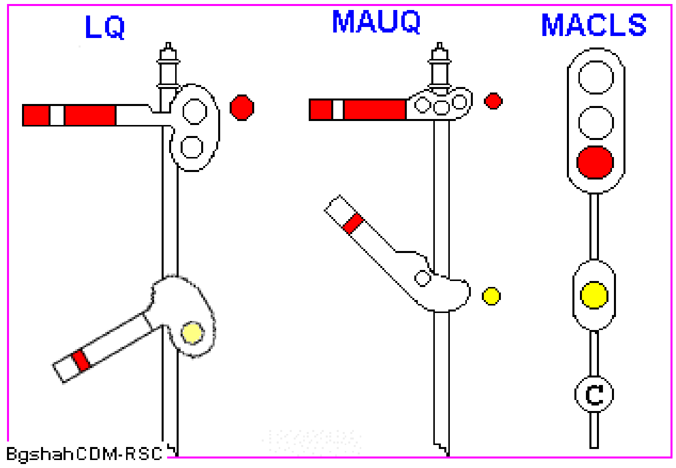
b. **<u>Permissive Signals</u>** Warner ; Distant

Subsidiary Signal

1. Calling on Signals
2. Shunt Signals
3. Repeating Signals
4. Starter Indicator

Calling on Signals

1. Placed below a Stop Signal governing the approach of a train.
2. Not worked at the same time as the Stop Signal
3. Taken OFF only after the train has been brought to a stop (Achieved by Track-circuit and Time-delay circuit.)



Shunt Signal

Used for shunting purposes and not applicable to a running train. May be separately located on posts or close to the ground or below a stop signal.

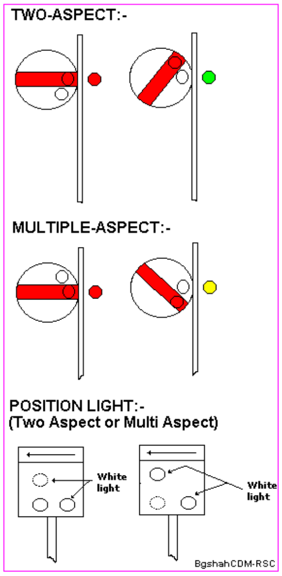
Shunt Signal May be of

1. Miniature ARM
2. DISC
3. The position light type

Can be used for number of Diverting routes without showing a particular route.

1. Miniature arm is like a STOP Signal in miniature on a separate port.

2. DISC TYPE :-



Repeating Signal

A Signal placed in rear of a fixed signal for the purpose of repeating to the driver of an approaching train the aspects of fixed signal in advance is called a Repeating signal

Repeating Signal . May be of

1. Banner type
2. An arm type
3. A Colour loght signal

Starter Indicator

Provided to repeat aspect of starter. May be provided at a convenient place. Exhibits no light when starter is ON and yellow when it is OFF.

Hand Signal

Day- Red Flag, Night-Red light
Proceed hand signal
Day-Green Flag, Night-Green light

Proceed with caution Hand signal
•Day-Waving green flag, Night-Waving green light

Hand signal for shunting
•Move away
Day-Green flag moved up down, Night-Green light up down

•Move toward
Day-Green flag side to side, Night-Green light side to side
•Move slowly
Day-Red and Green flag held above head, Night-Green light Held above head

Detonating Signal
Utilized in
•Fog
•Obstruction in line

Appliances fixed on Rail, When Engine or vehecle passes,they explode

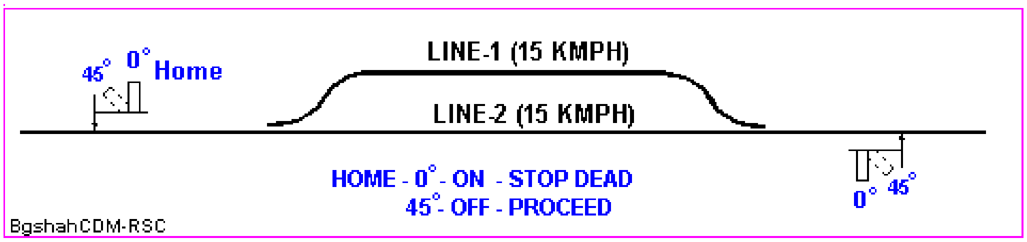
Method of using
Thick foggy weather
•Two 10 mt apart
•270 mt from signal concerned
In case of obstruction
•One at 600 mts from obstruction
•Three at 1200 mts from obstruction 10 mts apart

Possession of Signal

•Guard
•Driver
•Station master
•Gateman
•Gangmates

Chapter 3
Evolution of Signalling Systems

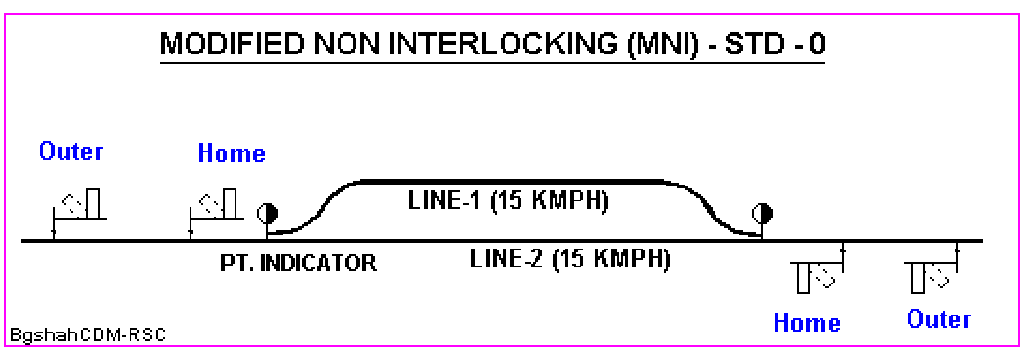
4.1.1 Rudimentary Interlocking :- The signalling system provided initially at a station, where two trains from the opposite directions can cross, consisted of an elementary type of interlocking between points and signals. The maximum speed was **restricted to 15 kmph**. Only one signal was provided at each side as shown in the figure given below. Since the location of the signal happened to be the place where policemen used to have their homes, this signal was named as **Home Signal.** The signal has two aspects viz., **'ON'** when the arm is horizontal, '**Proceed**' when the arm is lowered to 45 to 60 degrees below the horizontal.



4.1.2 The disadvantage with this arrangement is that there is only one signal protecting any obstruction in the station. If by mistake any driver ignores this signal, there is a possibility of a serious accident. Hence it is necessary to have a second line of defense by adding one more signal in rear of home signal. This signal is called an **Outer signal.**

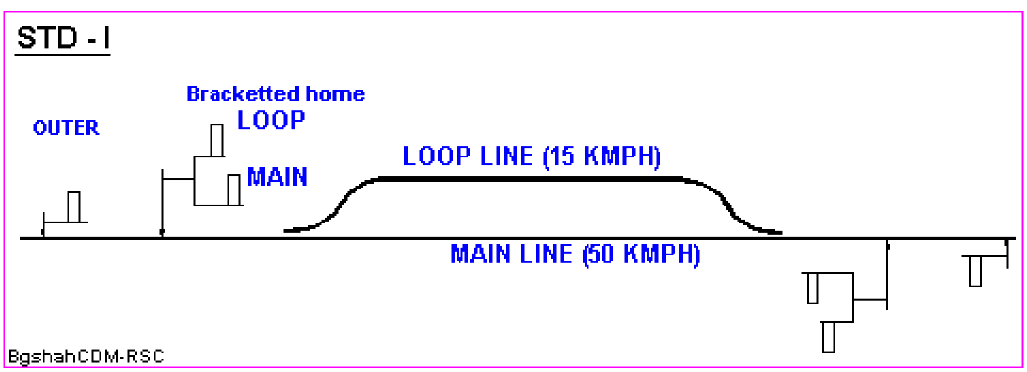
Provision of an **Outer Signal** also facilitated shunting within the station, as the movements between home signals at either ends at a station can be permitted without the need to take line clear from the other station. Since the maximum speed permitted on all lines at a station is only 15 kmph, no separate indication is given to driver at the home signal as to which line his train is being received.

However, it is always desirable to indicate to the driver the line on which his train is being received. For this purpose point indicators are provided at the points which will indicate whether a point is set for the straight or for the turnout. This type of signalling is called **Modified Non Interlocked or Standard "0" Interlocking** (Standard Zero Interlocking).



4.2 The next stage in the evolution is to permit a higher speed of **50 kmph** when the train traverses the straight route over a point. The speed of a train is always restricted to 15 kmph when it traverses the other route because of curvature. The line on which a higher speed was permitted is called a 'Main Line' and all other lines are called 'Loop Lines'. Indication is also given to the driver at the home signal itself whether the train is being received on the main line or loop line by having a bracketed home signals with the number of arms equal to the number of lines at a station and the arm corresponding to the main line placed at a higher level.

Since the route is indicated by some signal itself, the point indicators are eliminated in this system. This system is known as Standard I interlocking. This system has bracketted home signals and outer signals for the reception of a train. However, no signals are provided for the dispatch of a train. Start permit memos are given to the driver as an authority to start the train. The lay out of a standard I interlocked station is given below. The maximum speed permitted over the facing point on the **main line is 50 kmph.** The maximum speed on the **loop line is restricted to only 15 kmph**.



4.3.1 The next stage in the evolution is to permit unrestricted speed subject to the maximum permissible speed on the main line. This system is called **Standard III** interlocking. Two requirements are considered very essential in this system. Firstly, it is essential to provide dispatch signals for authorizing driver to leave the station. Secondly when the speed permitted on the main line is quite high, it is essential to inform the driver while he is approaching the station whether he is running through the station. This information will facilitate the driver in maintaining the maximum speed while passing through the station and thus result in considerable reduction of running time between stations.

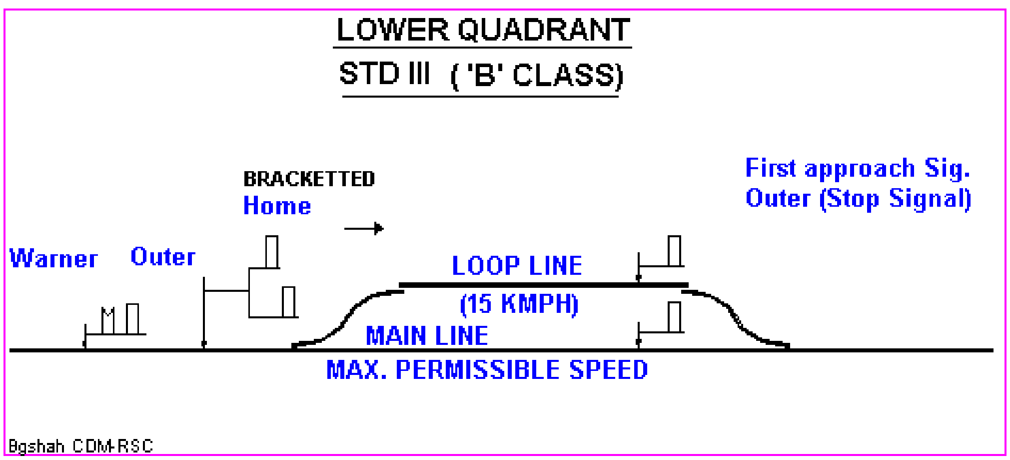
4.3.2 The signals used in this system is capable of displaying only two information to the driver viz., stop or proceed, it is necessary to adopt some means to indicate the third information of run through main line. This is achieved by providing one more arm below the outer signal. This arm is called **Warner** signal. The Warner signal has a fishtailed arm, unlike other signals which have square ended arm, and is called a '**Permissive**' signal. The different information conveyed by the combination of Outer and Warner signals are as indicated below :-

Outer Horizontal & Warner Horizontal : Stop Dead

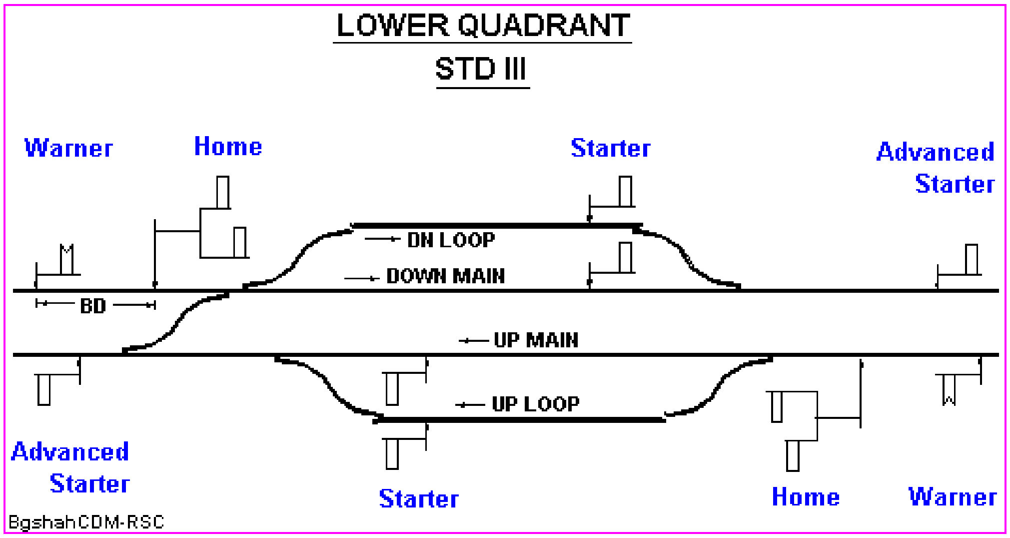
Outer lowered 45-60 & Warner Horizontal : Stop at Station

Outer lowered 45-60 & Warner lowered 45-60 : Run through Main line

4.3.3 This system is called **Lower Quadrant, B Class** where the first approach signal at a station happens to be **Outer** signal, which is a stop signal. The driver approaches this signal without pre-warning and when this Signal is at **ON**, the driver has to necessarily stop at this signal. The safety depends entirely on the vigilance of the driver and the visibility offered by the outer signal. Hence this system is not considered suitable for speeds higher than 100 kmph. **For high speeds, the first signal should not be a stop signal and the first stop signal should also be pre-warned.** The layout of a station with Standard III interlocking is shown in the following figure.



4.4.1 As pointed out in para 4.3.3 the main disadvantage of Lower Quadrant B Class is that First approach signal at a station is a stop signal and the driver approaches this signal without pre-warning. To overcome this shortcoming, a system of signalling was adopted in 50's on Indian Railways especially on high speed and heaving density double lines. In this system, called Lower Quadrant 'A' Class, the first signal at a station is not a stop signal but a permissive signal. The Warner which is provided in 'B' Class system below an Outer was separated and provided as a separate signal at braking distance in rear of Home Signal and the Outer Signal is eliminated. The arrangement is shown in the figure given below.



4.4.2 Since Warner is a permissive signal, this does not have a stop aspect and has only two aspects. When the Warner arm is horizontal, it means caution, i.e. the train may be required to stop at Home signal, which is the First stop signal. **Warner lowered to 45-60 degrees means proceed i.e. the train is running through the main line. For run through, via loop line, Warner cannot be lowered. Thus, Warner is lowered only for run through via Main Line.**

Hence this system is ideally suited for a section where number of trains run through most of the stations. Warner can convey only two information, viz., Caution or Proceed. When the train has to be stopped at the station either on main line or loop line, the Warner has to display only Caution aspect. The Caution aspect of Warner thus gives ambiguous information. The caution aspect may be due to a train stopping at Home signal or main line Starter or loop line Starter. Since the most restrictive of these three information is stop at Home, the drivers are forced to apply brakes when the Warner is displaying Caution aspect. The other two information can be confirmed only after seeing the aspect of the Home signal. Since the brakes must have already been applied, the trains which are stopping at station lose considerable time. This system has the advantage of having first signal viz., Warner a Permissive signal. However, the disadvantage of ambiguous indication is due to LQ system, where two information can only be displayed. So the only way to eliminate an ambiguous information is to go in for multiple aspect signalling where signals can display more than two information.

4.5 MAUQ System :- In this system the signals can display three information. Since for high speed operation, the first signal at a station has to be a Permissive signal, in MAUQ system also the first signal is a Permissive signal, **but called Distant Signal and has three aspects**. The change of name of the first signal from Warner to Distant is necessitated because Distant signal is not going to convey the information, which was conveyed by Warner in Lower Quadrant system. The main purpose for which Warner signal was introduced was to convey the information of running though main line. Thus Warner is a Speed signal, because if Warner is cleared, the train can go at a maximum speed through station and Warner can be cleared only after all the dispatch and reception signals for the main lines have been cleared. However, Distant signal displays three aspects - arm 0 degree or arm raised to 45 degrees or arm raised to 90 degrees. The information conveyed by these three aspects are –

Distant Signal Name of the Information

Arm Aspect

0Degree	Caution	Stop at Home
45Degree	Attention	Proceed and be prepared to pass next signal at such restricted speed as may be prescribed by Special Instructions. Train is being received either on Main line and is required to stop at the Starter signal; or on a Loop line required to stop at the Starter signal or to pass run through via Loop Line
90Degree	Proceed	Run Through Via Main Line

4.6 Since MAUQ signalling has the advantages of pre-warning and having first signal a Permissive signal, this system is being extensively used on all important routes. In sections provided with 25 KV traction, Semaphore signals cannot be used, as the visibility of Semaphore signals are very much affected by the presence of overhead traction wires and fittings. Hence it is necessary to go in for Colour Light Signals in electrified section.

This system is called Multiple Aspect Colour Light Signals (MACLS) and is identical to MAUQ except the identification of a Permissive signal and display of route. The Permissive signal is identified by a painted black letter P on a white board. In case the signal is blank, (P) marker is an authority for the driver to pass this signal. The route in case of MACLS in indicated by a single yellow or green light for main line or yellow with a row of 5 white lights for loop lines. The row of 5 white lights is called a junction type indicator. It is possible to indicate up to a maximum of 6 loop lines and a main line with Junction type route indicator. In case of junction stations or terminal stations where there are more than 7 lines, a different type of route indicator called multilamp indicator is used. Multilamp indicator displays the line number by an arrangement of lamps with 7 rows and 5 columns. It is possible to display up to 19 lines with this multilamp indicator.

4.8 Comparison of different systems

1. Lower Quadrant 'B' Class :- No. of aspects .. Two

First stop signal is Outer. Run through main line given by lowering of Outer and Warner. First approach signal is a stop signal with no prewarning. Safety depends on the visibility of the first stop signal. Not suitable for high speeds. Also not suitable for stations where there is rising gradient at the approach to the station, where a loaded goods train if stops, will not be able to restart. Shunting is possible in station section without taking line clear from the other station.

2. Lower Quadrant 'A' Class :-

No. of Aspects …. 2

First approach signal - Permissive signal - Warner on a separate post.

Suitable for high speed section, especially on a double line where most of the trains run through.

Also provided on single line stations with a rising gradient at the approach to the station to avoid stopping of trains on rising gradient.

Ambiguous indication given by caution aspect of Warner.

Not suitable for sections where most of trains stop at number of stations.

Shunting is possible only between Starter to Advanced Starter without taking line clear.

Line clear can not be granted if all the reception lines are occupied. Hence generally full train length is provided in advance of starter to draw ahead a train and grant line clear, when all reception lines are occupied.

3. MAUQ Signals/MACLS :-

No. of Aspects ……. 3

First approach signal is a Permissive signal.

Prewarning of all stop signals.

Suitable for run through and stopping trains single line or double line, high speed section.

Shunting is possible in station section.

Run through indication given close to the station.

4.9 Comparison between Distant and Warner signals :-

	WARNER		**DISTANT**
1.	APPEARANCE		
	Fish tailed arm Red with white band		Fish-tailed arm Yellow with black band

	Night - Green/Red Two Aspects.		Yellow Two/Three Aspects
2.	LOCATION		
	On a separate post at braking distance in rear of First stop signal. Below Outer/Home. LQ/MLQ Sections.		Always on a separate post at braking distance in rear of First stop signal. MAUQ/MLQ/MACLS Sections.
3.	CLEARANCE		
	Can be cleared only all stop signals for main line are cleared.		Can be cleared after Home signal is cleared.
4.	INDICATION		
	Clearance indicates run through main line.		Cleared to 45 degrees Proceed and be prepared to pass next signal at such restricted speed as may be prescribed by Special Instructions. Train is being received either on Main line and is required to stop at the Starter signal; or on a Loop line required to stop at the Starter signal or to pass run through via Loop Line; Cleared to 90 degrees Run through via Main Line
	Speed signal.		Route Signal..
5.	NORMAL ASPECT		
	Caution (Permissive signal) stop at Home, Main line reception, loop line reception. Ambiguous. Can be fixed in case of junction/terminal stations non- working.		Stop at Home Unambiguous. Always working.

Chapter 5
Basic Concepts of Signalling

5**.1.1 Braking Distance :-** Braking distance is an important concept in signalling and is a very crucial factor in determining intersignal distances. The distance covered by a train after the brakes are applied is defined as the braking distance.

5.1.2 Factors affecting Braking Distance :- Important factors affecting braking distances are -

1. Train Speed

2. Train Load

3. Gradient

4. Brake Power

5. Types of Brakes

6. Condition of Rails

7. Rail/Wheel Adhesion

5.1.3 The most important factor affecting braking distances is **train speed.** The braking distance is proportional to the square of the speed. The next important factor is load of the train. The momentum of a train depends on the **load**. Therefore, **goods trains have longer braking distances than passenger trains.** Gradient also has an effect on the braking distance. If there is a fall in gradient, the momentum of a train is increased and the braking distance will also be more. Therefore, in case of very steep gradients, as in the case of Bombay-Ghat Sections, it may be necessary to impose a speed restriction to reduce the braking distance.

5.1.4 The two other important factors affecting braking distance are **brake power and types of brakes**. Since in trains continuous braking is necessary, it has to be ensured before starting a train that the brake power is adequate. A certificate to this effect called Brake Power Certificate is given by a Train Examiner (TXR) to the driver/guard of a train. It has also been stipulated that in case of passenger trains the brake power availability should be 100% (brakes are effective in all coaches) and in case of goods trains brake power availability should be at least 85%. Drivers are also required to conduct brake tests while the train is in motion and satisfy themselves that brake power available is adequate. In some cases, specific tests are also conducted on all the trains to check the brake power availability. Fixed boards are provided on the track for this purpose. The drivers are required to apply the brakes when they approach the board and the trains should stop before the board provided ahead. The distance between the two boards is equal to the normal braking distance at the maximum load/speed gradient. If the driver is not able to stop within the board provided ahead, he has to immediately inform the train examiner from the next station about the inadequacy of brake power.

5.1.5 The braking distance is also influenced by the type of brakes provided. The different types of brakes used are - (i) vacuum brake (ii) air brake (iii) electro pneumatic brakes and (iv) disc brake. Most of the passenger coaches and goods wagons on Indian Railways are fitted with vacuum brakes. Since the destruction of vacuum from the engine to the last vehicle takes more time as compared to other types of brakes, vacuum brakes are least efficient of all and require longer braking distance. Besides, maintenance required in case of vacuum brake fittings is also more. Hence vacuum brakes are gradually being replaced by air brakes, especially in case of high speed trains like Rajdhani Express/Shatabdi Express and in case of wagons used for heavy haul operations. These wagons are painted green. The braking distances required with air brakes are only 40% to 50% of the braking distances required with vacuum brakes. Even air brakes require some time for application to all coaches. To further reduce the delay in the application, Electro-pneumatic brakes are used, where brakes at all coaches can be applied simultaneously. This will result in the minimum braking distance. Electro-pneumatic brakes (EP) are provided in the suburban electric multiple unit trains (EMU). A suburban train running with super dense crush load at 90 kmph can be stopped within a distance of 400 metres because of EP brakes. Disc brakes are normally used for speeds higher than 160 kmph to reduce the braking distance.

5.1.6 The condition of rail would also affect the braking distance. If the rail table is wet, braking distance would be more. Another factor affecting braking distance is rail/wheel adhesion. The normal adhesion ranges from 0.035 to 0.12. Too much of adhesion is also not considered desirable as this would cause the wheels to skid.

5.1.7 Types of Braking Distances : - The brakes can be applied suddenly or gradually. When the brakes are applied suddenly, the braking distance required would be less but the rate of deceleration may cause discomfort to passengers and in case of freight trains, may damage the consignments. The braking distance with sudden application of brakes is called Emergency Braking Distance (EBD). The drivers are not supposed to apply sudden brake application unless there is emergency. The drivers are normally supposed to apply brakes gradually, so that the braking may not cause discomfort to passengers. The braking distance obtained with gradual application of brakes is called Service Braking Distance (SBD) or Normal Braking Distance (NBD). SBD is 1.2 times EBD. **The intersignal distance is always based on Emergency Braking Distance.**

5.1.8 Actual Braking Distance : -RDSO had conducted Emergency braking trials with Mail/Express trains at various speeds and with freight trains. The details of braking distances are given below :

Main /Express Trains

EBD for Mail/Express trains at 100 kmph	1.0 km
EBD for Rajdhani Express at 130 kmph	1.3 kms (level gradient) 1.5 kms (1 in 200 falling)

EBD for Shatabdi Express at 140 kmph 1.8 kms

Freight Trains

EBD for a freight train with 72 4-wheeler wagons at 72 kmph with a trailing load of 2700 t.	1.3 kms - 1.4 kms (level gradient) 1.6 kms (1 in 200 falling)

The braking distances with air brakes in case of freight trains is only 50% of the EBD with vacuum brakes. However in case of Mail/Express trains, provision of air brakes will not result in the reduction of EBD because braking rate can not be increased beyond a limit in case of passenger trains. However additional coaches can be attached without an increase in the braking distance.

5.1.9 Since the EBD for a Mail/Express train at 100 kmph is 1 km, inter-signal distance has been kept as 1 km. The difference between SBD and EBD is provided as an additional visibility distance for every signal.

5.2 **Reaction Time** : - When the driver approaches and observes a signal, he can not be expected to instantaneously react to the aspect of a signal, but only after some time. This time is called the reaction time. When the driver is in the process of reacting to the aspect of a signal, the train is running at maximum speed and distance covered during this reaction time is called 'reaction distance' (RD). **The reaction distance on Indian Railway is taken as 200 m**. Reaction Distance plays a crucial role while determining the minimum visibility required for a signal. In case of Lower Quadrant 'B class', the minimum visibility required for outer signal should be at least equal to Emergency Distance + Reaction Distance i.e. 1.2 km. This is the disadvantage in having a stop signal without prewarning.

5.3.1 **Minimum Visibility Requirements** :- Railway Board have specified the minimum visibility required for signals in different systems. The minimum visibility requirements as stipulated by Board are given as under:-

Lower Quadrant System

OUTER -

if the approach speed >100kmph 1.2 km.

if the approach speed <100kmph 0.8 km.

Home 400 m.

Main Line starter 400 m.

Loop Line starter 200 m.

For MAUQ/MLQ/MACLS All signals 200 m. (RD)

5.3.2 The visibility required for Home signal is only 400 m because Home signal is pre warned by Outer signal. The Outer signal can be cleared only after clearing any one of the Home signals. The visibility requirement of MAUQ/MACLS/MLQ is equal to Reaction Distance since all signals are pre warned in these systems. However, if only 200 m visibility is provided for a signal, then the driver is required to apply Emergency brakes when a signal is showing On aspect, since Intersignal distance is kept as Emergency Brake Distance. Normally, the drivers are required to apply service brakes. Hence the practical visibility should be equal to RD + (SBD -EBD). Since SBD - EBD = 200 m., the practical visibility required would be 400 m. This visibility should be insisted for all signals.

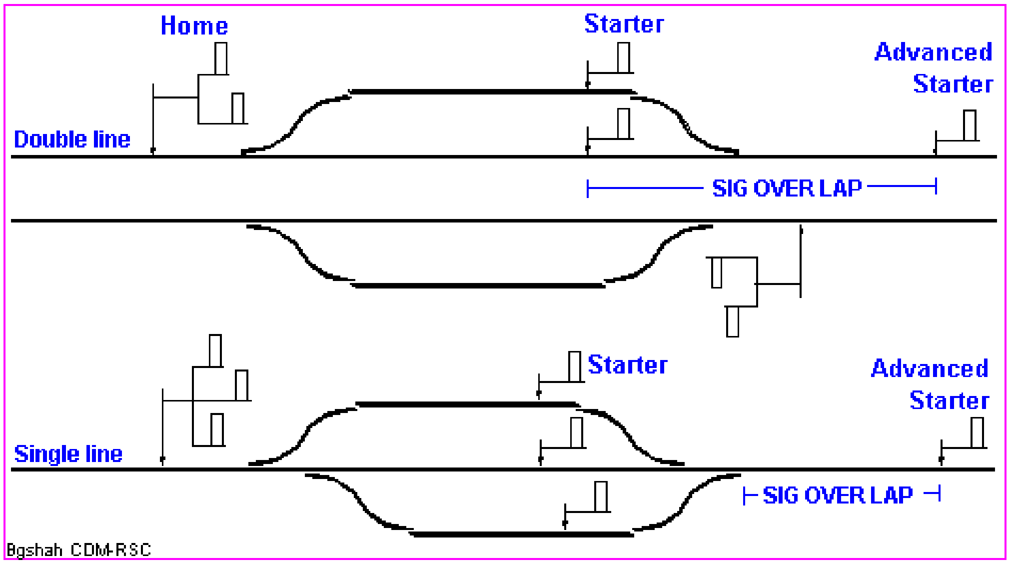
5.3.3 **Sighting Committee** :- Fixed signals can be commissioned only after ascertaining the minimum visibility available for these signals. The visibility test is done by a Committee called Sighting Committee consisting of senior supervisors from motive power department (Electrical or Mechanical), traffic department and signal department. They will go by Footplate, or trolley and check the visibility during day and night. The signals can be commissioned only on clearance by Sighting Committee. Efforts are taken to improve visibility of semaphore arm, by providing tall posts so that the signal could be seen from a long distance. Similarly, in case of colour light signals, the visibility is improved by superior lens system. However, visibility of signal becomes a problem in case of semaphore signals during night time. Night visibility is normally provided by kerosene lit lamps. The night visibility entirely depends on the upkeep of lamps by station staff. There is also a problem of kerosene lamp going out in which case it is a problem to lit the lamp again especially if the signal is located far from the station. Hence the kerosene lit lamps which are far away from the station like outer/Warner/distant are being replaced by electrically lit lamps.

5.4.1 It is essential to provide a safety margin ahead of a stop signal to act as a cushion in case driver passes a signal at danger. This safety margin can only take care of minor equipment failure or misjudgment by the driver. It can not offer protection when the driver is negligent or disregards a signal. The safety margin is defined as adequate distance in the General Rules. First stop signal is considered more important from the safety point of view as the drivers approach the signal with maximum speed. Hence safety margin provided should be more in case of first stop signal.

5.4.2 The safety margin provided for the first stop signal should be kept clear, before the line clear is granted for a train to enter block section, as the Station Master in advance can not have any control over the train once the line clear is granted. The granting of line clear is also called block operation. **So this safety margin ahead of first stop signal is known as block overlap.**

5.4.3 The other type of overlap is required for any stop signal is called signal overlap. **The length of track in advance of a signal which should be kept clear before the signal in rear can be cleared is signal overlap**. In manually operated signals, the signal overlap is generally provided for Home signals. In case of automatic signals, all signals are provided with signal overlap.

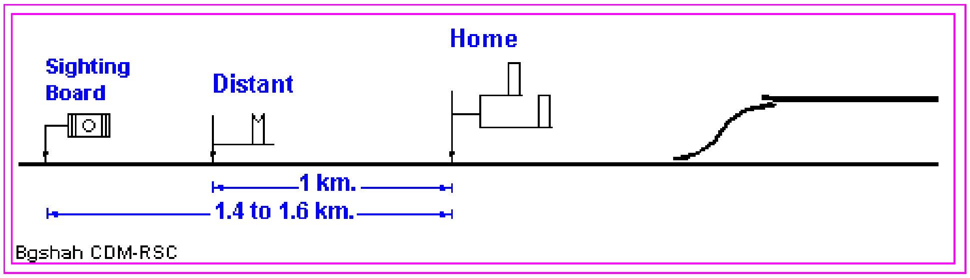
5.4.4 The point from which the signal overlap is to be considered for Home signal depends on whether a section is a double line section or as single line section. In case of double line section, since there is unidirectional traffic, the overlap is considered from next stop signal viz., Starter. Whereas in case of single line, the traffic is from both the directions, hence an extra safety margin is required. So the signal overlap is considered from the outermost trailing point as shown in the figure below. However, with the approval of Commissioner Railway Safety, even in case of single line also, the signal overlap for Home signal can be considered from starter signal.



5.4.5 The details of two types of overlaps are given below :-

Name of overlap		**Meant for signal**		**Point of consideration**		**Overlap distance**
Block		**Last stop signal of the station in rear**		**From first stop signal**		**LQ - 400 m** **MAUQ/MACLS/MLQ - 180 m**
Signal		**Normally for Home signals (manual sections)**		**From starters (double lines) from outermost trailing point (single line)**		**LQ - 180 m** **MAUQ/MLQ/MACLS - 120 m**
		All signals (Automatic sections)		**From next signal in advance**		**120 m**

5.5.1 **Warning Boards** :- The Warning Board is an indication to the driver that he is approaching the first stop signal or a gate signal. This board, however, does not indicate to the driver the aspect displayed by that signal. Since the Emergency Braking Distances are different for passenger and goods trains, there are two types of Warning Boards, one for passenger and the other for goods trains. The drivers are required to look for the signal from the Warning Board. If the signal aspect is not visible, the driver should immediately apply brakes.



5.5.2 **Passenger Warning Board :-** The Passenger Warning Boards are placed at 1 Km. in case of B.G. and 960m. in case of M.G. in rear of the first stop signal. If the first stop signal is pre-warned by a Warner signal (LQ/A Class) or a Distant signal (in case of MAUQ/MACLS/MLQ), no passenger Warning Board is provided, the permissive signals themselves serve the purpose of Warning Board.

5.5.3 **Goods Warning Board** :- The Goods Warning Boards are provided in case of B.G. where goods train speeds are above 72 kmph. And located at 1.4 km. to 1.6 km. in rear of first stop signal (Outer/Home). Since EBD for Rajdhani Express is almost equal to that of Goods trains, the Goods Warning Board will be used in case of Rajdhani Express also.

5.5.4 The Warning Boards are provided with reflectors to give good visibility during night time.

5.6.1 **Isolation** :- In any station or yard there could number of simultaneous movements. These movements should not interfere with each other. Besides, when loose vehicles (vehicles not attached to an engine)could roll and obstruct important lines, isolation is a method adopted to protect important lines in a station/yard. The important lines are those - (i) where speed is above 50 kmph, (ii) all passenger lines as compared to goods lines/siding and (iii) goods lines as compared to sidings.

5.6.2 **Rules of Isolation** :- There are three rules of isolation as given in Rules for Opening Railways. These rules ensure the protection of important lines. The rules are -

(i) The line on which speed is higher than 50 kmph should be isolated from all other running lines.

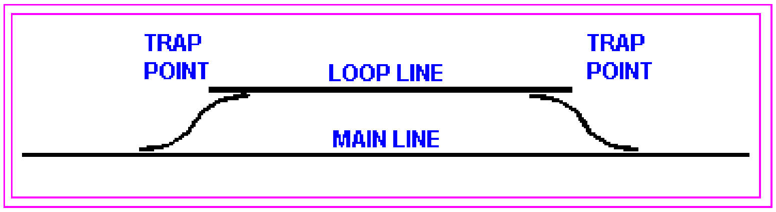
(ii) All passenger line irrespective of the speed should be isolated from goods lines/sidings.

(iii) It is desirable to isolate goods lines from sidings.

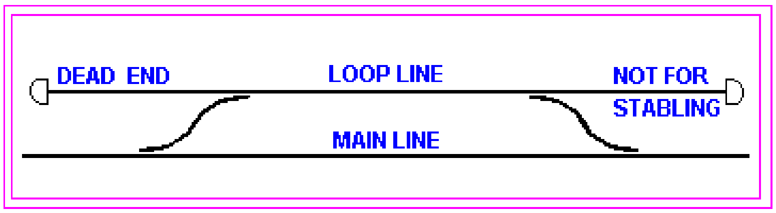
Rules (i) and (ii) are obligatory. Rule (iii) is optional.

5.6.3 **Methods of Isolation** :- In all the methods of isolation, the two lines are not directly connected but through a cross over. The different methods are -

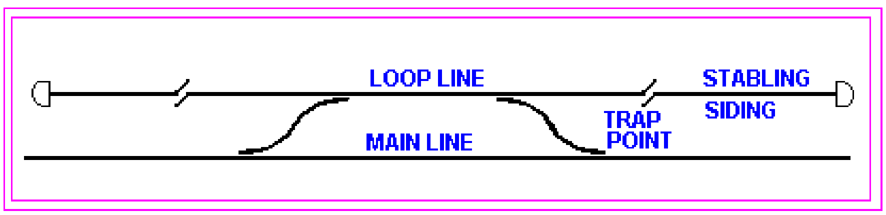
(i) **Trap Points** :- Trap points are points with single switch. In the normal position or open position, when any vehicle passes over the point, it gets derailed. So, it is not desirable to provide trap points on lines where there are frequent movements.



(ii) **Dead End** :- This is another method where instead of a trap point, the unimportant line is connected to a dead end, so that when any vehicles escape from this line or when there is simultaneous movements, the line will be set to dead end. The only disadvantage is that dead ends serve only as a method of isolation and no vehicle is permitted to be stabled on this line. Since the dead ends are connected to running lines, it is necessary to isolate them from sidings. IF any vehicle is stabled on a line it becomes a siding. In case, a stabling facility is required, dead end with trap point is provided.

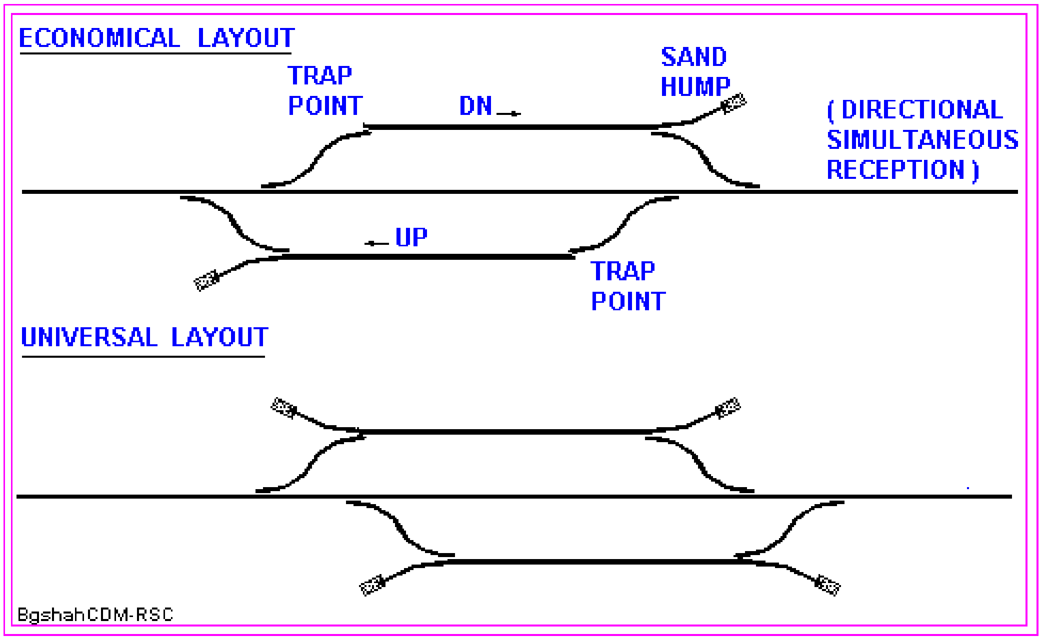


(iii) **Dead End with Trap Points** :- This method is adopted wherever a stabling facility is required.



All these three methods are used only for the purpose of isolation and protecting an important line from an unimportant line. However there is one more method which serves two purposes viz., isolation and a substitute for signal overlap. Hence this method is very extensively used.

(iv) **Sand Humps Or Snag Dead Ends** :- Sand hump or snag dead end is a small length of 60 m of track connected to a running line normally loop lines. This track is on a slightly rising gradient and filled with sand. Hence is called sand hump. The purpose of the rising gradient and sand is to retard the movement of any vehicle over the sand hump. The advantage with this method is this sand hump is a substitute for signal overlap and can be used for simultaneous reception/despatch of trains. In a single line since signal overlap is to be considered from outermost trailing point, when two trains approach simultaneously from either direction, one of the train has to be kept waiting at home signal while the other train is being received. Stopping of a train besides resulting in loss of time, increases fuel consumption. Hence simultaneous reception is considered very advantageous. Two trains can be received simultaneously on loop lines by making use of sand humps. There are two layouts with sand humps. One is called economical layout, where only two sand humps are used. This has the disadvantage that the simultaneous reception can only be directional. The other called universal where 4 sand humps are used and simultaneous reception can be in any direction. The two different layout are shown in the diagram given below.



5.6.4 Normally, no sand humps are permitted on main lines where speeds are high. But there are two exceptions where sidings are provided on the main line to protect the main line. All station yards are to be located at a gradient flatter than 1 in 400. But there could be a falling gradient towards a block section in the vicinity of station. In such cases it is necessary to protect the block section from loose vehicles escaping from the station. So the main line is normally connected to a small siding called slip siding. Any vehicle escaping from the station slips into the siding and thus protecting the block section. The slip siding is protected by a stop signal and the signal can be cleared after the siding is set for the mainline. As soon as the train passes the slip siding, a warning bell sounds in the cabin to remind that the point is required to be restored to the normal setting. Slip siding is required to be provided wherever there is falling gradient of 1 in 100 or steeper towards block section.

The other exception is the in the case of ghat section, where is a continuous falling gradient in the block sections, it is necessary to protect the station section as there is possibility of a train getting out of control and collide with a vehicles at the station. The main line in the block section is connected to a siding called catch siding. The length of catch siding may vary from a short length to full train length depending on the gradient in the section. Catching siding are required wherever the gradients are 1 in 80 or steeper. The catch siding is also protected by a signal. The signal can be cleared only after the train comes to a stop at the signal, in case of trains stopping at a station. In effect, the signal overlap for this signal is extended to on block section.

Chapter 6
Signal Layouts

6.1 The layout of signals at a station depends on the type of signal system adopted. For speeds above 50 kmph, five types of system can be adopted :

i) Lower Quadrant "B" Class

ii) Lower Quadrant "A" Class

iii) Multiple Aspect Upper Quadrant (MAUQ)

iv) Multiple Aspect Colour Light Signals

In the layout of signalling, signals at a station will be shown besides Warning Board. In the layout, Block Overlap, Signal Overlap, Station Section and Station Limits are also indicated. In addition, for each system, an aspect control chart is also given, which shows the aspects of various signals at a station for different conditions of train receptions. The reception of a train at a station can be classified as :-

i) Stop at Home Signal

ii) Main Line Reception - Stop at M/L Starter

iii) Loop Line Reception - Stop at L/L Starter

iv) Run Through Main Line

v) Run Through Loop Line

6.2 The engineering layout at a station has to fulfill the requirements specified by rules. The aspects to be considered and shown in the Engineering Layout are :-

i) Indication of fouling marks, where two lines cross or join with each other.

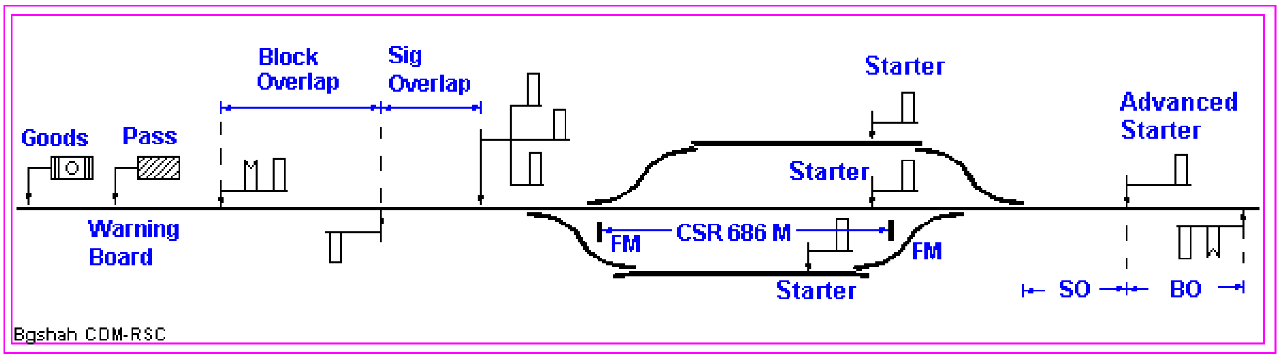
ii) Requirements as per rules for isolation. Normally, trap points are provided for isolation purposes. However if simultaneous reception/despatch is required, sand humps are provided.

iii) In case of double lines, a facility to change over to the other line should be provided. For this purpose, a cross over connecting up and down lines is provided in the trailing direction. The reason for providing cross over in the trailing direction is that the safety requirement for such cross over is far less as compared to a cross over in the facing direction. However, if only an emergency cross over in the trailing is provided on a double line station, in case of emergencies to divert a train from the normal to the other line, lot of effort and time is required. Hence, in order to save time, it is advisable to provide one cross over in the facing and one in the trailing direction at a station to give the facility of receiving train from both directions on one of the loop line called "common loop". This will facilitate direct dispatch of trains from one loop and thus result in saving of considerable time.

iv) Reception lines should have the length to accommodate a longest goods train from FM to FM. This length is called clear standing room (CSR). The CSR is calculated as the length of 72 veh. (4 wheeler goods wagons) + 2 E + 1 IC (Inspection Carriage) + 7% (of total length of wagons) for brake pipes etc. This will work out to 686 m in case of BG. In case of MG it will be about 600 m. It is necessary to provide CSR of at least 686 m. in case of BG between starter signal to starter signal or Fouling Mark to Fouling Mark where starter signals are not provided.

6.3 The signalling arrangement can be shown after the Engineering layout is prepared. The signalling arrangements for four systems are shown in the next 4 paras.

6.4.1 Signalling with Lower Quadrant 'B' Class on single line :-

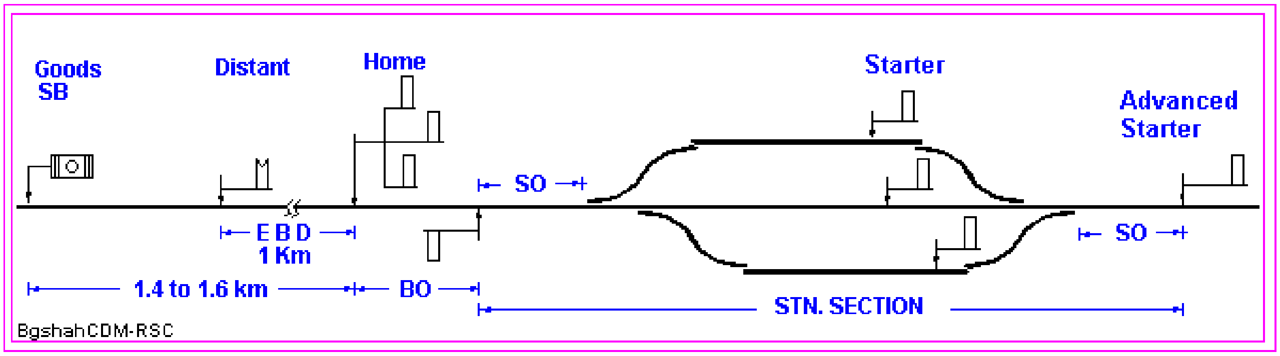


6.4.2 Locations of Signals

- Starters are located at the Fouling Marks
- Advanced starter is located at 180m. (Signal Overlap) from outermost trailing point
- Home signal is located at 15m. from the first facing point
- Outer/Warner is located at 400m. (Block Overlap) from advanced starter to provide the facility of simultaneously receiving a train from one direction and giving line clear for a train in the opposite direction
- Passenger Warning Board located at 1 km.(EBD) from Outer Signal (First Stop Signal)
- Goods Warning Board Located at 1.4 to 1.6 km. from Outer
- Block Overlap 400 metres from first stop signal (Outer)
- Signal Overlap 180 metres from outermost trailing point (upto Adv. Starter)
- Station Section Advanced Starter to Advanced Starter

- Station Limit Outer to Outer

6.5.1 Signalling with Multiple Aspect Upper Quadrant signals on single line.

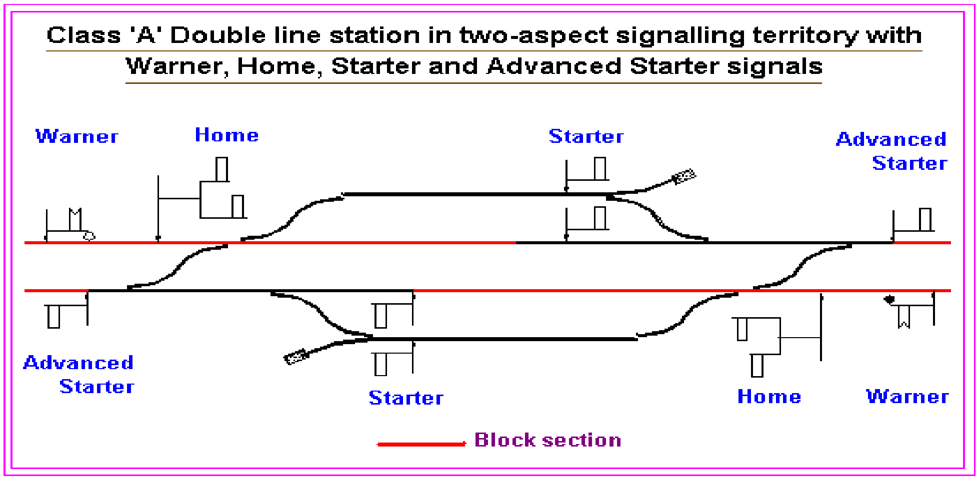


6.5.2 Location of various signals

- Starter located at the fouling mark.
- Advanced Starter located at 180 m (signal overlap distance) from outermost trailing point.
- Home signal located from 180 m (Block Overlap from Advanced Starter).
- Distant signal at 1 km (EBD) from Home Signal.
- Goods Warning Board at 1.4 to 1.6 km from first stop signal (Home)
- Block Overlap 180 m from Home (First Stop Signal)
- Signal Overlap 120 m from Outermost trailing point
- Station Section Adv. Starter to Adv. Starter

- Station Limit Distant to Distant

6.6.1 Signalling with LQ 'A' Class on Double Line



6.6.2 Location of Signals

Starters located at the Fouling marks

Adv. Starters located at Full train length (686m. B.G.)

from outer most trailing point.

Home signal located at 15m. from the first facing point

Warner located at 1Km. from Home

Goods Warning Board at 1.4 - 1.6 km. from Home

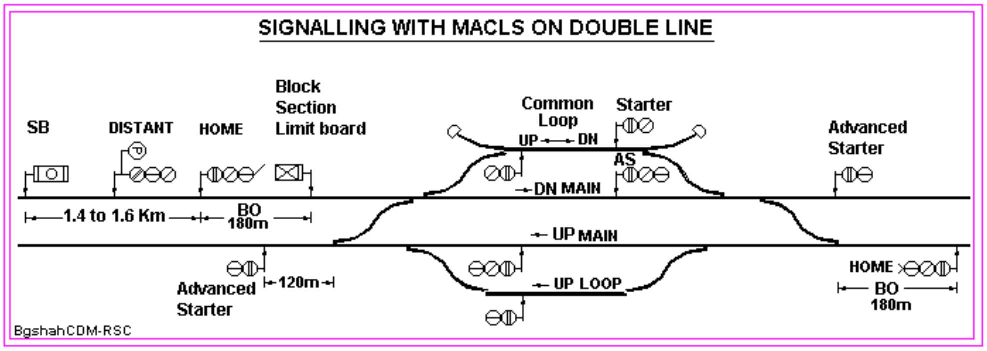
Block Overlap Home to Starter

Signal Overlap 180m. from Starter

Station section Starter to Adv. Starter

Station Limit Warner to Adv. Starter

6.7.1 Signalling with MCLS on Double Line



6.7.2 Location of Signals

Same as MAUQ single line except Home signal is located at 180m. from the Block Section Limit Board, Where there is a trailing crossover, as shown in the dia
Block Overlap:- 180m. from Home Signal

Signal Overlap:- 120m. from Starter.

Station Section:- Block Section Limit Board to

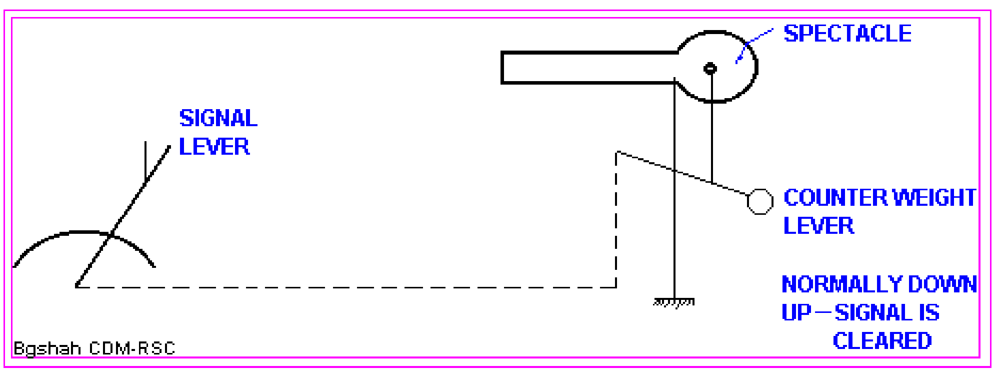
Adv. Starter or First Facing Point to Adv. Starter

Station Limit Distant to Adv. Starter in either direction

Chapter 7
SIGNAL OPERATION

7.1 Two types of signals are used on Indian Railways :- (i) Semaphore and (ii) Colour light signals. Semaphore signals can be operated mechanically or electrically. Mechanical operation of semaphore signals can be through either single wire or double wires.

7.2.1 Single Wire :- This was the first mechanical system adopted for semaphore signals. A single wire is run from the cabin to the signal. The signal is operated by pulling the wire from the lever which in turn raises the counter weight lever at the signal post. The counter weight lever is connected to the semaphore arm through a down rod. The raising of the counter weight lowers the signal. When the lever is put back to normal, the counter weight lever drops down by gravity and brings the signal to ON. The main disadvantage of single wire operation is erratic operation due to expansion or contraction of signal wire cause by temperature change. When the wire expands, the wire length increased and causes a sag in the wire. The signal can be operated properly only after removing the sag. Otherwise the signal may get lowered to 20-25 degrees below the normal. Similarly contraction of the wire cause slight drooping even when the signal is not operated. When the distance of signal is more than 300 m, a device called cabin wire adjuster is provided in the cabin. The cabin wire adjuster is operated before pulling the signal lever to remove the sag. It should be ensured that cabin wire adjuster is brought back to the normal position after every signal operation. If the cabin wire adjuster is left in the pulled condition, a signal may drop due to contraction.



7.2.2 The other disadvantages of single wire operation are -

(i) More possibility of outside interference. The signal can be operated by pulling the wire from outside or pressing the signal arm.

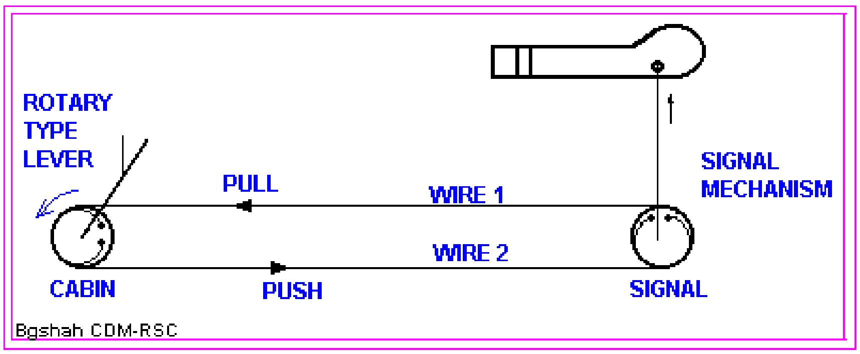
(ii) Range of operation is only 950 m.

(iii) It can be used only for two aspect signalling.

(iv) Signal return is gravity based. Damage to down rod more prominent due to return impact of signal arm.

7.3.1 **Double Wire** :- In this system, for operating any function viz. signal, point etc., two wires are used. Hence the system is called double wire. The two main advantages of double wire system are - (i) outside interference totally eliminated and (ii) automatic compensation of temperature effects.

7.3.2 The wires of the system form a continuous loop between the lever in the cabin and signal or point mechanisms as shown in the diagram given below. The lever used in the cabin is of a rotary type. When the lever is operated, the lever drum gets a rotation. This causes pull in wire (1) and push in wire (2). This pull and push in the wire causes the point or signal mechanism to operate the points or signal. The rotary motion of the mechanism is converted into a linear movement by using cams and cranks. The signal arm is connected to the signal mechanism by a rigid down rod.



7.3.3 The outside interference is eliminated by pre-tensioning the pull and push wire of the double wire system to 150 1b. by means of 205 1b. weights in the cabin. Because of pre-tensioning, it will not be possible to pull the wire from outside. The temperature effects are compensated by a device called compensator. Double wire compensators are provided for every point/signal and are generally located in the ground floor of the cabin. The three main functions of the double wire compensators are -

(i) Pre-tensioning the wires to 150 1b. with 205 1b. weights.

(ii) To maintain the transmission in constant tension by self-adjusting the variations in length due to temperature changes.

During static conditions, tensions in pull and push wires are almost equal. Since the two wires in the loop have the same length and are run out under similar atmospheric conditions, any variations in these tensions due to expansion or contraction will be equal and thus the mechanism drum will not move except the length of the transmission wires will increase or decrease as the temperature rises or falls. This change in length of the wire is compensated in the double wire operation by D.W. compensators. The two wire are loaded with 205 1b. floating weights which keep the transmission wires in constant tension and therefore at constant effective length, irrespective of expansion or contraction, by the weights of the compensator either falling to take up the expansion or rising to pay out the wires to cater for contraction.

(iii) When a break or disconnection occurs, the falling compensator ensures that the signal resumes its most restrictive aspect.

7.3.4 The advantages of double wire operation of signals are -

(i) Outside interference eliminated.

(ii) Automatic compensation against temperature changes.

(iii) Range of operation increased to 1400 m.

(iv) Can be used for two aspect or MAUQ signalling.

(v) Signal return due to the operation of lever. Hence it is smooth and impact on the signal arm considerably less.

(vi) Since the range of operation for signals is more, it is possible to have one central cabin and operate all points and signals from this cabin.

7.4 **Electrical Operation** :- The range of operation is 950 m in case of single wire and 1400 in case of double wire. If any signal is located beyond this range, it will not be possible to operate this semaphore signal by mechanical means. In such cases electrical operation using signal machine is adopted. Signal machine consists of a 12v. direct current motor and other mechanical parts. The signal machine can be operated through primary cells or secondary cells charged by solar panels, provided at signal location.

7.5.1 **Colour Light Signals** - Colour light signals are used in modern signalling systems. The main advantages to colour light signals over are semaphore signals are

i) Day and night aspects are same.

ii) Range is considerably more.

iii) It can be used to display more than 3 aspects.

iv) Ease of operation.

v) No moving points

vi) Night visibility is far superior to semaphore signals. In electrified section the visibility of semaphore signals is very much impaired by the presence of OHE (Overhead Equipment) structures, insulators and catenary wire. It is necessary to go in for colour light signals to get better visibility.

7.5.2 In colour light signals, an electrical lamp operated with 12v and a superior lens assembly are provided to get a visibility around 1 km. The lens assembly consists of an inside coloured lens (red, yellow or green) and an outside plain lens. The assembly is called double combination of lenses. The signal lamp is kept at the focal point of the inner lens. It is possible to tilt the signal lamp both vertically and laterally to bring it to the exact focus of inner lens. This operation is called focusing the signal. All lenses are provided with hoods to prevent the sun's light from falling on the signal and reducing the visibility.

7.5.3 There is one serious problem of signal displaying no aspect with colour light signal. This can happen due to a signal lamp fusing or power supply failure. A signal lamp fusing is taken care of by procuring good quality lamps from approved suppliers after thorough inspection and testing before using them on the signals. In spite of these precautions, it is quite possible that some signal lamps fuse prematurely before their normal rated life of 1000 hours. So, a safety feature called cascading or cutting in arrangement is adopted to prevent a blank signal. In the cascading arrangement whenever, a signal lamp of an aspect fuses, the next restrictive aspect is automatically brought in. For example, if a signal lamp is displaying green and the green lamp fuses, an yellow aspect will be displayed automatically. Similarly, if a signal is displaying yellow and the yellow lamp fuses, a red aspect will come automatically. But if a signal is showing red and the red lamp fuses, the signal will be blank. To prevent this occurrence, all red lamps are provided with two filaments. One main filament and an auxiliary filament. The life of the auxiliary filament is prolonged by rating it for higher voltage (16v) and operating at a lower voltage (12v). When a main filament fuses, the signal will be dim with auxiliary filament . All off aspect lamps are provided with single filaments. Red aspect lamps of the stop signals and yellow aspect lamps of the Distant signals are provided with double filaments.

7.5.4 The power supply failure is taken care of by providing three sources of power for colour light signals. In case of double line sections with 25 kv electric traction, the three sources of power are -

i) power tapped from Down Line - Normal source

ii) power tapped from Up Line - Standby source

iii) local power (power from Electricity Board or diesel generator).

Single line sections with 25 kv electric traction

i) power tapped from Up/Down line - Normal source

ii) local power (EB)

iii) diesel generator

Sections without electric traction

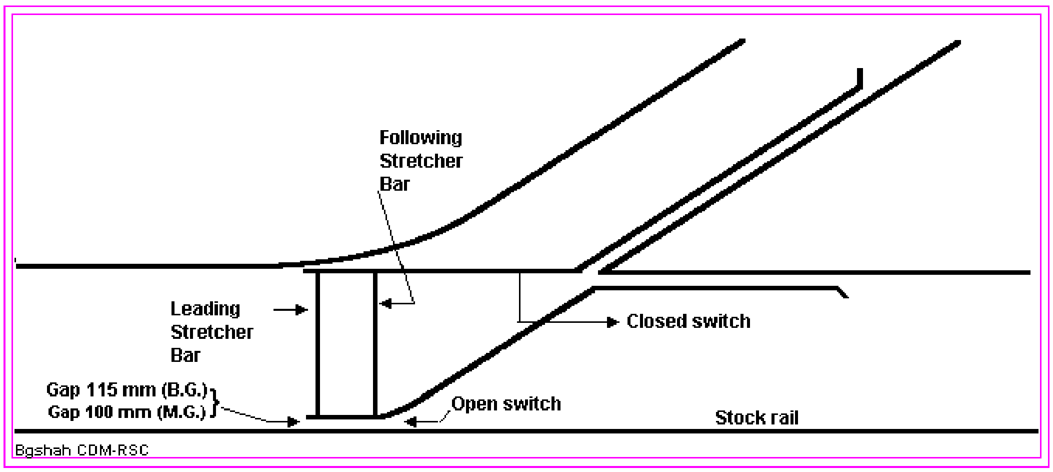
i) local power - Normal traction

ii) 2 - diesel generators

Even though 3 sources are provided, when one source fails, the power supply has to be changed over to the alternate source manually. During this change over time, the signal will be blank. This situation is not considered desirable especially in a heavy density route with electric traction. So, in such section an uninterrupted power supply (UPS) with battery and inverter is provided.

Chapter 8
POINT OPERATION

8.1 Points are the most important equipment provided to change the path of a train from one line to another. Points are classified as facing or trailing. Point assembly consists of two fixed rails called stock rails and two movable rails called switch rails. These two switch rails are kept in position by two stretcher bars, leading and following stretcher bars. At any time, one of the switch rails should be housed with stock rails and there should be sufficient gap between the other switch rail and stock rail. The switch rail, which is housed with the stock rail, is called closed switch. The switch which has a gap is called open switch. The point assembly is shown in the following sketch.



8.2 There are some safety considerations to be fulfilled in the operation of a point especially facing point. The considerations are -

i) A suitable means to set the point to one of the two positions.

ii) A lock to prevent the movement of the switches due to the vibration of train.

iii) To prevent the operation of point when it is occupied by a vehicle.

iv) Means to ensure that closed switch is housed and locked properly.

8.3.1 Setting - A point is said to be set :-

i) when the gap between open switch and stock rail is less than 5 mm and

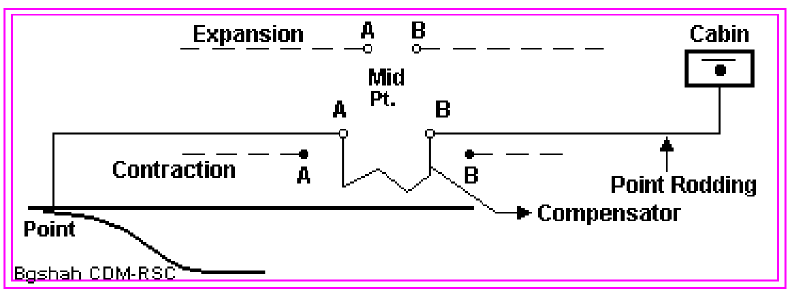
ii) when the gap between open switch and stock rail is 115 mm in case of BG. and 100 mm in case of MG.

8.3.2 The points can be set either locally or from a central location. The local operation of point is used where the train density is low or in case of unimportant points like siding points, goods lines points etc. A spring type lever is provided at the point and is connected to the leading stretcher bar. When the lever is operated, the point moves to the other position. Whenever point is required to be changed, an operating staff has to go the point to operate it.

8.3.3 **Central Operation** : where the train density is heavy, it will not be feasible to send a man to site to change the position of points. Hence the points and signals are operated from the same central location. The central operation can be through (I) Mechanical means and (ii) Electrical means.

Mechanical Means - Points can be mechanically operated from a central location. The mechanical operation can be provided through (I) Rodding or (ii) Double wires.

8.3.4 **Rodding** - The levers in the central cabin connected by means of point rodding to the point at site. The point rodding is made of 32 mm diameter solid or tubular mild steel rods. The stroke from the cabin is transmitted through the rodding to the point. The range of operation is generally restricted to about 350 m. (even though theoretically a range of 450 m. is possible). The point rodding should be provided with some arrangement for compensation against temperature effects. The mild steel used for point rodding has a linear expansion coefficient of 5 mm/90 m per 100^0 F. It is therefore necessary for all the point roddings exceeding 12 m in length to be compensated for changes in temperature, which is done by inserting, a Rodding compensator, of the type shown below, exactly midway in the rodding run.



The compensator consists of an obtuse angle crank and an acute angle crank connected by a link. Any movement of the rod on one side due to expansion or contraction is neutralized by an equal and opposite movement on the other side of it.

8.3.5 **Double Wire Operation** - Where signals are operated by double wire, points can also be operated by double wire. The double wire operation has a range of about 700 m. The double wires are provided with a compensators for automatic compensation. In the cabin rotary type of lever is provided and at the points, double wire point mechanism, is connected to the points. Double wire point mechanism converts a rotary movement to linear movement and also provides broken wire protection.

8.3.6 **Electrical Operation** - In modern signalling systems, the points are electrically operated. The main advantages of electrical operations are :-

i) Range unlimited

ii) Ease of operation

iii) More reliable

iv) Less maintenance

Points are electrically operated by a point machine. Point machine consists of a direct current electric motor operated by 110v. with the associated mechanical parts like gears etc. to convert rotary to a linear movement. The operation by point machines is generally fast taking about 2.5 seconds. This machine is considered suitable for most of the points. But in case of maqrshalling yards provided with humps, where two wagons follow one another in quick succession, the points are required to operate within a time of ½ second. In such cases electric points are not suitable, but points are operated by compressed air mechanism controlled electrically. Such a method is called Electro Pneumatic point operation.

8.4.1 Locking of a point - It is necessary to lock a point especially a facing point to prevent the movement of switches due to the vibration of a train. Different methods can be adopted for locking depending on the maximum speed permitted over the points.

8.4.2 Padlock locks and clamps - In this arrangement, a clamp is provided between closed switch and stock rail and the clamp is locked with a padlock. This arrangement is suitable for speeds upto 15 kmph.

8.4.3 Key Lock - Key lock is an arrangement provided between the tracks in a point assembly to lock the switches. The switches are locked by means of a plunger in the key lock unit. When the locking is proper, a key is taken out from the key lock.

8.4.4 Hand Plunger Locks - This is an improved system of key locking and can be used with locally operated point for speeds upto 75 kmph.

8.4.5 Facing Point Locks (FPL) - This arrangement is adopted with mechanically operated points from a central cabin. The locking is actuated by a plunger in the Facing Point Lock unit at the point through point rodding from the cabin. The point rodding for FPL are also provided with rodding compensator for compensation against temperature effects.

8.4.6 **Point Machines -** Point machines which are used to operate the points electrically have also the locking facility provided inside the machines.

8.4.7 The points are operated from central cabin by (1) Rodding (2) Double wire and (3) Point machine. In case of rod operated points, the points normally remain unlocked. Only before clearing a signal, the facing points are locked. The trailing points are only correctly set. Whereas in case of points operated by double wire/point machine, all points whether facing or trailing, are normally locked.

8.5.1 **Route Holding** - It is very essential to ensure that the points are not unlocked when a vehicle is over the point. The arrangement provided for this purpose is called route holding. In case of key locked points, by virtue of location of a key lock unit in between the tracks, route holding feature is available. If the vehicle is over the points, the key lock is not accessible and hence, it will not be possible to insert the key and unlock a point.

8.5.2 In case of facing point locks, a device called lock bar is provided for the purpose of route holding. Lock bar is a mild steel angle of size 50 mm x 50 mm and of length 13 m (42') in case of BG and 12.2 m (40') in case of MG. The lock bar is fitted closed to the tip of the switch and remains 38 mm (1 ½") below the rail top. When a point is to be unlocked, the lock bar rises to the rail top and then goes below. If there is a wheel standing on the rail, i.e. point is occupied, the lock bar cannot rise and hence the point can not be unlocked. The length of the lock bar has to be more than the maximum distance between the longest wheel base of any rolling stock.

8.5.3 In case of electrically operated points, route holding is achieved by a device called track circuits, which is described in detail in chapter 11.

8.6.1 **Detection** - It is necessary to ensure that in case of facing points, the closed switch is housed properly (gap less than 5 mm) with stock rail and points are locked before clearing a signal. This is achieved by a device called detection. This is the most important safety device as far as points are concerned. The detectors are provided at the point itself. They are classified into mechanical detectors or electrical detector.

8.6.2 Mechanical Detectors - Two types of mechanical detectors are used. One is with single wire and the other is with double wire. The single wire transmission operating the signal is passed through a detector, provided at the facing point, called 'unit detector'. The unit detector ensures that signal transmission wire can move only if the facing points in the route are set correctly and locked. In case of a double wire operated point, a rotary type detector is used. This detector lever is required to be operated before the operation of the signal lever. If the points are not set properly, the detector lever cannot be operated and hence signals cannot be operated.

8.6.3 Electrical detectors are used with colour light signals. In this device, one set of electrical contacts will be made when points are correctly set and locked in one position, other set of electrical contacts corresponding to other point position. Indication is also given in the cabin through these contacts and colour light signals are also controlled through these contacts.

8.6.4 Point machines have electrical contacts inside the machine to ensure that the points are correctly set and locked. Point machines perform three operation viz, setting, locking an detection.

8.6.5 Detection being an important safety device, its working has to be periodically checked. Whenever there is a derailment at an interlocked point, it is also essential to check the proper functioning of detectors. The functioning of the detector is checked by test called an **'obstruction test'**. In this test a physical obstruction is provided between the stock rail and closed switch and it is seen whether the detector fails with this obstruction. All the signal inspectors/maintainers are provided with an obstruction piece made of mild steel of size 5 mm. **This obstruction piece is kept at a distance of 50 mm from the tip of the switch between the stock rail and the switch rail. The point is operated with this physical obstruction and the detector should fail.**

Chapter 9
ESSENTIALS OF INTERLOCKING

9.1 Points, signals and other connected equipments should be operated in a proper sequence. This sequence cannot be left to the human element, but is ensured by interlocking. Interlocking is a safety arrangement to ensure that points, signals and other connected equipments are operated in a predetermined sequence. The four essentials of the interlocking as stipulated in the Signal Engineering manual are given below :-

9.2.1 Essentials of Interlocking :-

It should not be possible to take off a signal unless the Route is properly set. Route setting involves (1) setting of all points viz. facing, trailing and isolation, (2) locking the facing points in case of rod operated points, locking all points in case of D.W. or electrically operated points, (3) closing and locking the interlocking level crossing gate against road traffic, not only for the line on which the train is going to run but also for the signal overlap. This condition is called route setting condition.

9.2.2 It should not be possible to change a point, unlock a facing point (in case operated by rodding), unlock any point (in case operated by D.W. or electrically), unlock level crossing gate in the route or the signal overlap portion unless the signal is replaced to ON. This condition is called route holding condition and ensures that the route set for a signal remains in tact as long as signal is Off.

9.2.3 It should not possible to take off the conflicting signals at the same time. The signals which can lead to head on collision, if cleared simultaneously are called conflicting signals. Main signal and subsidiary signals cleared for the same route are also conflicting signals. The examples of conflicting signals are -

On single line

Home/Outer/Warner and Adv. Starter of opposite direction.

Home and Starter of opposite direction.

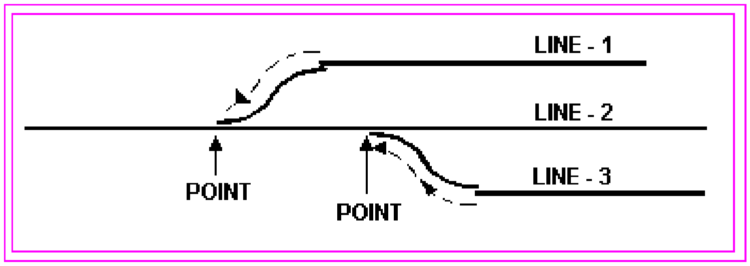
Home and Home of opposite direction.

On Single/Double Lines

Main Signal - Shunt Signal (for the same route)

Main Signal - calling on signal

9.2.4 Whenever feasible, conflicting points should be locked. Two trailing points taking off from the same line are called conflicting points, as shown in the figure:-



If points 1 and points 3 are set for line 1 and line 3, and two simultaneous movements from these lines to the main line are permitted, there is possibility of side collision. This essential is required to protect against such happenings during shunt moves. When any main signal is cleared from these lines, this is ensured by the rules of isolation. However, in case of major yards there may be many trailing points from the main line. In case where there are heavy shunt moves, some times two or three of these points may be required to be operated for simultaneous shunt moves. Hence in this essential clause 'wherever feasible' is given so where flexibility is required, the interlocking between conflicting points need not be provided. Generally, wherever the distance between the trailing points is 100 m - 150 m, there could be no parallel moves possible and interlocking between conflicting points is provided. Where the distance is greater than 150 m, conflicting points interlocking is not provided to provide flexibility.

Chapter 10
STANDARDS OF INTERLOCKING

10.1 The maximum speed of a train over facing point on the main line of a station depends on the equipments used at the points, signals provided, type of interlocking and provision of isolation between main line and other lines. There are four standards of interlocking used on Indian Railways permitting 15 kmph to maximum permissible speed. The set of equipments to be provided for different standards of interlocking is stipulated in the Signal Engineering Manual.

10.2 Requirements for different standards of Interlocking

Type of Equipment /arrangement	Rudimentary Std. 0	Std. I	Std. II	Std. III
1. Max. speed over the Facing Point unrestricted on the main line in kmph	15	50	75	maximum permissible
2. Point equipment				
i) Setting	Local operation	Location operation	Local operation	Central operation
ii) Locking	Padlocking	Key lock	Hand plunger	Facing point lock or point machine
iii)Route holding	---------------	No arrangement	---------------	Lock bar or track circuits
iv)Detection	No required	Required	Required	Required
3)Isolation	-----do ---------	Not Required	-------do--------	--------do------
4)Interlocking	Indirect	Indirect	Indirect	Direct
5)Signals LQ	Outer common Home	Outer bracketed home	Outer bracketed home starter warner	Outer bracketed home starter warner Advanced starter (if necessary)
MAUQ	Distant home starter		Distant Home starter	Distant home starter Home starter Advance starter (if necessary)

10.3 In case of Std. I and Std. II, interlocking points are locally operated and locked by key locks. The key released from the key lock is inserted in the lock on the signal post before a signal can be cleared. Once the signal is cleared the key locking the points can not be taken out. Hence there is indirect interlocking between points and signals. The difference between Std. I and Std. II interlocking is the requirement of isolation, i.e. main line from other lines, as the maximum speed permitted is 75 kmph in Std. II.

10.4.1 The main difference between Std. II and Std. III interlocking is the types of interlocking. Since in Std. II, points are operated locally and signals from a cabin, there is indirect interlocking between points and signals. Whereas in case of std. III, points and signals are operated from the same location and hence there is direct interlocking between points and signals. Standard II interlocking is not generally adopted in view of the necessity to send the staff for operating the points locally. The signalling system is upgraded to std III directly from std. I. There are about 25 stations with std. II interlocking on Indian Railways.

10.4.2 In case of major and terminal stations, full compliments of Standard III interlocking are provided. In spite of that these stations are classified as std. I because no isolation between passengers lines is provided at these stations.

10.4.3: Addendum & Corrigendum Slip No 6 to Signal Engineering Manual (Dated 19.5.2004) (As per revised Para 7.131)

Sr No	Item	STD I	STD II	STD III	STD IV
	Allowable Speed (KMPH)	Upto 50	Upto 110	Upto 140	Upto 160
1	Isolation	Y	Y	Y	Y
2	2 Aspect Semaphore(2A)/Multi Aspect (MA) Signalling	2A/MA	2A/MA	MA	MA
3	Double Distant	N	Y(where goods trains have Braking Distance more than 1 KM)	Y	Y
4	Point operation	Mech	Mech/Elect	Mech/Elect	Elect
5	Point Locking	Key/FPL/HPL	FPL/Point Machine	FPL/Point Machine	Clamp Type Direct (Desirable)
6	Point detection	Mech/Elect	Mech/Elect	Mech/Elect	Elect
7	Lock Detection	N	Y	Y	Y
8	Interlocking	Key/Mech	Mech/Elec/Electronic	Mech/Elect/Electronic	Elect/Electronic
9	Track circuiting	N	**Mech I/L**: Run Thru Main Lines **Elect/Electronic I/L**: All Running Lines	All Running Lines	All Running Lines
10	Block Working	Token	Token/SGE	SGE/TC	SGE/TC
11	Preventing Signal passing at danger	N	N	N	Y (Desirable)

The provisions of the new revised Para 7.131. will only apply to future signaling & interlocking installations.

Chapter 11
TRACK CIRCUITS

11.1 Interlocking is one of the vital safety features provided in signalling to ensure that a route is properly set before a signal can be cleared. Interlocking, however, does not ensure that the route on which the train is to be received, is clear of vehicles. This aspect has to be verified by Operating staff. In signalling whenever we depend on human element, we involve at least two agencies, if not more, to verify the safety aspects. In spite of associating more than two persons, large number of accidents had occurred in India and abroad due to the reception of a train on an occupied line. It is very essential to eliminate the human element from this important and vital check by providing suitable safety arrangement. Such an arrangement is called 'Track Circuits'.

11.2 Track circuit was first invented in the year 1872 in U.S.A. by William Robinson. Since this arrangement was very simple, nobody would have thought that the track circuit would make such an impact on signalling**. Track circuit has become one of the most important safety devices in Railway signalling and has become an essential and integral part of modern signalling systems.**

11.3 The principle of track circuit is quite simple. The presence of a vehicle in a particular section is checked by passing an electric current through the rail from one end. If the current reaches the other end, then the track is clear. If any vehicle remains in the section, the wheels and axles of the vehicle will short circuit the current and prevent it from reaching the other end. Since the current is passed through the rails and rails form an electrical circuit, this arrangement is called 'Track Circuits'.

11.4 The track circuit consists of the following components :-

1) To ensure that the flow of current is restricted to a particular section, insulated joints are provided at both ends of the section. The insulated joints consists of insulating material made of Nylon 66, which prevents the flow of current between rail to rail, fish bolt to rail, fish bolt to fish plate and fish plate to rail of the adjacent rail joints.

2) Rails of 13 m standard length are provided in most of the stations and they are joined together by fish plates. The fish plates do not provide reliable electrical connection and hence they are bridged by two mild steel wires to get good a electrical connection. These wires are called bond wires.

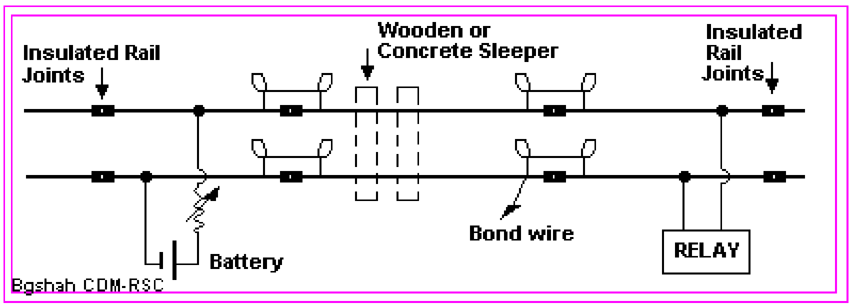
3) The current is passed by means of battery (2v) at one end and current is regulated by a resistance.

4) The current at the other end is sensed by a device called Relay. This is an electromagnetic device, the relay remain energized when track is clear due o the current flowing through the relay. But when a vehicle occupies a track circuit, most of the current is diverted through the wheel and axle of the vehicle and very little current flows through the relay. Hence he relay will be de-energized. It is possible to control the signal as well as indicate the occupancy of a track through the relay contacts. A red indication is given when the track is clear. Since normally the track is clear, the relay remains in the energized position. The relay used in track circuits is of a special design compared to the conventional electrical relay. A conventional relay works with a current

or no current. But a relay used in track circuit has to sense a drop in current. Since we can not positively say that the current through the relay will be reduced to zero value when a wheel and axle occupies a track circuit, when the current through the relay reduces to 32% of the normal current, the relay should get de-energized. Such relays are called relays with high percentage release.

5) The sleepers used in the track circuits should be of an insulating type viz. wooden or concrete sleepers. Cast iron or steel sleepers can not be used in track circuited section as they would directly short circuit the rails.

11.5 The arrangement of a track circuit is shown in the following sketch:-



11.6.1 Requirement of track circuits - There are two very important requirements of track circuits - one concerning the safety aspect and the other concerning the reliability. The ideal condition of a wheel and axle occupying track circuit is causing a dead short circuit across the rails. Normally, the resistance offered by wheel and axle of a train is about 4 to 5 milli 0hms which is almost zero. However, it is very essential to provide some factor of safety. Hence our, track circuits are designed in such a way that even when wheel and axle offers a resistance of 0.5 0hms, the relay would be able to sense it. This provides a factor of safety of (500/0.5 = 100). **This resistance of 0.5 0hms is called Train Shunt Resistance.** Indian Railways is one the few world Railways who have adopted such a high train shunt resistance.

11.6.2 Sometimes a track circuit will show as occupied though the track is clear. This is due to the continuous leakage of current through the ballast especially under wet and poor drainage conditions. This affects the reliability of a track circuit. **It is stipulated in Signal Engineering Manual that the ballast resistance should not be less than 2 ohms/km in station section and 4 0hms/km in block sections.**

11.7 Applications of Track Circuits

(i) To prove the track occupancy: the main application is to prove that a particular section is clear of vehicles. The track circuits in a station is normally done under three priorities.

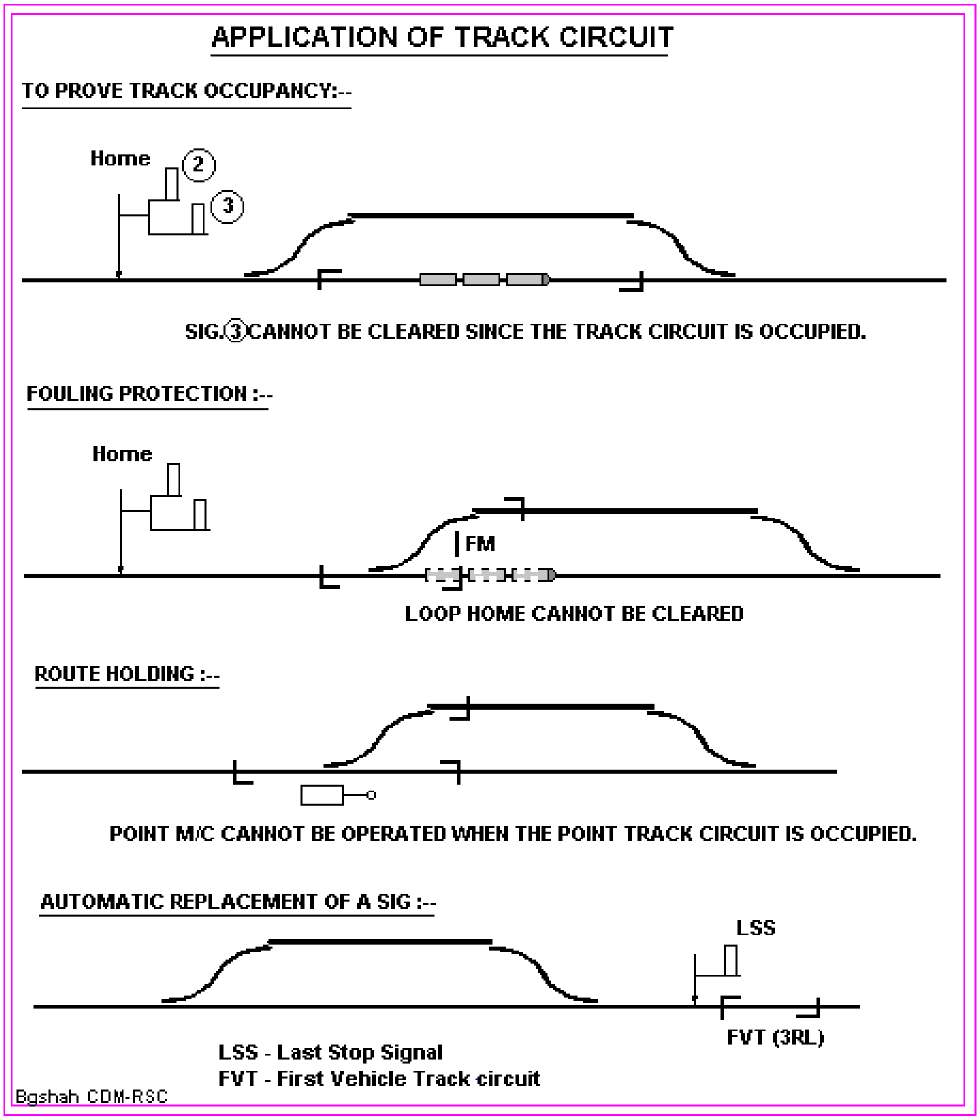
(a) First priority is for track circuits between fouling mark to fouling mark on the run through/main line. Second priority is for track circuits between Home Signal to Fouling Mark and Fouling mark to Advanced Starter. Third priority is for providing track circuits on loop lines.

(ii) Automatic Replacement of a signal :- A small track circuit of 3 rails length (60 m) is provided ahead of Last Stop Signal (LSS) so that as soon as the train occupies this track circuits, the LSS signal is replaced to On. This small track circuit is called FVT (First Vehicle Track). This arrangement is required to ensure that only one train can enter the block section with the clearing of Last Stop Signal.

(iii) To indicate clearance of block overlap :-A small track circuit of 3 rails length (60 m) is provided at the block overlap limit from First Stop Signal. When the train occupies and clears this track circuit, an indication is given in ASM's Office to inform the arrival of a train. The ASM/SM must ensure complete arrival of the train by checking the tail lamp/LV Board. This small track circuit is called Last Vehicle Track.

(iv) Route Holding - Wherever electrical operation of point is provided, track circuits are used to hold the route. The track circuits will be provided over the point portion. When the first point is occupied, it will not be possible to operate the point.

(v) Fouling Protection - Track circuits are also provided over point portion with mechanically operated points and lock bar to ensure that the fouling mark is clear. This will help to prevent side collision of two trains, whenever there is an infringement of fouling mark.



(vi) **Automatic Warning for LC Gate** - Track circuits are also provided in rear of the level crossing gates at a distance of about 2 kms so that when the trains occupy the track circuits, the gate-men will get a warning to close and lock the gate before the train approaches the gate signal.

(vii) **Approach Lighting of signals** - It is also possible to light the signals only when the train is approaching by having track circuits at a distance of 4 kms from the signal. The signals are lit up only if this track circuit is occupied by a train. This arrangement will help to reduce energy consumption.

(viii) Track circuits are essential part of all modern signalling systems like panel interlocking, route relay interlocking, axle counter etc.

11.8.1 Types of Track Circuits - The following types of track circuits have been used on Indian Railways :-

(i) DC Direct Current Track Circuit

(ii) Alternating Current Track Circuit 50 C/S or 83-1/3 C/S

(iii) High Voltage Impulse Types Track Circuits

(iv) Jointless Track Circuits

11.8.2 The most widely used track circuits in Indian Railways is Direct Current Track Circuits. Direct Current Track Circuits cannot be provided in sections with Direct Current Electric Traction like Bombay-Poona, Bombay-Igatpuri Sections. Track Circuits with Alternating Current at 50 C/S frequency is provided in these sections.

Chapter 12

SLOTTING AND INTERCABIN CONTROL

12.1 Interlocking provides safety by ensuring proper sequence of operation. Interlocking can only ensure that the levers in the cabin are operated in a predetermined sequence. However, if the function at site fails to correspond to the operation in the cabin, interlocking can not provide safety. For example, in case Outer and Home signal, Outer signal can be operated only after the operation of Home signal. Interlocking ensures this condition. However if Home signal fails, to correspond with the operation in the cabin, the Outer signal also should fail. This is achieved by slotting. Normally, all signals have a minimum of an control viz. the lever controlling the signal. But in case of some signals there may be more than one controls, like Outer, Distant, Warner, Advanced Starter. In case of such signals a method called slotting is used. The two important principles involved in slotting are -

(i) the slotted signal can be cleared only if all the controls required for the signal have been received.

(ii) any one the controls should be able to independently replace the slotted to 'ON' position.

12.2 Two types of slotting devices are used on Indian Railways viz. (i) Mechanical Slotting and (ii) Electrical slotting. Mechanical slotting can be used where there are only two controls for a signal. Two types of Mechanical Slotting devices are in use - (i) Disengager - This is provided at the foot of the Home signal and ensures that the Outer signal can be lowered only after one of the Home signal arm is lowered to 45 degrees - 60 degrees. In case Home signal goes to danger, Outer signal is also replaced to 'ON' position.

(ii) Three Lever Slot :- This is provided at Outer/Warner signal to ensure that Warner signal can be cleared only after Outer signal is lowered to 45 degrees to 60 degrees. Three counter weight levers are provided on Outer/Warner post. One weight is connected to Outer lever in the cabin and arm. The second weight is connected to Warner lever in the cabin. The third (middle) weight is connected to Warner arm. The weights are balanced in such a way that Warner signal can be lowered only if both weights connected to Outer lever/arm and Warner lever are raised. In case Outer lever goes 'ON' Warner also goes to 'ON'.

12.3 The mechanical slotting can be used with two controls. Besides, if an electrical track circuits is to be proved on a mechanical semaphore signal, an interface is required. Such an interface is provided by electrical slotting arrangement. In electrical slotting, there can be more than two controls for a signal. In case of electrical slotting, the transmission from the signal cabin and the arm are physically connected through an interface called Electrical Signal Reverser (ESR). The transmission and the arm are connected only if the ESR is electrically energized. If ESR is not energized, the transmission is delinked from the signal arm and even if the signal lever is operated, the signal cannot be lowered. The ESR is energized only if all the controls are received. Now a days all slotting arrangement provided is of electrical type.

12.4 One of the applications of slotting is inter cabin. The clear standing room required for B.G. = 686 m. If a central cabin is provided, the Outer most point will be located at a distance of 423 m (686/2 + 100m. cross over length). This distance is beyond the range of rod operation. Hence if rod operation is to be adopted, two cabins are used, one at either end. With two cabin working, whenever Home signal is to be cleared, the overlap portion will be with the control of the cabin at the other end. A control from the other cabin is required to ensure that the overlap points are properly set and locked, before lowering a Home signal. Such a control is called inter cabin control. In addition, it has been stipulated by Board, that all reception and despatch of trains have to be controlled by Station Master/Assistant Master. So, SM's control is provided in ASM/SM's office for giving control on Home and Advanced Starters. Inter cabin control consists of a control from other cabin and SM/ASM in case of Home signal, a control from SM/ASM in case of Advanced Starter. A safety feature known as 'one slot one train' is provided with inter cabin control. A control given by the other cabin and ASM/SM is valid for one train only. With the same control, the signal cannot be cleared for the second time, after the passage of the first train. The control lever/slides have to be replaced to the normal position and again given for the second train. This feature is called 'one slot one train'.

CHAPTER 13
BLOCK INSTRUMENTS

13.1 The trains are run with space interval systems, maintaining definite distance between two trains. The equipments provided at stations for ensuring space interval system of working are called 'Block Instruments'. Each block section has one instrument at either end electrically connected by overhead wires in case of non-electrified section or by underground cable/wireless in case of electrified sections. No trains can enter a block section, even when the block section is clear, unless line clear is taken from the other side. The block section normally remains closed. The working of trains with block instruments can be called 'Closed Block' working.

13.2 Block instruments provided can be classified into two categories viz. (i) Cooperative and (ii) Non-cooperative type. In case of cooperative type, block instruments for doing any operation on the instruments, cooperation from the other side is required. For example, granting line clear for a train or closing a block after the arrival of a train can be done only with the cooperation from the other side. In case of non-cooperative type block instruments, all these operations can be done without the cooperation from other side. All single line token instruments and single line tokenless instruments (Daido Make and Kyosan make) are cooperative type. All double line block instruments and single line tokenless instruments with push buttons (Podanur Make) are non-cooperative type.

13.3 Single line token instruments are provided with operating handle having three positions. Normally, operating handle remains in te centre position. The handle is turned to 'Train Coming From or (TCF)' position at the receiving end and 'Train going to' or TGT position at the sending end. When the handle is turned to TGT position, a token comes out, only one token can come with one operation, thus ensuring there can be only one train in a block section. Once a token is taken out, the block instruments are locked in TGT position at the sending end and TCF position at receiving end. The instruments can be normalized only after the token is inserted either at the sending end or at the receiving end, with the cooperation from the other side.

13.4. The sequence of operation in case of sending a train from A to B is given as below :-

Station A	**Station B**
Sending Station	**Receiving Station**
ASM gives one beat by pressing the plunger to call the other side ASM	ASM responds with one beat.
Asks for line clear by giving two beats, and at the end of the second beat keeps the plunger pressed (cooperative working)	Turns the handle from line closed to TCF position and gives two beats keeping the plunger pressed at the end of second beat (cooperating)
Turns the handle from line closed to TGT. Token comes out, hands over the token to the driver as the authority to	

enter block section.	
Train enters block section, gives 3 beats (train on line)	Acknowledges train on line with 3 beats, clears Reception signals. Train passes the signals. ASM checks the LV Board/Tail Lamp. All reception signals replaced to 'ON'. Inserts the token into the block instrument & gives four beats (train out of section) and keeps the plunger pressed at the end of the fourth beat (cooperating).
Turns the handle to line closed from TGT and gives 4 beats keeping plunger pressed at the end of fourth beat.	Turns the handle to line closed from TCF.

13.5 Disadvantages of Token Working

(i) Block operation time is more because of the need to get the token from the driver for normalizing the instruments. Hence with token instruments the crossing time, taken by the trains to cross each other on a single line, is about 10-15 minutes. This reduces the line capacity to about 18 trains each way (total 36 trains0 in 24 hours. By introducing tokenless working, the crossing time can be reduced to about 5 minutes and increasing the capacity to 21 trains each way (42 trains total) in 24 hours.

(ii) The difficulty in picking up token at high speed.

(iii) The problem of damaged token. If the tokens are not handed over in a proper pouch, the tokens are likely to get damaged due to dropping of token from the engine.

(iv) Missing tokens or lost tokens. If the token is missed or lost, considerable delay is caused to the train.

(v) Balancing of token. There are 36 tokens, normally 18 in each instrument. If the traffic in one direction becomes heavy, the tokens get accumulated in one instrument. The tokens will have to be physically brought to the other instrument and inserted. Indication is given in the block instrument when the number of tokens in an instrument is 5.

(vi) In view of number of mechanical parts inside the block instruments, periodical attention required is more and the block instruments are required to be overhauled once in 10 years.

13.6 Single line tokenless instruments and double line block instruments are worked on the principle of lock and block.

The essentials of lock and block working are -

(i) The last stop signal (Advanced Starter) is interlocked with block instrument and can be cleared only after the line clear is taken from the other side. This is the lock condition.

(ii) Automatic replacement of Last Stop Signal to ON :- A short track circuit provided just ahead of LSS (FVT) replaces the LSS to ON as soon as the train enters block section, to prevent the entry of second train with the same line clear. This ensures one line clear one train condition.

(iii) The last stop signal can again be lowered for a second train only after the first train clears the block overlap at the receiving station, all reception signals are replaced to ON at the receiving station, the block instruments are normalized and again fresh line clear granted.

The instruments remain blocked till these conditions are satisfied. Hence the working is called lock and block working.

13.7 Double line Block Instruments :- Double line block instruments work on the lock and block principle. They are non-cooperative type. All the block operations are done at the receiving end. The instrument is much simple to operate as compared to single line block instruments. These instruments are called SGE type instruments (Siemen's and General Electric). The instruments consists of a commutator with three positions, two needles having each three indications one for Up and Dn lines. The two corresponding needles at each ends are connected electrically. The commutator normally remains in the centre position i.e. line closed. The line clear is granted by the receiving end station by turning the commutator to right (line clear - LC position), when the needle corresponding to this line at both ends will indicate 'Line Clear'. As soon as the train enters the block section the sending end station will give three beats to the receiving end. The Station Master at the receiving end turns the commutator handle from Right (line clear) to Left position (TOL position) when the needles at both ends will indicate 'TOL'. This is the most important operation in double line. Only when this operation is done, the blocked condition as stipulated in lock and block working is ensured. When the handle is turned from LC to TOL, the handle is electrically locked in TOL position. This electrical lock is released only after the train clears block overlap at the receiving station and all reception signals are replaced to ON. The Station Master only after verifying the complete arrival of a train must turn the commutator handle from TOL to Line Closed position.

If the Station Master at the receiving end fails to turn the handle from LC to TOL, the block instrument will fail for the subsequent train. The main difference between single line tokenless and double line instrument is that in case of single line tokenless, the TOL is automatic, as soon as the train enters block section. Train on line indication comes on instruments at both side whereas in case of double line block instruments, the TOL indication comes only after the commutator handle is turned manually at the receiving end from LC to TOL position.

The commutator handle can be turned at any time from centre position line closed to TOL (left). When such an operation is done, the electrical locking at TOL position will not be effective. The electric locking at TOL is effective only if the handle is turned from LC to TOL position, the normal sequence in a train working. The turning of the handle from line closed to TOL is required to be done whenever there is obstruction in the block section or a shunting is to be done from the receiving end side in the block section.

CHAPTER 14
AUTOMATIC BLOCK WORKING

14.1 The double line block instruments are non-cooperative type. In spite of this feature, the maximum number of trains that can be run on a double line section is 45 trains each direction in 24 hours (90 trains total). This capacity can be increased to 60 trains each direction by splitting the long block sections into two by the provision of Intermediate Block Signalling (IBS). This is the maximum capacity that can be achieved with manual block working. In case of suburban sections like Bombay, Calcutta, etc. the train density is much higher than 60, hence it is necessary to adopt a system, where space interval between trains is maintained by trains themselves, and not by manual operation of block instruments. Such a block working is called Automatic Block Working.

14.2 Essentials of Automatic Block Working :-

(i) The section should be provided with complete track circuiting or Axle Counter (substitute for track circuits to ensure a particular length of track is clear) and colour light signals.

(ii) The normal aspect of an automatic signal is 'proceed' unlike the manual signals whose normal aspect is 'stop'.

(iii) The automatic signal turns to 'ON' as soon as the train enters the block section.

(iv) This signal displays 'caution' aspect when one block section and a overlap of 120 metres is clear.

(v) This signal displays 'proceed' aspect when two block sections and a overlap of 120 metres is clear.

14.3 The aspects of a signal are changed by the movement of trains. In case an automatic signal displays Red aspect, the driver must get an authority to pass the signal at danger. This authority is given by (A) Market. When any automatic signal is 'ON', the driver can pass the signal after waiting for 1 minute by day if the visibility is good and for two 2 minutes in case of night and during poor visibility. But he should proceed at 15 kmph till he reaches the signal post ahead and then guided by that signal. Most of the accidents in automatic block section occurs due to drivers not following this rule.

14.4.1 Signals in Automatic Block Section :- Three types of signals are used in automatic block section :-

(i) Automatic Signal

(ii) Manual Signal

(iii) Semi Automatic Signal

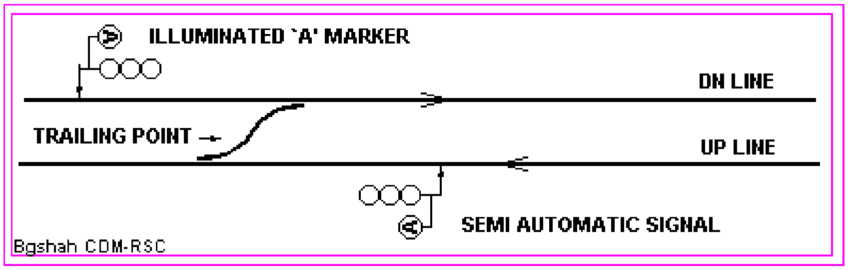
In a section provided with automatic block working, automatic signals are used in sections where there are no points or level crossing gates.

Manual signals are used at the approach to stations, since in case of stations, signals are manually operated.

Semi-automatic signals are those which can work either automatically or manually. Semiautomatic signals are provided in sections with a point or a level crossing gate or both. The semiautomatic signals are fitted with an illuminated (A) Marker. When the A marker is lit up, the signal works as an automatic signal. When the A marker is extinguished, the signal works as a manual signal.

14.4.2 Automatic Section with a point

Generally, points are provided in the trailing direction in case of an automatic block section to divert a train from one line to other line as shown in the following figure :-



When the points are correctly set for the normal main lines, the signals in both directions work as automatic signals and illuminated A markets are lit up. The rules for passing this signal at 'ON' remains the same as that of an automatic signal. If the points are not correctly set for the normal main lines, the signals in both directions work as manual signals and A market is extinguished. The driver should get a written memo to pass this signal at 'ON'.

14.4.3 Automatic Block Section with a Level Crossing Gate :-

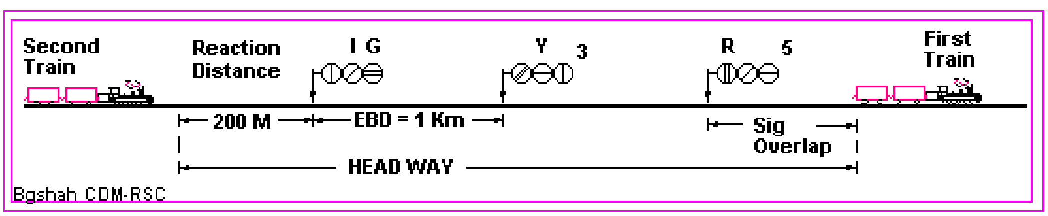
When there is a level crossing gate in an automatic block section, the signals are provided with an illuminated A marker and painted G Board (black G on a yellow back ground). The normal position of a level crossing gate is open to road traffic, the signal works as a gate signal with A marker extinguished. If this signal is at "ON" the driver should wait one minute by day and two minutes by night and pass the signal at a slow speed of 15 kmph, and must watch for the gate. If the gate is closed, he can proceed at 15 kmph, till he reaches the signal post head.If the gate is open and the gate-man is not present, the driver should stop the train before the gate, close the gates, draw ahead the train till train clears the gate, again stop the train to enable the guard to open the gates. Then he should proceed at 15 kmph till he reaches the signal post ahead.

14.4.4 Automatic signal with a Gate and a Point - When there is a gate and a point in an automatic block sections, two illuminated markers A and AG are provided. The indications given by these marks are -

(i)	Point set for normal main lines and gates		A marker is lit up		Signal works as an automatic signal.
(ii)	Point set for normal main lines and gates open		AG marker is lip up		Signal works as a gate signal
(iii)	Point not set for normal main lines Gate open		A marker and AG marker extinguished		Signal works as a manual signal
(iv)	Point not set for normal main lines gate closed.				

14.5.1 **Headway -** The main purpose of providing an automatic signal is to increase the train density. The train density can be increased if the trains can follow one another at close intervals. The train density is generally indicated by the term headway. Headway is defined as the distance between two trains running in the same direction always getting proceed aspect.

14.5.2 **Headway with the three aspect signals** - The second train can get a proceed aspect after the first train clears two block sections and an overlap of 120 m. Since the minimum visibility required is 200 m., the headway in an automatic block section with three aspect signal (as shown in the figure given below) is 2EBD + 200 + 120 m + TL = 2.320 km + TL.



14.5.3 Automatic Block Section with four aspect signals - In case of am automatic section with 4 aspect signals, an automatic signal displays

Caution Aspect (Y) - When one block section + overlap of 120 m is clear.

Attention Aspect (YY) - When two block section + overlap of 120 m are clear.

Proceed Aspect (G) - When three block sections + overlap of 120 m are clear.

The inter-signal distance in case of 4 Aspect signals is emergency braking distance between a signal showing 'Attention Aspect' (YY) and a signal at 'On' as shown in the following figures -

The headway in case of 4 Aspect signals is EBD + ½ EBD + 200 + 120 + TL = 1.820 km + TL

With the provision of 4 aspect signals, Headway is reduced by 500 m, i.e. 25% and hence the train density can be increased by 25% as compared to 3 Aspect signals. Therefore, in very busy suburban sections like Bombay, four aspect automatic signals are provided.

Chapter 15
Route Relay Interlocking/Panel Interlocking & Solid State Interlocking

15.1 BRIEF DESCRIPTION OF SYSTEM: Route Relay Interlocking

This system is based on a geographical layout of signal switches and push buttons. All that is required by an operator to move trains is to know where a particular train is and to which line it has to be routed. Therefore, to set up a particular route, the operator is required to perform some action on the geographical layout of Control Panel at these two points, viz., at ENTRANCE and EXIT

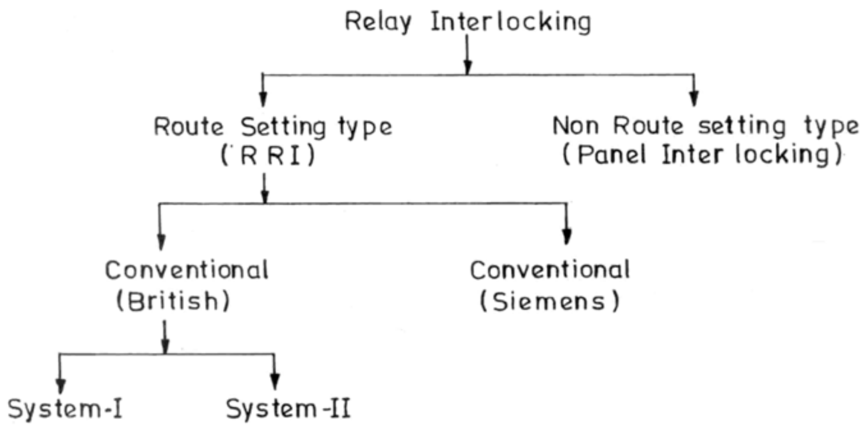
15.2 CONTROL PANEL: All the points and signals are operated from a combined indication diagram cum control panel located in the cabin/Station Master's Room.

The combined indication diagram cum control panel consists of an inclined console on which a clear geographical representation of the entire track layout with signals, points, Control switches, push buttons and various types of indications and alarms available. The track layout is sub-divided into track sections according to the track circuit configuration with distinctive colour for each track circuit section. (All colours except Red).

When a route is set and locked, the route is illuminated by white strip lights in the track circuit configurations throughout the route (except the overlap). This indication remains lit as long as the route is locked and disappears only after the relevant signal switch is restored to normal position and the route is released. This indication turns to Red when track is occupied or track circuit failed, irrespective of whether the route is locked or free.

When the speed and frequency of the trains are to be increased, Relay interlocking is ideal. In Relay Interlocking the Interlocking is achieved through relay circuitry at a centralised place. The time required for installations is also less. The Relay Systems are generally trouble free since the moving parts involved are less and replacement is easier. Indian Railways are having time tested experience in Relay Interlocking since 1958.

Route Relay Interlocking is a system in which Interlocking is achieved by means of Relays.



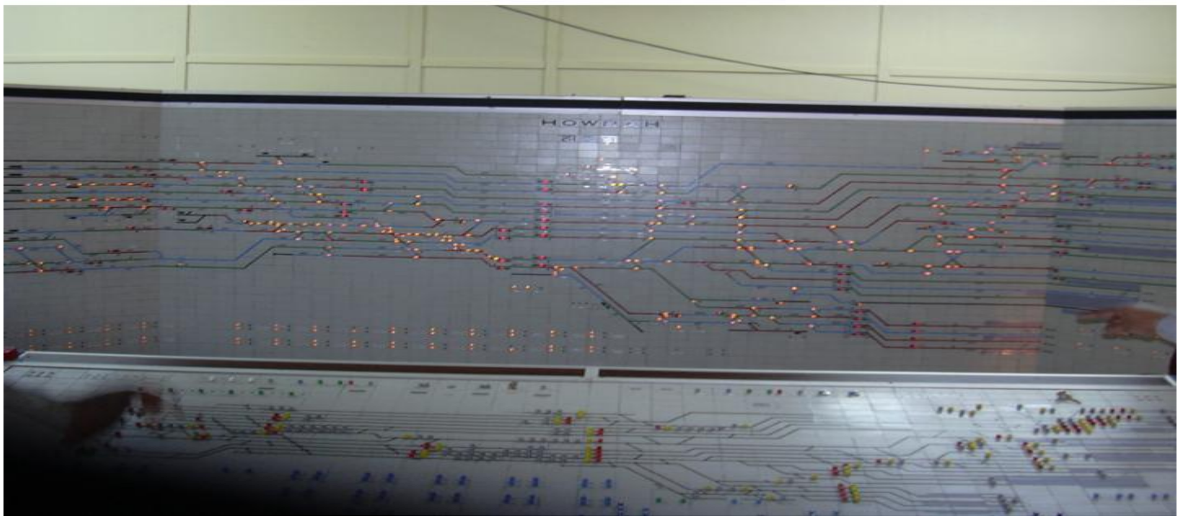
15.3 REQUIREMENTS OF RELAY INTERLOCKING

Relay interlocking systems are popularly divided as Route setting type (RRI) and Non route setting type (panel interlocking). The features of Relay Interlocking in general are as follows. The RRI will have the additional facility of automatic operation of all points in route, overlap and isolation with a single command by Entrance-Exit System.

15.4 FEATURES OF RELAY INTERLOCKING.

- All operations are controlled from a Control panel by the operator.
- Knobs are provided for operating signals and points and they will bear the same number as the functions indicated in Signalling Plan
- Colour light signals are provided.
- Yard is Fully track circuited, between home to home signals in single line and Home to advanced starter on either direction in double line. Approach track is optional.
- Stand by power supply is provided from a D.G. set or from traction supply.
- Track circuit occupied /failed indications are also given in Red Colour.

Note:- Before going for PI/RRI it is necessary to ensure reliable and stable power supply for smooth working after commissioning.



Comparison of RRI and PI : -

Route Setting Type (RRI)	Non Route Setting Type (PI)
1. Automatic Route setting facility is available, which means that with single command, points in the Route, Overlap and Isolation can be operated to the required condition.	1. Automatic Route setting facility is not available. Points have to be operated individually for setting the Route.
2. RRI is adopted for bigger yards generally.	2. PI is adopted for smaller yards.
3. Provision of Colour light signalling is compulsory.	3. Colour light signalling is compulsory.
4. Sectional route release facility is compulsory	4. Sectional route release facility is not compulsory

15.5 Electronic Interlocking:

Presently Indian railways with a network of 62,000 route kilometers have approx. 247 Route Relay interlocking (RRI) and 2428 Panel Interlocking (PI) installations. These installations use thousands of Electro- mechanical relays requiring complex wiring and Inter-connections. The wiring diagrams for such installations run into hundreds of sheets. Individual relays, wiring and interconnections along with thousands of soldered joints are required to be physically examined and certified. This exercise requires traffic blocks of long durations and large manpower to manage the traffic during blocks. Even for small yard re-modeling like addition of a loop line, all the above activities are required to be redone. Therefore, the advantages of relay based interlocking installations are being nullified.

With development of modern fault tolerant and fail safety techniques, electronics and particularly microprocessors have found acceptance in the area of railway Signalling world over. Railways in advanced countries of Europe, North America & Australia have gone for large scale introduction of microprocessor based Solid State Interlocking (SSI). This system occupies considerably less space, consumes less power, is more reliable and is easy to install and maintain. Also, initial commissioning & changes due to yard re-modeling can be carried out in negligible time requiring skeleton manpower for traffic management during the blocks.

Presently on Indian Railways 76 SSIs have been commissioned up to March’05.

15.6 **Advantages of Electronic Interlocking System:**

(a) System can be tested at factory level using simulation panels.

(b) Non-Interlocking period is less (*Typically few hours instead of few days.)* both for initial installation and also for yard alterations (which can be done using application software compiler which is user friendly.)

(c) Modular in design and easy for maintenance, thus requiring less staff . Expertise of hardware and software is not much needed for maintaining the equipment at initial stage.

(d) Requires less number of relays - vital EI replaces interlocking circuits Thus less space required for signal equipment room (Relay rooms).

(e) Less power supply as compared with existing PI/ RRI's. Less failures, less wiring, less soldering, less complexity in the circuit.

(f) Enables usage of OFC (with Object Controller) which reduces requirement of Copper cables , their cost & maintenance.

(g) Remote operation of signals, points, and level crossings controls is feasible. Thus Compatible with centralized traffic Control.

(h) All EI's are designed and manufactured as per the international safety committees - such as CENELEC STANDARDS (European countries).

(i) Standard of safety and reliability is higher as compared with existing relay interlocking systems (PI/RRI).

(j) Datalogger / Event logger is an integral part of EI.

(k) Self-diagnostic in feature: i.e. error code/ alarm code messages will be displayed on display cards or on the front panel of printed circuit boards. Hence easy for rectification of failures and reduces the failure duration.

Policy on type of Interlocking to be adopted :

Board has decided the following policy to be adopted on IR vide Board's letter Nos. 2003/Sig/G/5 dt. 10-09-2003 and 2003/Sig/G/5/Pt. Dated 30th January, 2006

Up to 50 routes Relay based interlocking of Metal to Carbon or Metal to Metal type according to the expertise available on the railway.

(In special cases, EI may also be adopted in installations below 50 routes on a case to case basis. Such proposals for EI at signalling installations below 50 routes have to be justified on a case to case basis based on life cycle cost including capital cost, annual maintenance cost, depreciation provision, saving due to avoidance of repeated relay wiring due to anticipated yard remodeling etc. and concurrence of the associate finance obtained.)

50 to 200 routes Electronic interlocking.

Above 200 RRI with relay based interlocking of Metal to Carbon or Metal to Metal
Routes type according to the expertise available on the railway.

(Note : Bd has directed RDSO to finalise new Specification for EI for above 200 routes also vide Lr No .2008/SIG/SGF/4 /EI /GEN dt 29/07/09)

Note :- The above policy will be applicable to all new works and such of those sanctioned works where detailed estimates are not yet sanctioned.

Chapter 16
TELECOMMUNICATION

Telecommunication is the key to effective control and efficient working of each and every organization. In Railways, for effective, efficient and economical train operations, a wide telecommunication network is required. Broadly the railway's requirements can be classified as

a. Administrative
b. Operational

I. ADMINISTRATIVE (MANAGEMENT SUPPORT)

Communication amongst Area Control Office, Divisional Offices, Zonal Offices, Railway Board office etc :-

a. Telephone Exchanges and
b. Microwave/UHF/Optical cable networks.

Location not on Railway network are provided with administrative communication on hired trunk lines from DOT (P&T)

Major Administrative Communication Services are :-

1. Telephones (STD, OTD, Trunk working)
2. Teleprinters
3. Fax/Telex
4. Intercom
5. Data Circuits

II OPERATIONAL COMMUNICATION

1. Telecom which spread over Long Distance

1. Control Communication
2. Hot lines for train operation
3. Magneto phone communication for L/C
4. Block phone commn.
5. Pagers for train crew

2. Telecom limited to station yard etc.

1. Paging and talk back
2. PA system
3. C.C.T.V.
4. Walkie Talkie (VHF)
5. Station intercom

3. In addition, the telecommunications play a vital role in the areas of

1. Passenger Amenities and
2. Disaster Management

For Passenger Amenities the important services are :-

1. Public Address System
2. PRS (Data communication)
3. Enquiry : Auto Announcing System, IVR
4. Train indicators (Arrival/Departure)
5. Platform clocks (Master-slaves network)

Communication during emergencies (Disaster Management)

1. VHF
2. Satellite phone communication
3. HF (SSB)
4. Single channel Radio through DOT network

CONTROL COMMUNICATION

Omnibus telephone ckts. Which provides common with each train working point.

1. Section control/Train control :-

For the control of train movements and effective utilization of section capacity.

Connected to way side stn., Jn. Stn., cabins, loco-sheds, yards.

2. Deputy control circuit :-

For supervision of traffic operation.

Communicates with important stns., Jns, terminal stns, YM office, Loco sheds.

3. Loco power control :-

For the optimum utilization of the locomotives, electrical, diesel or stream locos.

Connected to various loco sheds, important stns., yards.

4. Traction power control :-

Special circuit in electrified section

For the efficient maintenance and operation of the electric overhead system.

Provided between TPC and SM, Grid stns. Feeding posts, sectioning posts, sub-sectioning posts,

5. Emergency control circuit :-

Spl. Ckt. in electrified sections. For the train crew in emergencies. Terminated at every 1 km.

6. Engineering control :-

To obtain traffic block and to monitor ballast/material trains.

FUNCTIONS OF TRAIN CONTROL

1. Ensuring speedy and smooth movement of trains

2. Abnormal working

3. Control of engineering and other blocks

4. Recording train movement

5. Synchronizing of clocks at stations

REQUIREMENT OF TRAIN CONTROL

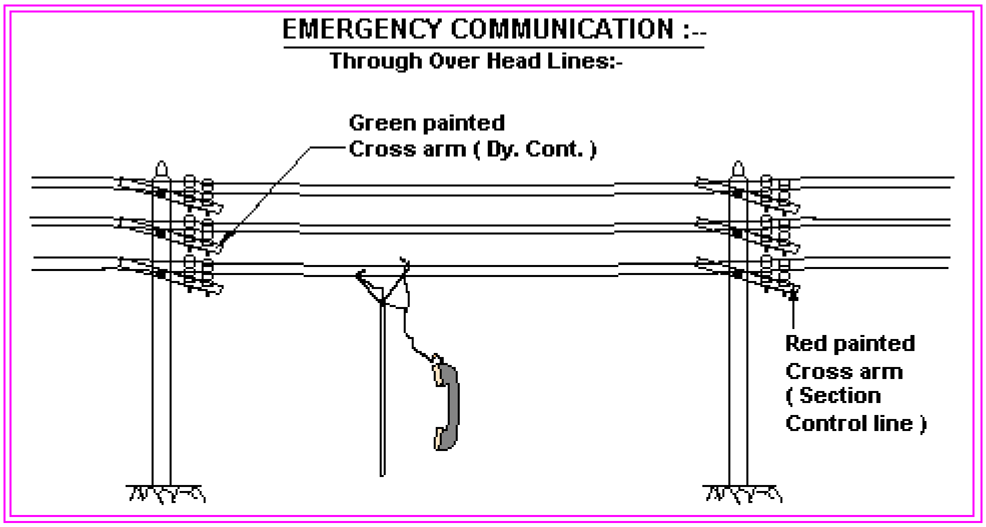
1. Controller able to talk to all stations

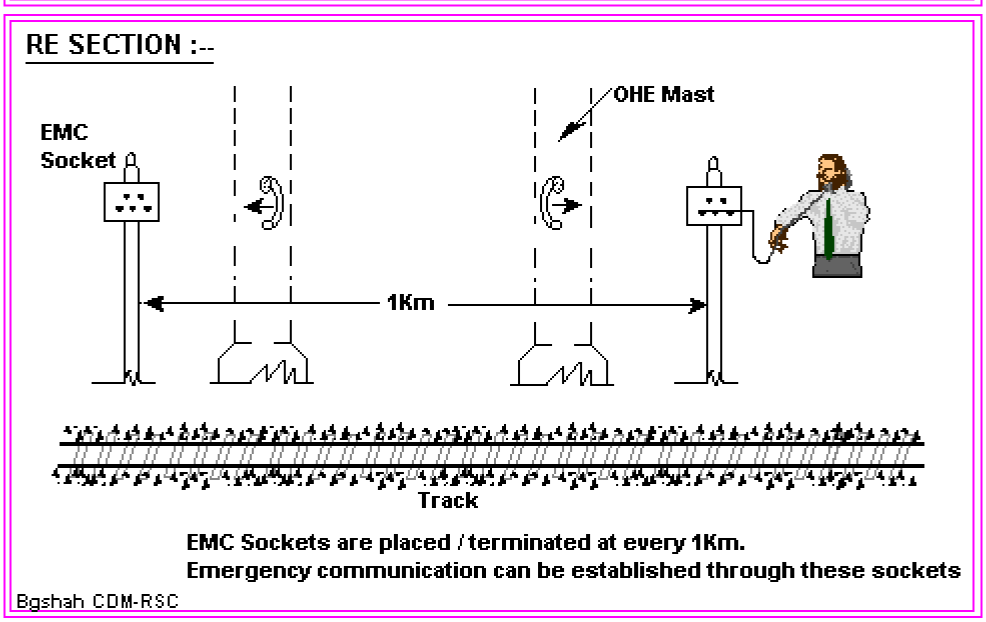
2. Ring up individually or simultaneously all stations

3. Ring back tone from way station Eqpt.

4. Way station able to call the attention of controller

5. Ringing should not interfere with speech





***Harnessing Railway's* "Right Of Way" *: Optic Fibre backbone for IR :* <u>RAILTEL:</u>**

- RailTel Corporation of India Limited has been established on September 26, 2000 as a Public Sector Undertaking (a 100% subsidiary under Ministry of Railways).
-
- RailTel has been set up primarily to exploit Railways' communication assets lying idle commercially. Railways have built a large telecom infrastructure over years for meeting their own communication requirement for train operation and safety.
- RailTel will augment and modernize the existing infrastructure for providing communication facilities to Railways and for commercial purposes.

OBJECTIVES of RAILTEL:

- To expeditiously modernise Railways' train control, operational and safety systems and networks.
- To create a nationwide broadband telecom and multimedia network to supplement national telecom infrastructure to spur growth of telecom internet and IT enabled value added services in all parts of the country specially rural, remote and backward areas.
- To significantly contribute to realisation of goals and objectives of National Telecom Policy, 1999 and
- To generate much needed revenues for implementing Railways' development projects, safety enhancement and asset replacement programmes

IMPLEMENTATION PLAN

RailTel has plans to build high speed OFC based network using DWDM/SDH technologies on 40,000 route kms in phased manner.

- RailTel has laid OFC upto 37000 km.
- It is planned to lay OFC on 46338 route km.
- RailTel has plans to lay Optical Fibre Cable for providing communication to the Railways as well as for commercial use of surplus capacity. As Railways communication requires dropping of channels at each station, bandwidth will be available at each railway station. Railways will need 2-8 MBPS out of 155 MBPS the remaining capacity will be used for other purposes like for Internet, STD/ISD services in rural and remote areas.

- Infrastructure Provider Services: RailTel would provide leased limes to telecom services providers to begin with along with other infrastructure like tower space, co-locational facilities under IP-I and IP-II licenses.

Mobile Communication on Indian Railways

Indian Railways is also going in for provision of Mobile Communication in a big way. Known as MTRC (Mobile Train Radio Communication)

GSM(R) technology has been selected for the MTRC Works (R stands for Railways). GSM(R) Global System for Mobile Communications is specially suited for railway applications. It has facilities of Broadcast Call, Group Call, Emergency Call as well as feature of calling trains by their train nos.

Loco Pilots, Motorman and Guards are entitled for CUG with Rs. 300 monthly CUG usage charges including rental.

Communication between Driver & Guard in Rajdhani & Shatabdi Trains

Magneto phone between Driver & Guard was provided in Rajdhani & Shatabdi Trains. At times it creates problem.

In place of Magneto Phone, Walki Talki VHF Sets are to be provided.

Chapter 17

Common Abbreviations Used in Signalling & Telecom

AWS: Auxiliary Warning System

ATO: Automatic Train Operation

AFTC: Audio Frequency Track Circuits

ACD: Anti Collision Device

BPAC: Block Proving by Axle Counters

CTC: Centralised Traffic Control

DWDM: Dense Wave Division Multiplexing

ERTMS: European Railway Traffic Management System

FOIS: Freight Operation Information System

GPS: Global Positioning System

KBPS: Kilo Bits Per Second

LED : Light Emitting Diode : LED Signals

LQ: Lower Quadrant

MBPS: Mega Bits Per Second

MPLS: Multi Protocol Label Switching

MTRC: Mobile Train Radio Communication

MACLS: Multiple Aspect Colour Light Signalling

MAUQ: Multiple Aspect Upper Quadrant

MRTS: Mass Rapid Transit System

OFC: Optic Fiber Communication

PI: Panel Interlocking

RRI: Route Relay Interlocking

SDH: Synchronous Digital Hierarchy

STM: Synchronous Transfer Module

SSI: Solid State Interlocking

TMS: Train Management System

TPWS : Train Protection & Warning System

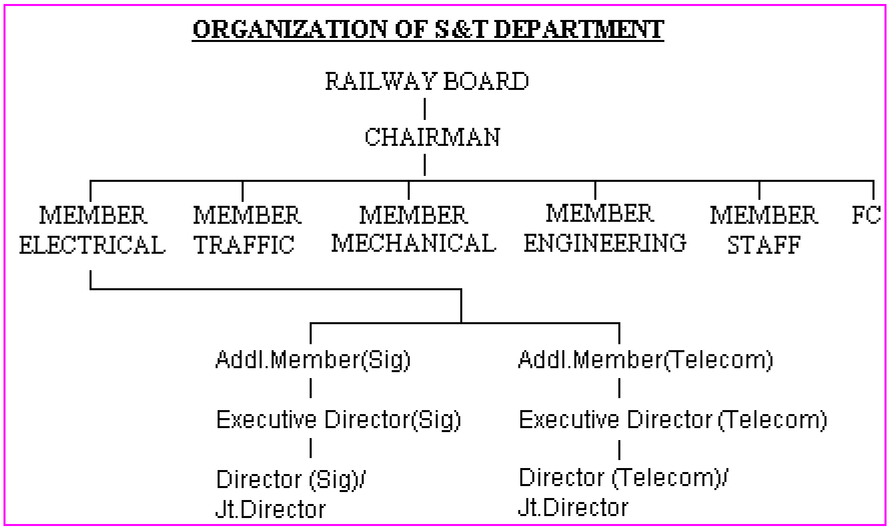
TAWD: Track Actuated Warning Device

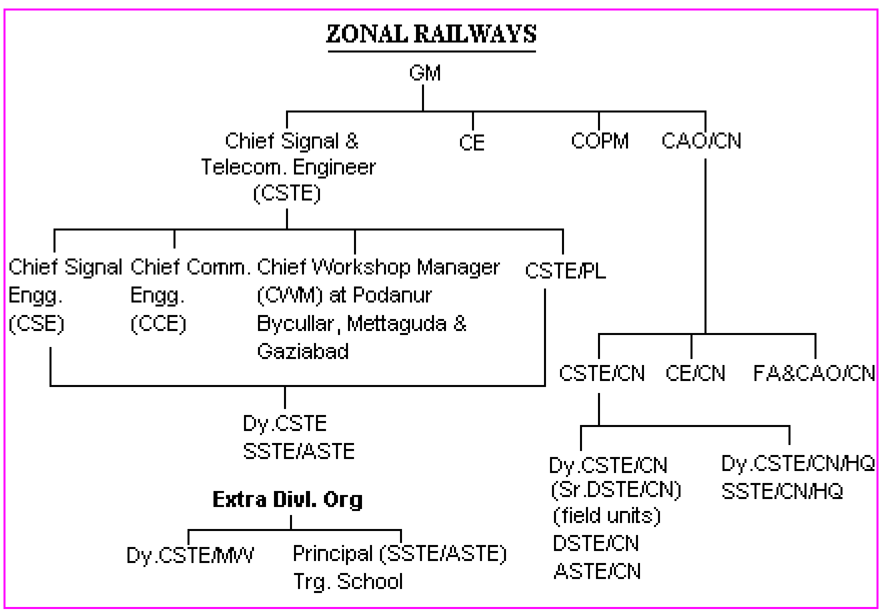
VSAT: Very Small Aperture Terminal

Wi Fi: Wireless Fidelity

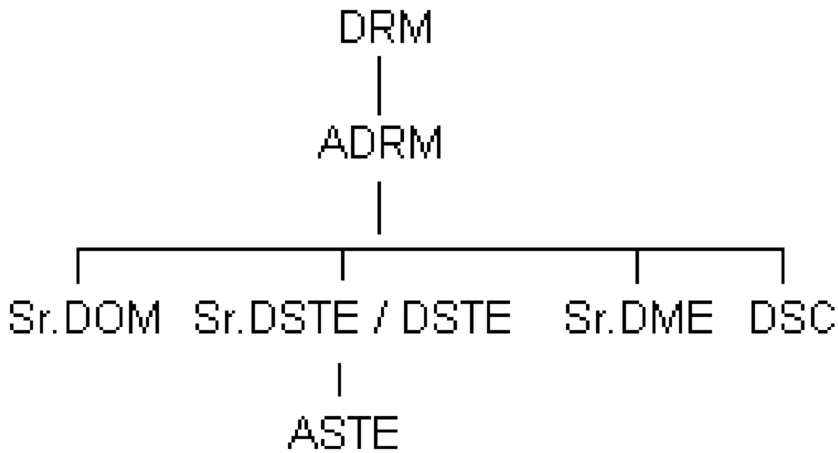
Chapter 18

ORGANIZATION CHARTS OF S&T DEPARTMENT





DIVISION



Supervisor