# Approach Distances And Times

## Suggested methods for computing distances for approach locking and approach indication and times for time release and and time locking

By George B. Dutton, Jr.

THERE seems to be no standard way of determining the length of an approach section. In some cases the approach section extends an arbitrary distance in approach of the approach signal; in some cases it extends to the first signal Clear when the home signal is at Stop; in some cases it extends an arbitrary distance in approach of the first Clear signal. According to Part 128 of the A.A.R. Signal Section Manual, the time interval for time release or time locking is computed as the time required to travel at 30 m.p.h. from a point 1,500 ft. in approach of the approach signal to the home signal. There seems to be no definite reason for using these particular values or this method of computation. The following reasoning from fundamental considerations is an attempt to formulate sound methods of computing safe approach distances and times. Where assumptions are made or arbitrary values are chosen, the writer has endeavored to point them out, so that their effects can be seen and the effects of different assumptions and values can be considered.

### General Principles

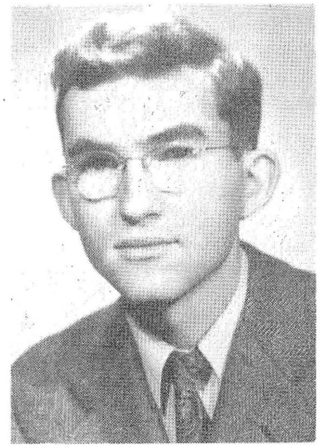
The purpose of approach locking at an interlocking is to make it impossible to change a route in front of an approaching train which is too close to be brought safely to a stop before reaching the home signal. A home signal may be a dwarf signal, since a dwarf signal is defined as a low home signal. Where a signal is used merely to hold trains back for some reason and governs no route which can be changed there is no need for approach locking. The purpose of approach locking can be achieved by arranging that the route will remain locked when the signal is restored to Stop unless the track circuits for a predetermined distance in approach are unoccupied. Approach indication from the same track circuits is provided with approach locking so that the leverman will know when approach locking is in effect, so that he will be notified of the approach of trains, and so that he will not inadvertently change a signal to a more restrictive indication in front of a train.

### Time Releases

Because it is sometimes necessary to change a route after a train has entered the approach section, a time release of the approach locking is provided. If there is a train in the approach section, a pretermined time must elapse after the home signal is restored to Stop before the route can be changed. The time interval must be long enough so that the train will either come to a stop or pass the home signal before the locking is released. If the train stops short of the home signal it is safe to change the route. If it passes the home signal before the time expires, route locking will be in effect. Since the time release, as described, provides full protection, time locking can be used in place of approach locking if the delay in changing routes is not prohibitive. The time interval for time locking should obviously be the same as for the time release of approach locking. These considerations for interlockings apply equally well to remotely-controlled interlockings, automatic interlockings, and centralized traffic control.

### At Hand-Throw Switches

Hand-throw switches in automatic block or centralized traffic control territory can have the same approach protection as interlock-



George B. Dutton, Jr.

*Mr. Dutton is draftsman in the office of the signal engineer of the New York, New Haven & Hartford at New Haven, Conn. He received his education at the Williamstown (Mass.) High School, Lawrenceville School, and Williams College. Mr. Dutton entered railway service with the New York Central System, Lines East, in 1940, serving as helper and draftsman in the signal department until 1942. He entered the services of the New Haven in 1946 as a student assistant in the personnel department, and has been draftsman in the signal department since 1948. In 1942, during World War II, Mr. Dutton was commissoned a second lieutenant in the electronics training group of the U. S. Signal Corps, having pursued courses in electronics at Harvard University, and in radar at the Massachusetts Institute of Technology. He served as project officer at the radiation laboratory of the Massachusetts Institute of Technology during 1943 and 1944, subsequently installing and testing radar equipment in the United States, Canada and Italy until appointed section officer at the Watson Laboratories of the U. S. Air Material Command in 1945. Mr. Dutton was separated from the service in 1946 as a captain in the Air Corps, and presently holds the rank of captain in a railway operating battalion of the U. S. Transportation Corps Reserve.*

ings. Since there is no route locking, the approach or time locking must cover the distance from the switch back to the signal protecting it, as well as a predetermined distance in approach of signal or a time interval after it is set to Stop. The predetermined distance for the approach section must be great enough so that if the home signal is set to Stop before a train enters it the train can stop before reaching the signal. Thus, the approach section must extend at least braking distance in approach of the home signal for the maximum speed at which trains may be approaching. Braking distance means braking distance under the worst conditions for the longest, heaviest trains, not just for passenger trains, and it includes a generous margin of safety in addition to the actual stopping distance.

### Length of Interval

The time interval for time release or time locking must be long enough so that the train will either come to a stop short of the home signal or pass it before the locking is released. The time for making a stop from a given speed can be computed as follows: The train will travel its braking distance in making the stop. Its speed in that distance will drop from the given speed to zero. Assuming uniform deceleration, the average speed for the interval will be half the given speed. Therefore, the stopping time will be the time required to travel the braking distance for the given speed at half the given speed.

In all of the following examples, values for speed, braking distance, etc., are chosen simply for illustration. In actual computation, actual values would be used. For example:

Speed, 30 m.p.h., 44 f.p.s. (feet per second). Braking distance, 3,000 ft. ½ speed = ½ x 44 f.p.s. = 22 f.p.s.

3,000 ft. at 22 f.p.s. = $\frac{3{,}000 \text{ ft.}}{22 \text{ f.p.s.}}$ = 136 sec., stopping time.

### Leave Considerable Margin

This method of computing stopping time, leaves a considerable margin because the braking distance is computed with a margin, and because deceleration is actually not uniform. Deceleration is gradual at first, building up as the brakes become effective. Thus, the actual average speed for the stop is greater than half the initial speed and hence the time is less than that computed. A train approaching at less than the maximum speed will stop in less time than one approaching at the maximum speed, since, although its average speed throughout the stop is less, its braking distance is much less. A train too close to stop short of the home signal will obviously pass the signal before the time runs out, since it will cover less than braking distance in less time than the full braking distance. In addition to the time interval, as computed, there should be added a margin to allow for inaccuracy of the timing device. The percentage margin used depends on the type of timing device.

### Home Signal Without Operative Approach Signals

A home signal should be without any approach signals only when all movements approaching it must be made at low speeds as at an exit from a siding or a yard. The signal must be visible far enough to provide braking distance at the maximum speed at which movements may approach it. A home signal should have an inoperative approach signal only if the maximum speed through the interlocking is fairly low. The I.C.C. permits a maximum of 20 m.p.h. The indication of a fixed approach signal is, "Proceed preparing to stop at next signal. Train exceeding medium speed must at once reduce to that speed." Hence, even if the home signal can be seen not to be at Stop for a considerable distance, trains must approach it at not exceeding medium speed, especially since the maximum speed through the interlocking is fairly low. If the home signal is not visible any great distance, trains must approach it at a lower speed, low enough so that the sighting distance is greater than braking distance. From this discussion it can be seen that an approach section for a home signal without operative approach signals is sufficient if it extends back just farther than the signal can be seen. When the home signal can be seen a great distance this is not practicable. In that case, the approach section should provide braking distance for the maximum speed of an approaching movement. Where there are no approach signals, this speed will be low and where there is a fixed approach signal, it will not exceed medium speed. However, it is possible that an engineman once having observed the home signal, not at Stop, might not continue to observe it, and might not immediately see it change. Some extra distance should be added to give the engineman time to look at the signal again and notice that it has been set to Stop. Fifteen seconds seems like a reasonable interval for the engineman to notice the change. In some cases, as at a large passenger station, trains always stop at a particular point. There is obviously no need of carrying the approach section farther back than that point.

### Length of Approach

Summarizing, the approach section for a home signal without operative approach signals should extend back just farther than the signal can be seen, or to a point at which all movements stop, or braking distance at the maximum speed at which the signal can be approached, plus a distance to provide 15 sec. at this speed. This maximum speed will not exceed medium speed with an inoperative approach signal, and will be lower with no approach signal. For example, assume a home signal with no approach signal, visible for a considerable distance, no nearby point at which all trains stop: Maximum speed approaching the signal, 15 m.p.h., 22 f.p.s. Braking distance at 15 m.p.h., 500 ft. Distance traveled in 15 sec. at 15 m.p.h. 15 sec. x 22 f.p.s. = 330 ft. Approach distance = braking distance plus distance traveled in 15 sec. = 500 ft. + 330 ft. = 830 ft.

### Time to Stop

Time release or time locking should be set for the time required to stop from the maximum speed at which the signal can be approached, plus the 15 sec. extra time provided above. Where the home signal is not visible very far beyond braking distance, only enough extra time need be provided to cover that extra distance, but it seems simpler to make the computation uniform. If there is a point at which all trains stop as mentioned above, the distance from this point to the home signal can be taken as braking distance to determine the maximum speed. This leaves a great margin since a train cannot accelerate instantaneously. For example, assume a home signal with an inoperative approach signal, visible for 1,000 ft., no nearby point at which all trains stop: Speed to give braking distance of 1,000 ft., 20.5 m.p.h., 30 f.p.s. Time to make the stop, 1,000 ft. at ½ of 30 f.p.s., $\frac{1{,}000 \text{ ft.}}{15 \text{ f.p.s.}}$ = 67 sec. Stopping time + 15 sec. extra time, 67 sec. + 15 sec. = 82 sec., time interval.

As another example, assume a home signal with no approach signal, no nearby point at which all trains stop:

Maximum speed approaching the signal 15 m.p.h., 22 f.p.s. Braking distance at 15 m.p.h., 500 ft. Time to stop, $\frac{500 \text{ ft.}}{11 \text{ f.p.s.}}$ = 45 sec.; 45 sec. + 15 sec. = 60 sec., time interval.

### Approach Distance for Home Signal With One or More Operative Approach Signals

When a home signal has one approach signal, that approach signal will be in approach at least far enough to provide braking distance from the maximum speed. If there is more than one approach signal, the farthest approach signal in approach of the home signal will be at least far enough to provide braking distance. If the approach section extends in approach of the farthest approach signal, a train which has not entered the approach section when the home signal is set to Stop will have opportunity to observe the approach signal or signals and stop short of the home signal. However, an engineman once having seen the approach signal at Clear may not continue to observe it, and may not see it change or, seeing it change, he may become confused and perhaps make an undesirable emergency brake application. To make sure that a signal is not inadvertently changed to a more restrictive indication in front of a train, to make sure that the approach signal will be displaying the proper indication as soon as it is observed, the approach section should be extended a short distance in approach of the first signal Clear when the home signal is at Stop. The short distance in approach is to provide a margin, so that the approach signal will not be changing just as the train comes into the block. With searchlight signals without approach-signal repeating circuits, and with slow-release relays in the circuits and track circuits which do not shunt instantaneously, three or four seconds might be needed. Actually, the approach section will probably include the first track circuit in approach of the first Clear signal, although that track circuit will probably be quite long. At the minimum, let the approach section extend 500 ft. in approach of the first signal Clear when the home signal is at Stop, as shown in Fig. 1.

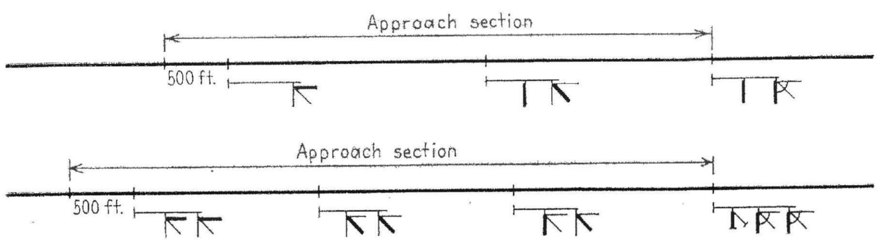


**Fig. 1—Approach distances for home signals with one or more approach signals**

Take 15 sec., as before, as the margin of time for an engineman to notice a signal changing to a more restrictive indication. If the home signal is set to Stop 15 sec. before the train reaches the approach signal it will stop short of the home signal. If the home signal is set to Stop later, the train may continue and run by the home signal, unless the speed is low enough to permit it to stop in sighting distance. Hence, the time interval should be the 15 sec. extra time, plus the time required to travel from the approach signal to within sighting distance of the home signal at a speed low enough to permit stopping within sighting distance, plus the stopping time.

Sighting distance is limited by curvature and obstructions and by weather conditions. Probably as a maximum it should be taken as 1,000 ft. or less to allow for snow and fog. This maximum depends on the type of weather encountered and on the signals. Searchlight signals can be seen much farther than oil-lighted semaphores. Where fogs are heavy, sighting distance may be impracticably short. The speed to stop in a distance of 50 ft., for example, would give a ridiculously long time interval. Unless heavy fogs are common, it would probably be sufficient to warn crews of trains moving slowly in a fog to approach home signals prepared to stop, and leverman to be particularly careful about changing routes when there is a fog. Rule 513(A) of the Standard Code provides that a train delayed in a block must proceed at restricted speed to the next signal. This provides protection for trains moving much more slowly than the speed used in computing the time interval.

Where there are cab signals, sighting distance is effectively the full block, since the cab signal will change to Approach when the home signal changes to Stop. Where cab signals are always used, the time interval should be the 15 sec. extra time plus the stopping time from maximum speed for the heaviest trains. Where the approach signal is considerably more than braking distance in rear of the home signal, the stopping time should be computed from the braking distance and not from the approach signal distance. The 15 sec. extra time will take care of the acknowledging time of the cab signal apparatus with something to spare. For example, assume a searchlight home signal visible for a great distance, using 1,000-ft. sighting distance, and an approach signal 8,000 ft. in approach of the home signal; speed to give 1,000-ft. stopping distance, 20.5 m.p.h., 30 f.p.s.: Extra time, 15 sec. Travel time from approach signal to sighting point 8,000 ft. – 1,000 ft. = 7,000 ft. $\frac{7{,}000 \text{ ft.}}{30 \text{ f.p.s.}}$ = 233 sec. Stopping time from 30 f.p.s., $\frac{1{,}000 \text{ ft.}}{15 \text{ f.p.s.}}$ = 67 sec. Time interval is extra time plus travel time plus stopping time: 15 sec. + 233 sec. + 67 sec. = 315 sec., time interval.

As another example, assume a home signal visible for 400 ft., and an approach signal 8,000 ft. in approach of the home signal; speed to give 400-ft. stopping distance, 15 m.p.h., 22 f.p.s.: Extra time, 15 sec. Travel time from approach signal to sighting point at 22 f.p.s. $\frac{7{,}600 \text{ ft.}}{22 \text{ f.p.s.}}$ = 345 sec. Stopping time, $\frac{400 \text{ ft.}}{11 \text{ f.p.s.}}$ = 36 sec. 15 sec. + 36 sec. = 396 sec., time interval.

In cab signal territory, assume braking distance for heaviest trains as 7,000 ft.; maximum speed for heaviest trains, 45 m.p.h., 66 f.p.s.:

Extra time, 15 sec. Stopping time, $\frac{7{,}000 \text{ ft.}}{33 \text{ f.p.s.}}$ = 212 sec. 15 sec. + 212 sec. = 227 sec., time interval.

### Time Interval for Home Signal With More than One Operative Approach Signal

Again, consider 15 sec. as the margin of time for an engineman to notice a signal changing to a more restrictive indication. If the home signal is set to Stop 15 sec. before the train reaches the approach signal farthest in approach it will stop short of the home signal. If the home signal is set to Stop less than 15 sec. before the train passes an approach signal, the train may continue and run by the home signal unless the speed is low enough so that the next approach signal provides braking distance, or if there is no next approach signal, unless the speed is low enough to permit it to stop in sighting distance.

### Plus Extra Time

The time interval should be the 15 sec. extra time, plus travel time from an approach signal to the next approach signal at the speed for which that next approach signal gives braking distance, plus stopping time from that next approach signal **or** the 15 sec. extra time, plus travel time from the first approach signal in approach of the home signal to the sighting point at the speed for which the sighting point provides braking distance, plus stopping time. The time should be figured from each approach signal and the longest time used. Ordinarily, the time figured from the approach signal farthest in approach will be the longest. For example, assume a home signal visible 1,000 ft. with three operative approach signals spaced 3,000, 6,000, and 9,000 ft. in approach: 6,000 ft. is braking distance for 72 f.p.s.; 3,000 ft. is braking distance for 50 f.p.s.; 1,000 ft. is braking distance for 30 f.p.s. Time interval is the longest of these three: 15 sec. plus travel time from approach signal to next approach signal or sighting point plus stopping time: $15 + \frac{3{,}000}{72} + \frac{6{,}000}{36} = 15 + 42 + 167 = 224$ sec. $15 + \frac{3{,}000}{50} + \frac{3{,}000}{25} = 15 + 60 + 120 = 195$ sec. $15 + \frac{2{,}000}{30} + \frac{1{,}000}{15} = 15 + 67 + 67 = 149$ sec. Or if sighting distance is 500 ft., braking distance for 20 f.p.s. $15 + \frac{2{,}500}{20} + \frac{500}{10} = 15 + 125 + 50 = 190$ sec. In either case 224 sec., the time figured from the approach signal farthest in approach, is the longest and hence the time interval to be used.

### Switch Locking in Automatic Block or Centralized Traffic Control Territory

The first signal in approach of a locked switch or crossover is similar to the home signal in the preceding discussions. The distance which the approach section extends in approach of this signal can be computed as before. In addition, the track section from the signal to the switch must be made a part of the approach section since there is no route locking, as shown in Fig. 2.

In computing the time interval for time release or time locking of a hand-thrown switch, take 15 sec., as before, as the margin of time for an engineman to notice a signal changing to a more restrictive indication. If the time interval is started 15 sec. before the train reaches the approach signal farthest in approach, it will stop short of the signal protecting the switch. If the time interval is started less than 15 sec. before the train passes an approach signal, the train may continue and run by the signal protecting the switch, and the switch as well, unless the speed is low enough so that the next approach signal provides braking distance to the switch or, if there is no next approach signal, unless the speed is low enough so that sighting distance to the signal protecting the switch will provide braking distance to the switch. If the time interval is started less than 15 sec. before the train passes the signal protecting the switch, it will run by the switch unless the speed is low enough to permit it to stop in sighting distance of the switch.

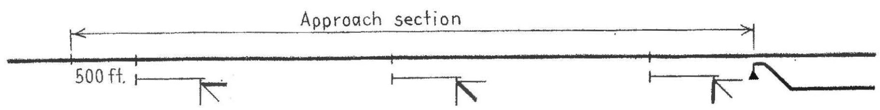



Fig. 2—Approach distance with reference to electric switch locking

The time interval should be the 15 sec. extra time, plus travel time from an approach signal to the next approach signal at the speed for which that next approach signal gives braking distance to the switch, plus stopping time from that next approach signal **or** the 15 sec. extra time, plus travel time from the first approach signal in approach of the signal protecting the switch to the sighting point for the signal protecting the switch at the speed for which the distance from that sighting point to the switch will provide braking distance, plus stopping time **or** the 15 sec. extra time, plus travel time from the signal protecting the switch to within sighting distance of the switch at the speed for which that sighting distance provides braking distance, plus stopping time. The time should be figured for each case and the longest time used.

Sighting distance for home signals has been discussed. The case with switches is similar. A switch target cannot be seen as far as a searchlight signal. In foggy weather the crew operating the switch should be particularly careful about flagging. For example, assume a switch target visible for 200 ft., located 1,000 ft. in advance of a signal. That signal visible for 400 ft., has two approach signals 4,000 ft. and 8,000 ft. in approach. Speed for which 200 ft. provides braking distance, 10 m.p.h., 15 f.p.s.: Sighting point of signal to switch, 400 ft. + 1,000 ft. = 1,400 ft., speed for which this is braking distance, 27 m.p.h., 40 f.p.s. Distance from first approach signal to switch, 4,000 ft. + 1,000 ft. = 5,000 ft., speed for which this is braking distance, 51 m.p.h., 75 f.p.s.

*First Case*: 15 sec. plus travel time from signal to within sighting distance of switch at speed for which sighting distance is braking distance plus stopping time: 15 sec. $+ \frac{800 \text{ ft.}}{15 \text{ f.p.s.}} + \frac{200 \text{ ft.}}{7.5 \text{ f.p.s.}} = 15$ sec. + 53.5 sec. + 26.8 sec. = 95 sec.

*Second Case*: 15 sec. $+ \frac{3{,}600 \text{ ft.}}{40 \text{ f.p.s.}} + \frac{1{,}400 \text{ ft.}}{20 \text{ f.p.s.}} = 15$ sec. + 90 sec. + 70 sec. = 175 sec.

*Third Case*: 15 sec. $+ \frac{4{,}000 \text{ ft.}}{75 \text{ f.p.s.}} + \frac{5{,}000 \text{ ft.}}{37.5 \text{ f.p.s.}} = 15$ sec. + 53.4 sec. + 133.4 sec. = 202 sec.

202 sec., the longest of the three cases, is the proper time interval.

### Conclusion

The methods and examples given in this discussion cover many of the situations for which approach distances and times must be computed. They naturally do not cover all situations, but it is hoped that they illustrate the reasoning well enough so that the reader can work out for himself any special cases that may arise. Since the computations developed in this article are based on an analysis of what trains should actually do, approach distances and times so computed should be long enough to provide complete safety yet not needlessly longer so as to delay operations.