Traffic Signal Design Manual

ORIGINATOR Director, Bureau of Highway Operations		8-1-5
CHAPTER 8	Detector and Controller Logic	
SECTION 1	Vehicle Detection	
SUBJECT 5	Advance or Far Detection	

The method of advance detection design must be compatible with the actual gap and duration of maximum green incorporated into the design. Detector placement strategies which require high values of allowable gap *may* be incompatible with safety and efficiency. Furthermore, under heavy traffic conditions, a long allowable gap *may* cause unnecessary delay to waiting vehicles or routinely extend the controller to maximum green even under moderate traffic.

Depending on vehicle speeds and roadway geometrics, advance detection *may* be augmented by the placement of intermediate and/or stop-line detection. Additional near detection is commonly used on low-volume side-street approaches and main street approaches not using recall.

There are a variety of strategies that can be employed for advance detection. However, primarily there are two which provide the most efficient and safe operation. These are single-point detection and dilemma-zone detection.

<u>SINGLE-POINT DETECTION</u>

Single-point detection consists of a single loop, normally 6’ x 6,’ in each through lane, or one loop covering all approach lanes (e.g. 6’ x 20’ or 6' x 18' for two lanes), located two to five seconds of travel time in advance of the stop line. Single-point detection is typically used where vehicle speeds are ≤35 mph or if the opposing volumes are such that it is inefficient to extend the green for sporadic arrivals.

Signal timing for this type of detector application is based on the distance from the stop line to the advance detection. The minimum green time is commonly set for approximately 6 to 10 seconds. The variable initial time *may* add green time beyond the minimum green to allow additional vehicles in the queue to enter the intersection. The variable green time can be determined several ways; one method is to divide the time for all vehicles to enter the intersection by the total number of vehicles in the queue (assume a queue extending from the stop line to the point detection). The passage time or allowable gap is established by determining the time it takes to travel from the advance detection to the intersection at the selected design speed. While this type of detection can also be used for higher speeds, ≥35 mph, it is recommended that the second type, dilemma zone detection, be employed where speeds exceed 35 mph. Figure 1 illustrates two commonly used layouts.

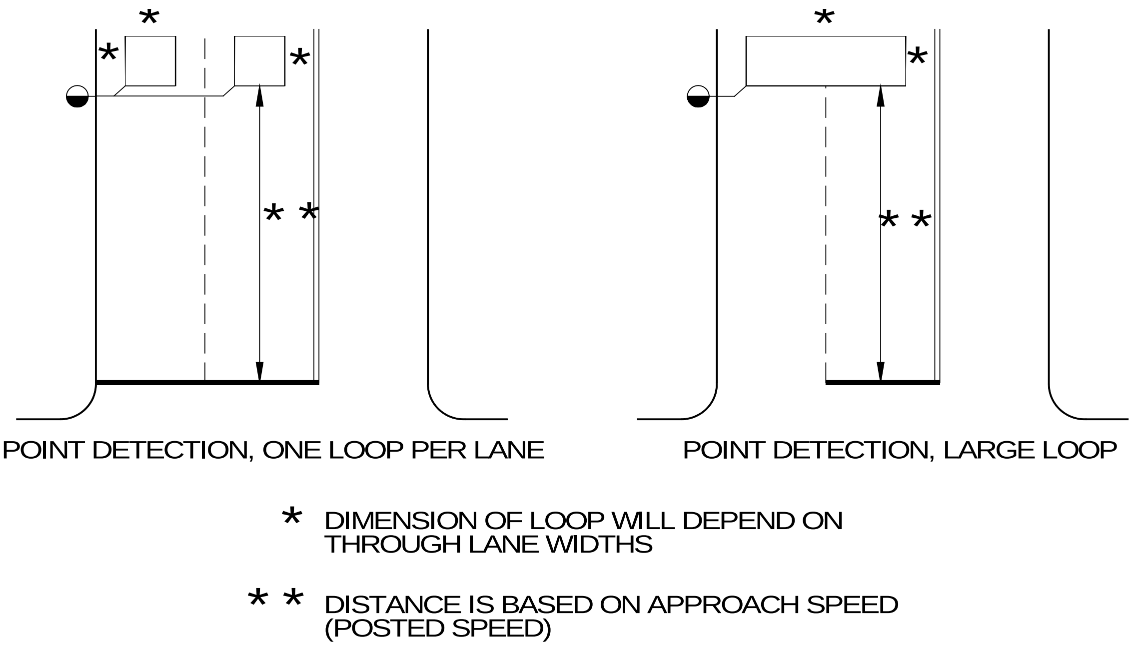

Figure 1
Advance-Detection Loop Layout

DILEMMA ZONE DETECTION

The dilemma zone is defined as that portion of the roadway in advance of the intersection within which a driver is indecisive regarding stopping prior to the stop line or proceeding into or through the intersection. Detection designed to minimize driver decisions in this area is called dilemma zone detection. This type of detector application is intended for high-speed approaches (>35 mph) where decision distances and stopping distances are critical and not fully accounted for in single-point detector applications. Although there are different methods used for dilemma zone detection, all methods utilize multiple-loop-detector configurations. The difference among methods is the number, placement, and loop size for a particular configuration.

The two primary dilemma zone detection methods are: (1) green extension system; (2) extended call detector system.

GREEN EXTENSION SYSTEM

The green extension system utilizes two loops per lane. The concept is to detect a vehicle as it enters the dilemma zone and then extend the green until the vehicle clears the dilemma zone. The advance loop (S_1) acts to extend the green time for a vehicle to reach the near loop (S_2). The near loop maintains the green time long enough to allow the vehicle to enter or clear the intersection. This method is best used where speeds are relatively consistent and the posted speed limit is ≥45 mph. The loop locations are governed by the percentile speed chosen by the designer. The 85th-percentile speed is commonly used; however, a higher percentile speed can be designed. Figure 2 illustrates the green extension system loop layouts.

It *should* be noted that regardless of the method employed, vehicles *may* still be caught in the dilemma zone if traffic conditions or timing parameters cause the respective phase to max out.'

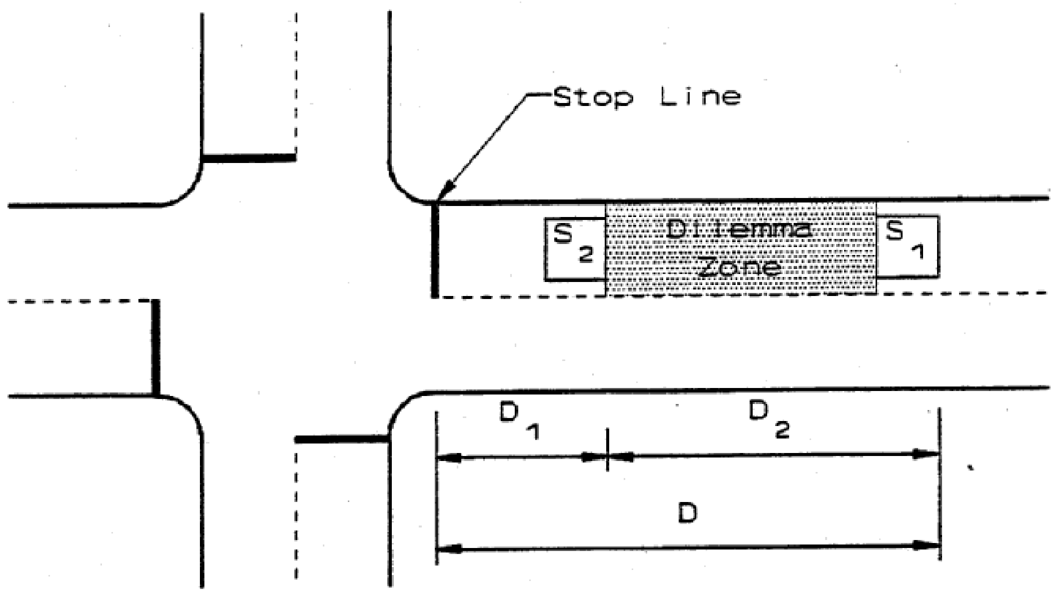

Figure 2
Green Extension System

Advanced Detector Placement based on 90% Stop Probability (Measured from front of detector to near right signal)		
	FAR LOOP	INTERMEDIATE LOOP
20 mph	150 (45 m)	
25 mph	180 feet (55 m)	
30 mph	225 feet (70 m)	
35 mph	250 feet (80 m)	
40 mph	290 feet (90 m)	
45 mph	330 feet (105 m)	200 feet (65 m)
50 mph	370 feet (115 m)	220 feet (70 m)
55 mph	405 feet (125 m)	245 feet (75 m)
60 mph	440 feet (135 m)	265 feet (80 m)

EXTENDED-CALL SYSTEM

The extended-call detector system also utilizes two loops. However, under this method a long loop or series of long loops is placed at the stop line for presence detection, and a single extended-call detector loop is placed upstream of the stop line. The advance loop (S_1), located at the beginning of the dilemma zone, extends the green time, allowing a vehicle to reach the stop line loop (S_2) (i.e. travel through the dilemma zone). The stopline loop (presence loop) ensures that vehicles queued at the intersection can enter the intersection without triggering a premature gapout when there are not subsequent calls from vehicles on the advance loops. The extended call system is best used where speeds are in the range of 35 mph to 50 mph and the vehicle volumes are relatively high. Figure 3 illustrates the extended-call detector system layout.

It *should* be noted that regardless of the method employed, vehicles might still be caught in the dilemma zone if traffic conditions or timing parameters cause the respective phase to max out.

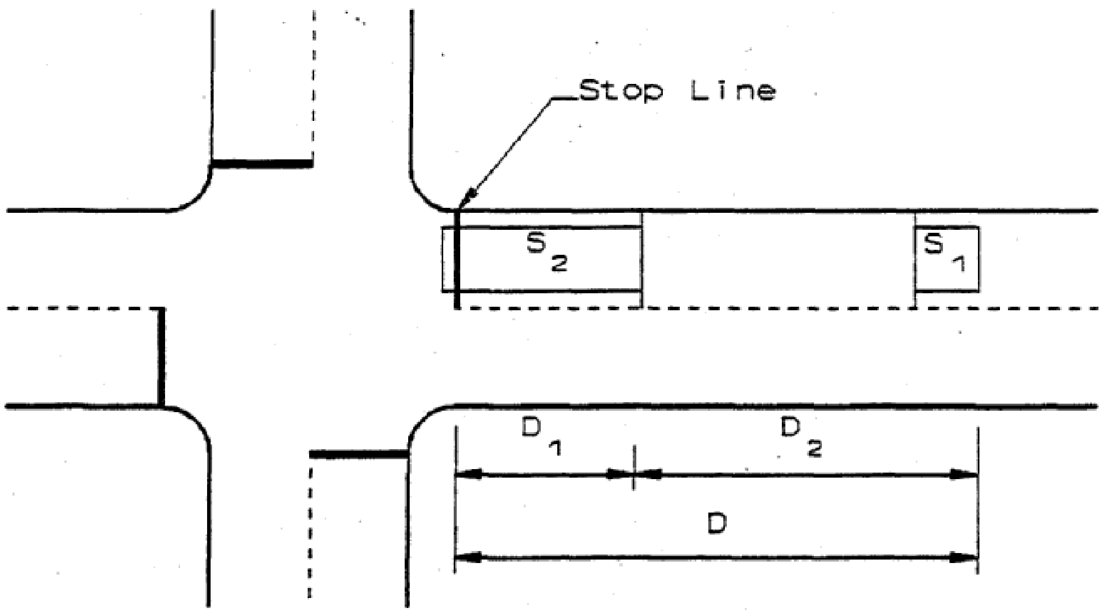

Figure 3
Extended-Call Detector System

There have been several tables published regarding the dilemma zone location for various design speeds. For the purpose of providing guidance, Chart 1 and Table 1 have been reprinted from a Northwestern University Traffic Institute course manual. Table 1 shows the dilemma zone response curves by vehicle speed and distance from intersection. The 90% Go and 90% Stop probability ranges have been marked for reference during design. Table 1 shows passage distances based on speed and time. The numbers shown in Table 1 are directly related to the curves shown in Chart 1. Chart 2 has been reprinted from the Federal Highway Administration Detector Manual. This chart shows various dilemma zone response curves by vehicle based on vehicle speed and percentage probability of stopping. The 90% and 10% probability ranges have been identified for reference during design. Chart 3 *may* be used to determine passage times for advance detection. Using the design speed and proposed passage distance, the passage time can be determined. It is the responsibility of the signal designer to determine the appropriate passage distance. The passage time *should* allow the vehicle to enter into the intersection; however, each case *should* be evaluated separately.

These tables and charts are provided only as a reference. In all cases the signal designer is responsible for selecting the appropriate design speed, passage time, and percentage probability of stopping.

ADVANCE DETECTION FOR EXTENSION

The same loop layout concept shown for point detection *may* be used for extending the green time for an approach, including left-turn lanes. If extend-only detection is installed without recall, it must be supplemented with near detection. This is required since extend-only detection will not place a call from a passing vehicle when a red phase is being timed. See TSDM Subject 8-1-6 for details on near detection.

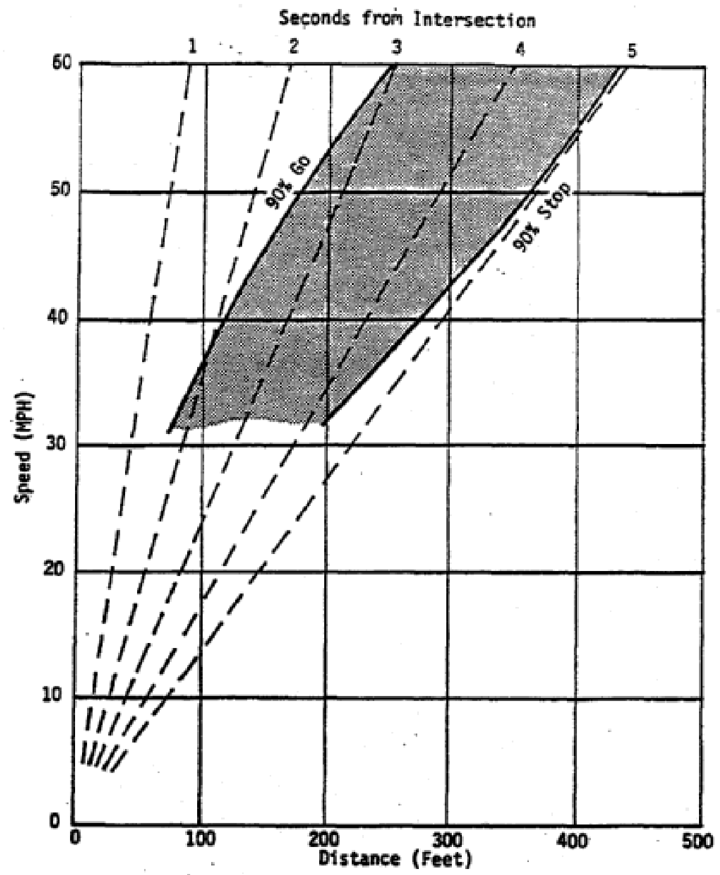

Chart 1
Dilemma Zone Response Curves

Passage Time in Seconds from Detector to Stop Bar

Approach Speed, Miles per Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
20	29	58	87	116	145	174	196	232	261	290	319	348	377	406
25	36	78	108	144	180	216	252	288	324	360	396	438	468	504
30	44	88	132	176	220	264	308	352	396	440	484	528	572	616
35	51	102	153	204	255	306	357	408	459	510	561	612	663	714
40	59	118	177	236	295	354	413	472	531	590	649	708	767	826
45	66	132	198	264	330	396	462	528	594	660	726	792	858	924
50	73	146	219	292	365	438	511	584	657	730	803	876	949	1022
55	81	162	243	324	405	486	567	648	729	810	891	972	1053	1134
60	88	176	264	352	440	528	616	704	792	880	968	1056	1144	1232
65	95	190	285	380	475	570	665	760	855	950	1045	1140	1235	1330

Legend: —— Basic Controllers; ---- Variable Initial Only; ····· Density; Dilemma Zone

Table 1
Dilemma Zone Values

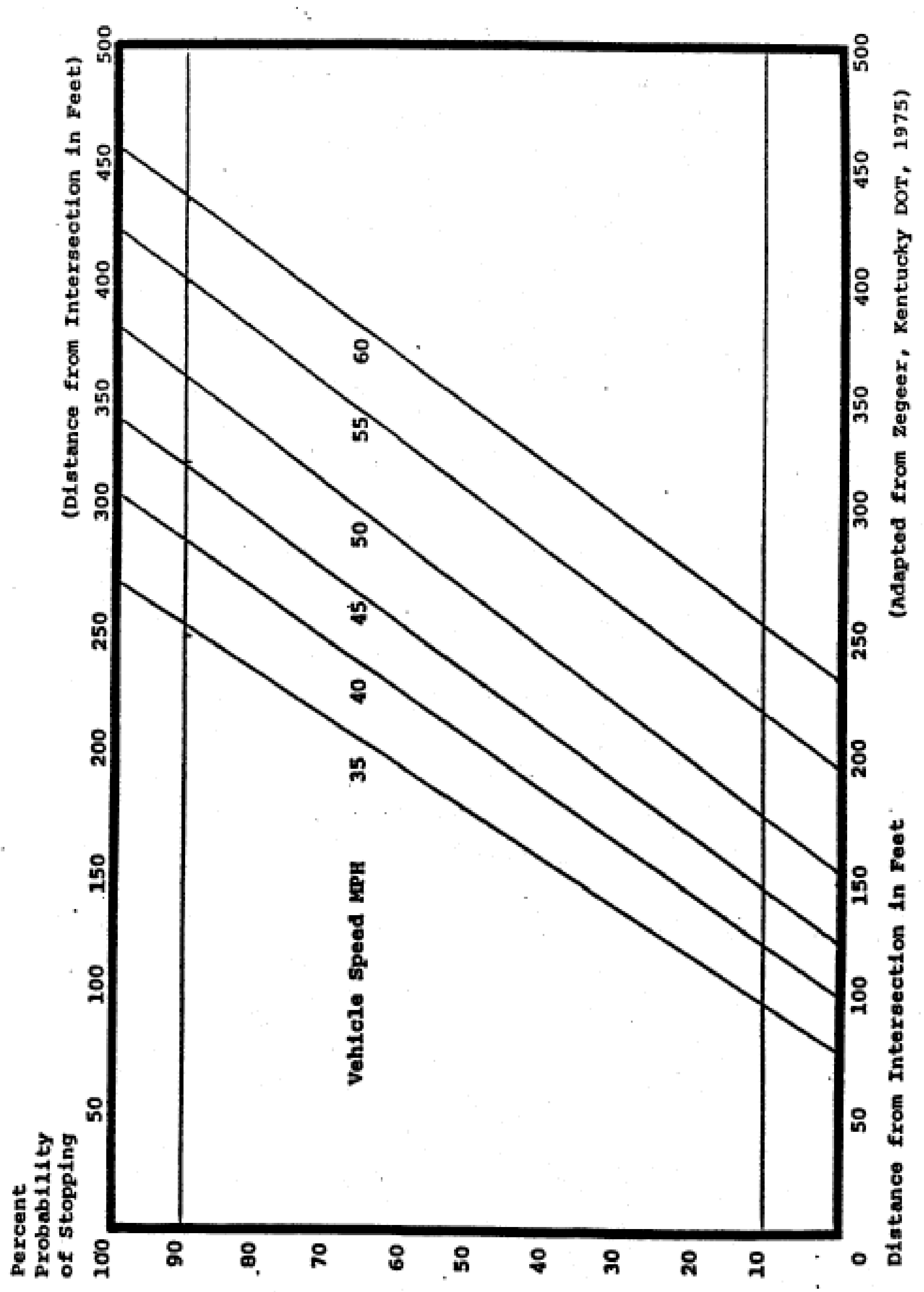

Chart 2
Dilemma Zone Response Curves

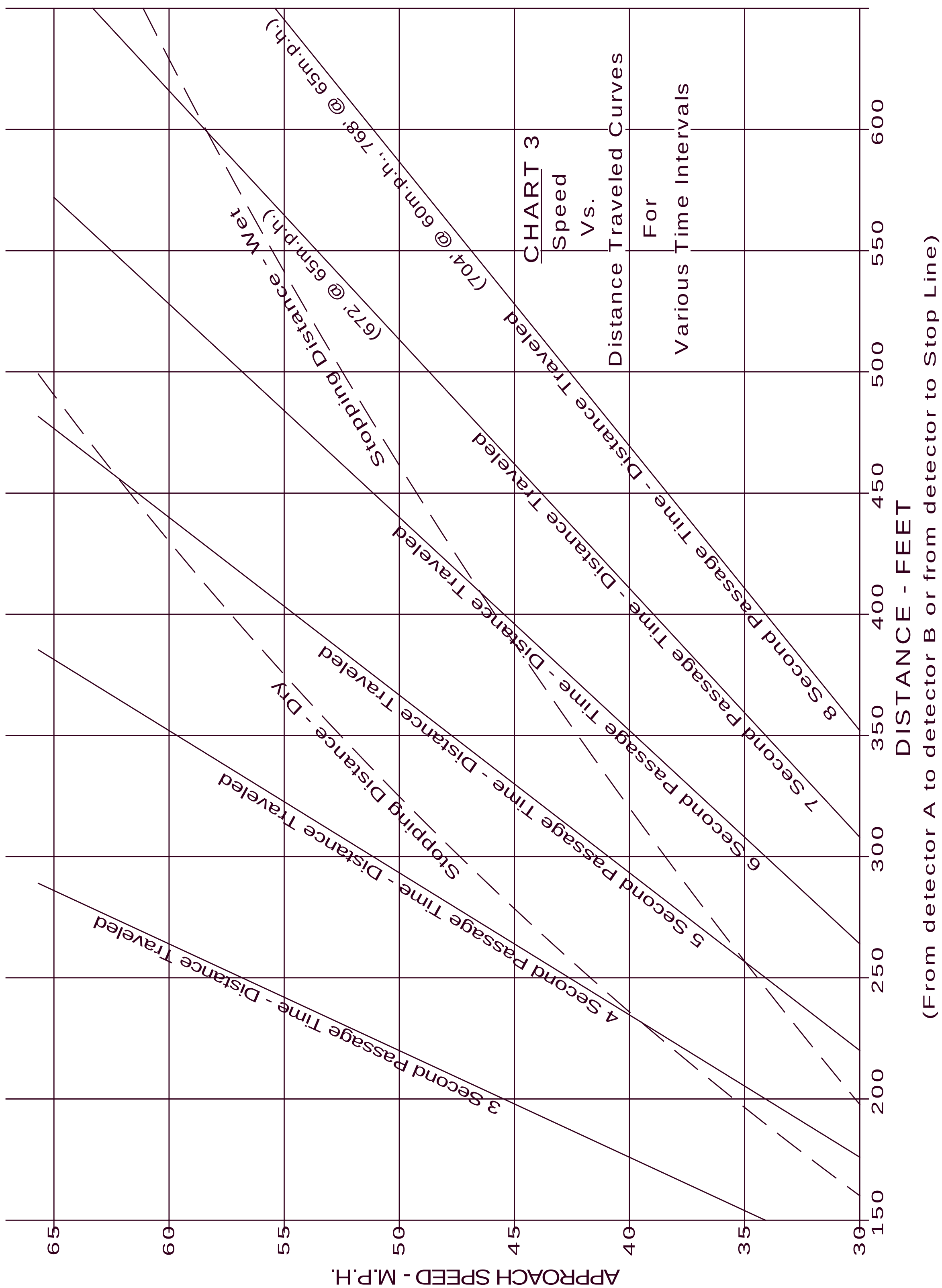

Chart 3
Passage Time Design Curves