Annexure – O
KAVACH
Braking Algorithm

1. Introduction

KAVACH shall follow the standard barking algorithm for uniformity.This section gives an outlook on general braking behavior and typical parameters to consider in calculation of braking distances. Typically, braking distances of same types of trains follow a distribution. So, it is be possible to predict the braking distance for a known type of a train which falls in a known braking distribution. To calculate/estimate these braking distances the ONBOARD KAVACH should know the train type information which will be selected by Loco pilot during start of mission. In this process the following assumptions are made

i. Brake system of the train functions as specified.

ii. wheel/rail adhesion is sufficient for the required deceleration

iii. Brake characteristics/Train type is correctly selected by Loco pilot during SOM.

In the following sections essential things need to be considered in calculations of braking distances are mentioned.

2. Elements effecting braking distances

i. Brake buildup times

ii. Traction cutoff interface

iii. Speed dependent deceleration values

iv. Gradient

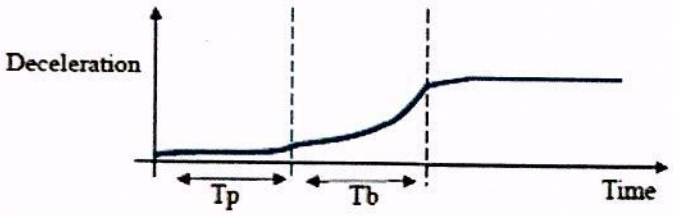
v. Speed Margins

3. Brake Buildup times

3.1 For trains when Brake is applied it takes some time to actually get the brake force. This is called brake lag. This can be further divided into two parts, Brake propagation time and brake build time.

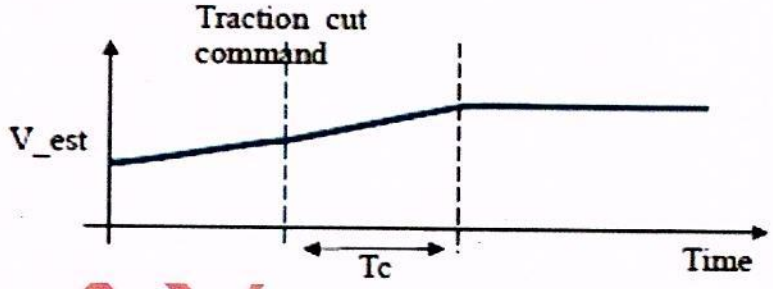
3.2 Brake propagation time is delay in building the braking effort (i.e time till brake cylinders get the pressure). During this time actual braking effort is zero.

3.3 Brake build time is the time required from starting of braking effort to till full braking effort is build. During this time partial braking effort will be available.

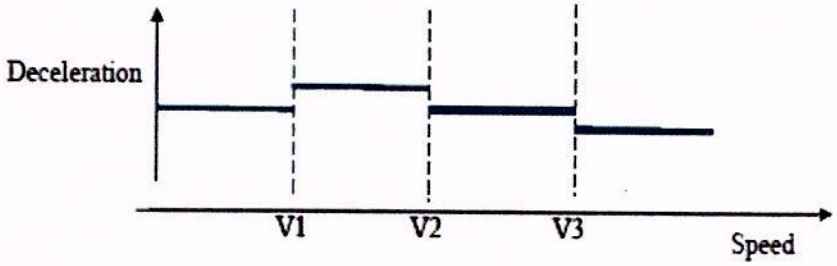


4. Traction cutoff time

Traction cutoff time is time required by the train propulsion system to bring the traction effort to zero. During this time the acceleration can be still exist. ONBOARD KAVACH should consider this delay and should estimate the speed by the time traction becomes zero (only if acceleration is positive).



Speed dependent deceleration values



The deceleration values of train are a function of speed. ONBOARD KAVACH should have provision to store four speed dependent deceleration values for a train type. These Deceleration values shall be acquired as part of train configuration data during start of mission.

5. Gradient

ONBOARD KAVACH gets track gradient as a profile. ONBOARD KAVACH have to calculate the weighted average for gradient profile. This weighted average should be compensated with rotating mass of the train. This rotating mass percentage shall be acquired as part of train configuration data during start of mission.

6. Speed Margins

Speed margins are used to avoid unnecessary ONBOARD KAVACH intervention while Loco pilot is driving at boundaries of allowed speed limits. Four speed margins are defined in ONBOARD KAVACH.

i. Warning Margin

ii. NSB Margin

iii. FSB Margin

iv. EB Margin

7. Ceiling Speed Monitoring

Ceiling speed monitoring (CSM) is used when ONBOARD KAVACH is monitoring only MRSP (Most restrictive speed profile). When Vest (estimated speed) crosses V_MRSP, ONBOARD KAVACH gives visual indication on permitted speed curve.

i. When Vest crosses (V_MRSP+Warning Margin) ONBOARD KAVACH gives Visual and Audio Alert.

ii. When Vest crosses (V_MRSP+NSB Margin) ONBOARD KAVACH Applies NSB.

iii. When Vest crosses (V_MRSP+FSB Margin) ONBOARD KAVACH Applies FSB.

iv. When Vest crosses (V_MRSP+EB Margin) ONBOARD KAVACH Applies EB.

v. Once ONBOARD KAVACH intervenes it will release brakes only when estimated speed falls below (V_MRSP+Warning)

8. Target Speed Monitoring

8.1 Target speed monitoring (TSM) is used when Train is approaching target area. A target is associated with a distance to target and target speed. In TSM along with CSM functions ONBOARD KAVACH has to compute additional brake commands based on current train position/speed and Approaching target distance/speed.

8.2 Onboard KAVACH has to select most relevant display target(MRDT) for the current position from available targets.

8.3 For MRDT, Onboard KAVACH has to compute EB intervention(EBI) distance, FSB intervention(SBI1) distance. And in order to avoid EB intervention an additional SB intervention(SBI2) has to computed using FSB brake lag.

8.4 Onboard KAVACH has to use most restrictive among SBI1, SBI2 for FSB application. Based on SBI Onboard KAVACH has to compute Warning and Permitted distances using Warning time and Driver response Time respectively.

i. Emergency Brake intervention(EBI) = Emergency brake Distance(EBD) + Distance traveled in EB buildup

ii. Service Brake intervention(SBI1) = Service brake Distance(SBD) + Distance traveled in FSB buildup

iii. Service Brake intervention to avoid EB (SBI2) = EBI+ Distance traveled in FSB buildup

iv. Effective Service brake intervention (SBI) = Most restrictive(SBI1,SBI2);

v. Warning Distance = SBI + (Vest * T_warning)

vi. Permitted Distance = SBI + (Vest * T_driver)

vii. When train position crosses service brake intervention location and speed is above (V_target+FSB Margin) ,ONBOARD KAVACHhas to apply FSB.

viii. When train position crosses emergency intervention location and speed is above (V_target+EB Margin) ,ONBOARD KAVACH has to apply EB.

Train brakes takes some time (T_BrkRel) to make braking effort to zero even after brake command is released. In case of target with speed greater than zero there shall be a provision to release the brake little early by considering T_Brkrel. This will be useful when loco pilot is driving in extremes of allowed speed margins.

9. Train Braking parameters Data

S.no	Parameter name	Description	Resolution	Bytes
1	Train Configuration number	Serial number for Train configuration	NA	1
2	Train Class	Train type (LE-1,ICFPassenger-2,LHB Passenger-3,EMU-4,Freight-5, Train Set-06)	NA	1
3	Train Description	Name of the Train type (Displayed to LP in selection)	NA	40
4	Train Max Speed	Max permitted speed for this train con-	1 kmph	1

		figuration		
5	Train Max Acceleration	Max possibleaccelerationfor this train configuration	0.01 m/s^2	1
6	Train Max Deceleration	Max possibledecelerationfor this train configuration	0.01 m/s^2	1
7	Train Length	Default train length	meters	2
8	Train Load	Weight of this train configuration in Tons	Tons	2
9	Rolling Mass percentage	Axle weight to Total Weight in Percentage	NA	1
10	FSB Propagation Time	Full service Brake Propagation Time	0.1 Sec	1
11	FSB Build Time	Full service Brake Build Time	0.1 Sec	1
12	FSB Release Time	Full service Brake Release Time	0.1 Sec	1
13	EB Propagation Time	Emergency Brake Propagation Time	0.1 Sec	1
14	EB Build Time	Emergency Brake Build Time	0.1 Sec	1
15	EB Release Time	Emergency Brake Release Time	0.1 Sec	1
16	ID Percent	Intermediate deceleration percentage(0-100)	NA	1
17	FSB DC1	FSB Deceleration value up to speed limit 1	0.01 m/s^2	1
18	EB DC1	EB Deceleration value up to speed limit 1	0.01 m/s^2	1
19	Speed Limit 1	Speed limit 1	1 kmph	1
20	FSB DC2	FSB Deceleration value up to speed limit 2	0.01 m/s^2	1
21	EB DC2	EB Deceleration value up to speed limit 2	0.01 m/s^2	1
22	Speed Limit 2	Speed limit 2	1 kmph	1
23	FSB DC3	FSB Deceleration value up to speed limit 3	0.01 m/s^2	1
24	EB DC3	EB Deceleration value up to speed limit 3	0.01 m/s^2	1
25	Speed Limit 3	Speed limit 3	1 kmph	1
26	FSB DC4	FSB Deceleration value above speed limit 3	0.01 m/s^2	1
27	EB DC4	EB Deceleration value above speed	0.01 m/s^2	1

		limit 3		
28	Spare1	Spare parameter 1	NA	2
29	Spare2	Spare parameter 2	NA	2