सत्यमेव जयते

FIRE PREVENTION IN IR COACHES

WHAT is FIRE-PROOF wikipedia

- **Fireproofing** is rendering something (structures, materials, etc.) resistant to fire, or incombustible; or material for use in making anything fire-proof.[1]
- It is a passive fire protection measure.
- "Fireproof" or "fireproofing" can be used as a noun, verb or adjective; it may be hyphenated ("fire-proof").
- Applying a certification listed fireproofing system to certain structures allows them to have a fire-resistance rating.
- The term "fireproofing" may be used in conjunction with standards, as reflected in common North American construction specifications.

- **An item classed as fireproof is resistant in specified circumstances, and may burn or be rendered inoperable by fire exceeding the intensity or duration that it is designed to withstand.**

THOUGHT :

- **Nothing is “Fire Proof”, passenger coaches can only be made fire retardant to give more time for safe evacuation from the affected coach……..**

- **It would be better to have less standards but standards which are Internationally recognized if possible , and to evaluate all aspects of Fire risk for each material deployed in coach …….**

Possible sources of Fire on coaches

- Inflammable goods carried by passengers
- Lighting of fire/smoking in coaches
- Coal or kerosene stove carried by unauthorized vendors
- Electrical Equipment and cabling
- Cooking gas in pantry cars
- Generators in power cars
- Locomotive fires
- Miscreant activities and vandalism

Fire can be aided by

- Soft luggage and cloths of passengers
- News papers and magazines
- Linen
- Coach furnishing materials etc.

FIRE SAFETY OBJECTIVES IN TRAINS

- Prevent the occurrence of Fire and explosion
- Reduce the risk of Life caused by Fire
- Reduce the risk of damage caused by fire
- Contain, control and suppress fire
- Provide adequate and readily accessible means of escape for passengers

FIRE SAFETY OBJECTIVES IN TRAINS

Objective	Target solution
Prevent the occurrence of Fire and explosion	• Regular checking by RPF, train staff • Vigilance by staff , passengers etc.
Reduce the risk of Life caused by Fire →	• Early warning • Early evacuation; (old, divyang etc.)
Reduce the risk of damage caused by fire →	• Better material strength to resist fire • Extinguish by self • Less toxic fumes
Contain, control and suppress fire →	• Extinguishing aids • Extinguishing systems
Provide adequate and readily accessible means of escape for passengers →	• Escape routes , identification , safety process etc.

STRATEGY FOR FIRE SAFETY IN COACHES

- **Prevent fire initiation and propagation**
  - Prevention of possible fire sources
  - Use of Fire retardant material
  - Onboard staff to be vigilant during wee hours.

- **Quick Detection of fire**
  - Smoke/Fire detectors with alarm system along with automatic braking

- **Fire Detection and suppression system in Pantry / Power Cars**

- **Quick and safe evacuation**
  - Escape routes have been provided through vestibules and after ACP (Alarm Chain Pulling) / break through doors
  - Escape routes should be clearly visible and should be un-obstructed
  - Toxic fumes and smoke from coach furnishing material should be as low as possible.

FIRE RETARDANT PROPERTIES OF FURNISHING ITEMS

The coach furnishing material should have properties of:

- Less ignitability.
- Delay/retard/stop propagation of fire so as to increase evacuation time and to start fire fighting operations.
- Toxicity of released fumes/gases should be as less as possible.
- On burning it should release least fumes/smoke/gases so that visibility is least affected and should contribute the least to bring down the level of oxygen in air.
- On burning, it shall not melt and drop and should form a carboneous char.
- The furnishing materials in coach end area should be able to withstand the elevated temperature to avoid propagation of fire from one coach to another coach.

THE FIRE RETARDANCY NORMS

Only flammability test was specified up to year 2004.

- Other properties concerning fire, smoke and toxicity were not specified i.e. :
  - Visibility due to smoke,
  - Limiting Oxygen Index &
  - Toxicity

- RDSO had taken consultancy from ***M/s SNCF*** (National State-owned Railway Company of France) France in 2004, who submitted their recommendations in Feb'2005.
- Based on their recommendations **FST** properties of all the furnishing materials were streamlined as per UIC norms and specifications for various furnishing items were developed in **2007-08 and circulated to PUs & Railways for implementation.**
- At present 100% of coaches have been covered confirming to UIC norms.

UIC-564-2 OR

International Union of Railway Standard

- UIC 564-2 : Regulation relating to fire protection and fire fighting measures in passenger carrying railway vehicle or assimilated vehicles.

- UIC has Head Quarter in Paris France

Fire properties adopted by IR

Fire property	Earlier Specified Value	Upgraded value	Test Standard
Resistance to Spread of Flame	Minimum Class B	Class A	Respective Appendices of UIC 564-2 OR
Deterioration in visibility due to smoke	Minimum Class B	Class A	Appendix-15 of UIC 564-2 OR
Limiting Oxygen Index	Min Class B (28)	Min 35	Appendix- 7 of UIC 564-2 OR (IS:13501 or IS:13360)
Toxicity	<1	<1	NCD-1409
Heat Release Rate (MARHE i.e. Maximum Average Rate of Heat Emission in KW/m2)	-	HL3 as per ISO:5660-1	EN 45545-2:2013

RESISTANCE TO SPREAD OF FLAME

- This feature has been added to ensure that the material burns slowly, takes longer time & property of self extinguish when the fire source is removed.
- Following points are noted during the test,
  - Length of time of continued burning or glowing after extinction/removal of flame in 2 seconds, 2 to 10 seconds and more than 10 seconds.
  - Fire damaged surface area in cm^2
  - Release of burning drops or particles
  - Whether specimen burn through to upper surface or not
- At present adopted value is Class A when tested as per respective appendices of UIC: 564-2 OR.

INVISIBILITY DUE TO SMOKE

- The deterioration in visibility due to smoke is measured by passing light of known intensity –100 Lux. Criteria is to measure density of smoke and the total opacity as per the following table:

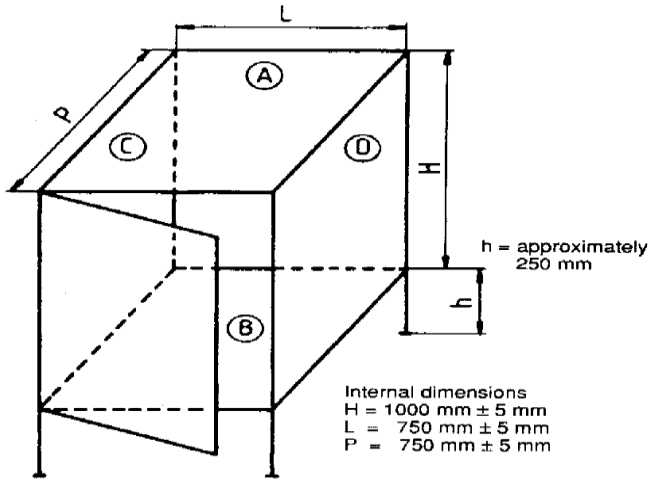
E_4 (Lx) $T_{(lx\ min)}$	$E_4 \geq 50$	$20 \leq E_4 \geq 50$	$E_4 < 20$
$T \geq 300$	**A**	**B**	**B**
$150 \leq T$, 300	**B**	**B**	**C**
T < 150	**C**	**C**	**C**

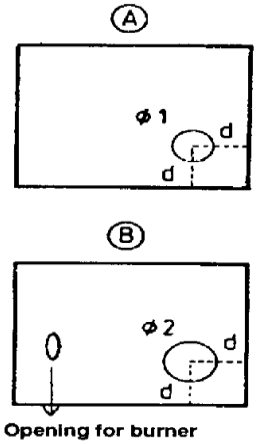
- Important for évacuation of passagers.
- The adopted value is Minimum Class A when tested as per Appendix-15 of UIC: 564-2 OR

However passenger's belongings can generate a lot of smoke and Railways have no control over these items.

Smoke chamber

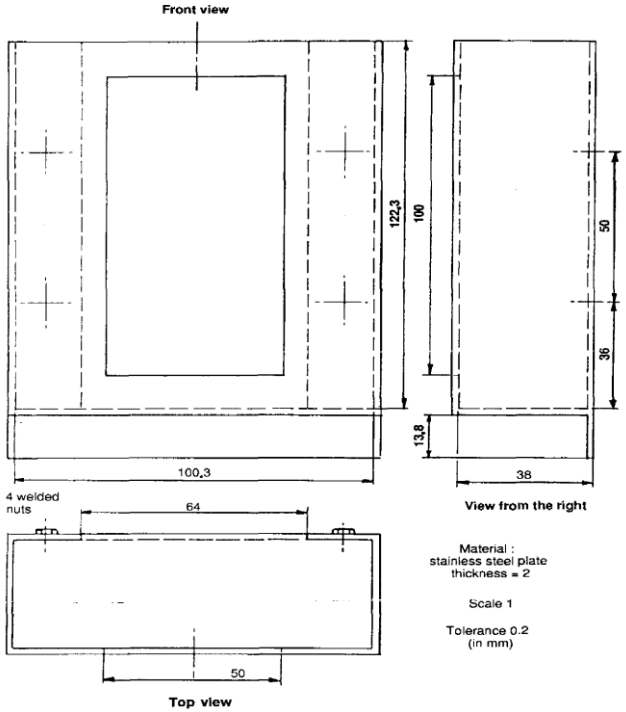
General view





Opening for burner

Specimen frame

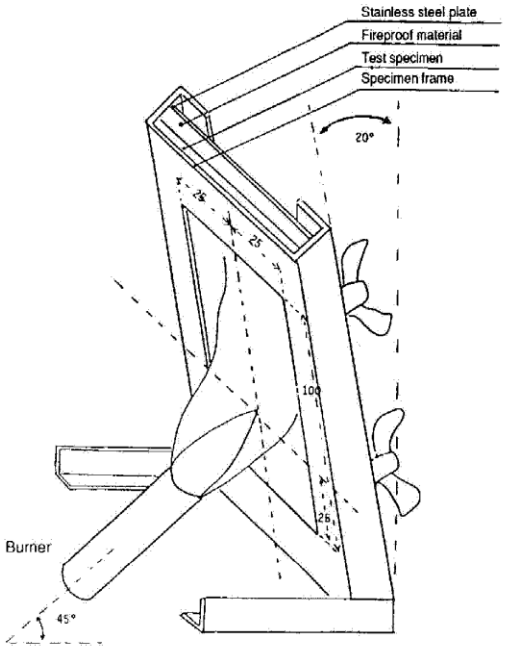


Material :
stainless steel plate
thickness = 2

Scale 1

Tolerance 0.2
(in mm)

Arrangement for combustion of specimen

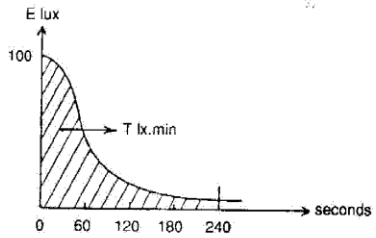


Model representation of results to determine deterioration of visibility due to smoke produced by a material

Point 4.3.1

E (lux)	t (seconds)			
	1st test	2nd test	3rd test	Arithmetic mean
100 90 80 70 . . .	0	0	0	0

Point 4.3.2

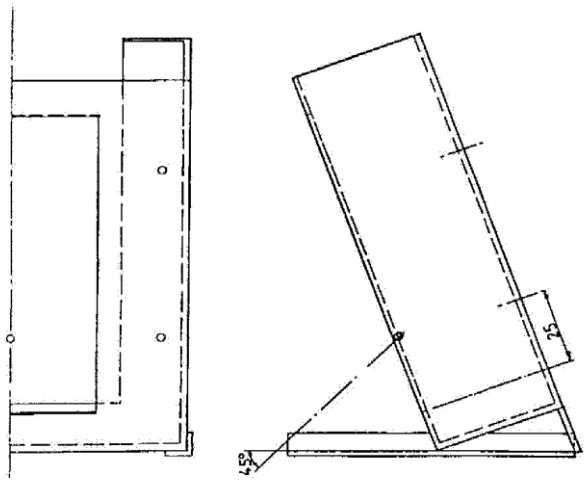


Point 4.3.3

1 - Illumination intensity in the 4th minute E4 =

2 - $T = \int_0^4 E(t)\,dt =$

Specimen frame tilted at an angle of 20° to the vertical



LIMITING OXYGEN INDEX

- Defined as percentage of oxygen in air required to maintain fire propagation in test specimen. The value of index ((Oxygen/(Oxygen + Nitrogen) x 100)) shall be noted where the specimen ignites. Higher the value, better the material.
- Minimum requirement is 35 which is equivalent to Class – A of Appendix – 7 of UIC – 564 –2 OR.
- Incidentally, usual oxygen available in air is 21%.
- The adopted value for all furnishing materials is Minimum 35 when tested as per IS: 13501.

Test-method for determining the fire-resistance of materials by measuring their oxygen number

The oxygen number of a material is the minimum oxygen content of the oxygen-nitrogen mixture required to maintain fire propagation on the tested material as accurately as possible within customary procedures.

In order to enable the fire-resistance of materials to be classified into three Classes A, B and C :

— Class A : material with very good fire-resistance,

— Class B : material with acceptable fire-resistance,

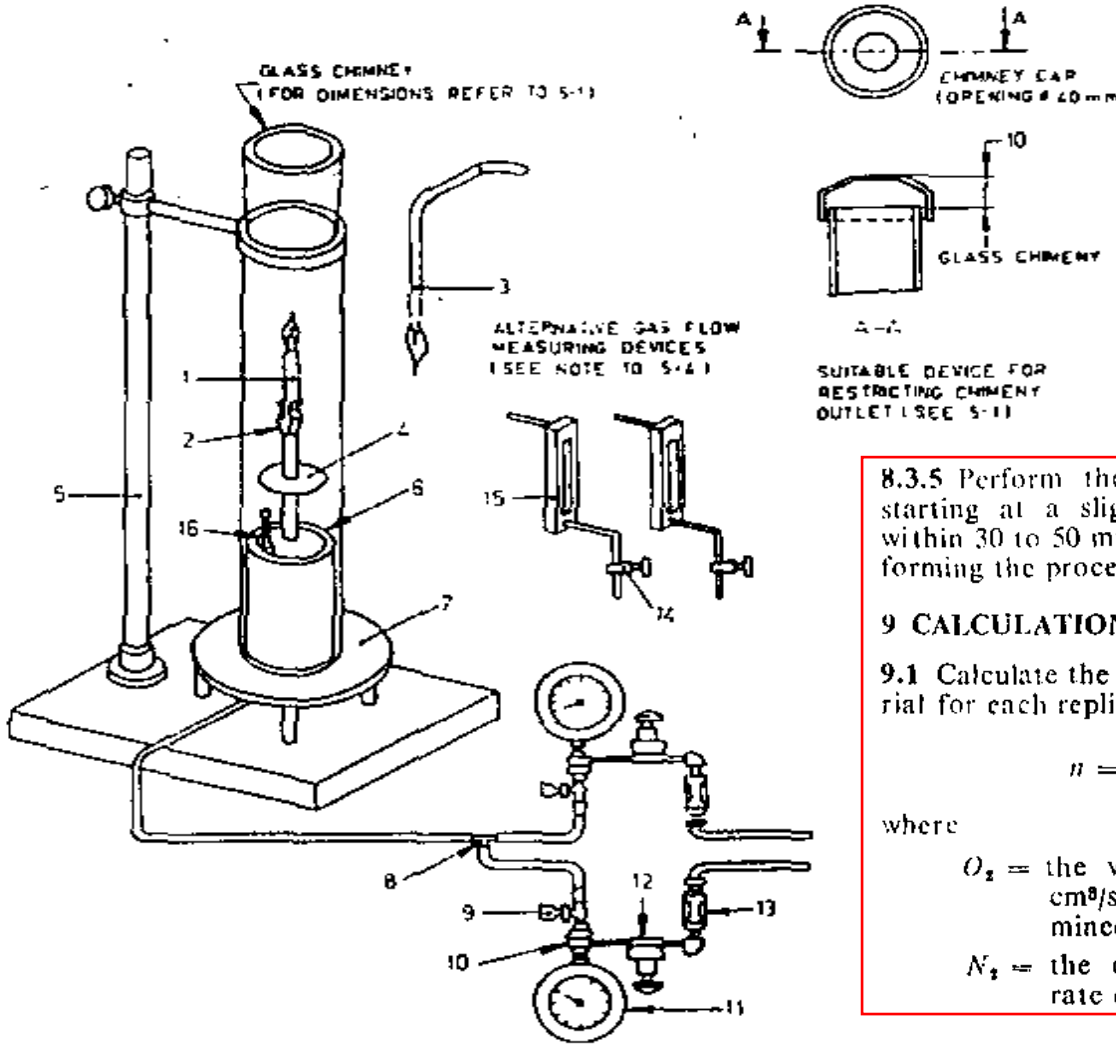
— Class C : material with poor fire-resistance ;

it is recommended that the following oxygen numbers be adopted :

— Class A : oxygen number $\geqslant 35$

— Class B : $28 \leqslant$ oxygen number < 35

— Class C : oxygen number < 28.



8.3.5 Perform the test at least three times by starting at a slightly different flow rate still within 30 to 50 mm/second limits and again performing the procedure from **8.1.5** to **8.3.4**.

9 CALCULATIONS

9.1 Calculate the oxygen index, n, of the material for each replicate in **8.3.5** by the formula:

$$n = \frac{100O_2}{O_2 + N_2}$$

where

O_2 = the volumetric flow of oxygen in cm^3/s, at the concentration determined in **8.3.4**; and

N_2 = the corresponding volumetric flow rate of nitrogen in cm^3/s.

1 Burning test specimen
2 *Specimen holder*
3 Igniter
4 Debris screen of wire mesh
5 *Chimney support*
6 Bead bed
7 Base plate
8 Gas premixing point
9 Cut-off valve
10 Orifice in holder
11 *Pressure gauge*
12 Precision pressure regulator
13 Filter
14 Needle valve
15 Gas flow meter
16 Temperature sensor

FIG. 1 DIAGRAM OF TYPICAL APPARATUS FOR DETERMINATION OF OXYGEN INDEX

Toxicity

- The sample is burned under test conditions by open flame of 1200 ^{0}C temperature. All the gases emitted are collected and analyzed for their compositions & concentrations using “dragger tubes”.

- Any compound when burned emits cocktail of gases, which are harmful to human. The significance of these gases is increased if area under fire is compact.

- This test determines the amount of various toxic gases emitted during the burning of various material.

TOXICITY

- IR is presently measuring Toxicity according to NCD 1409. As per EN 45545 toxicity is measured either 'Smoke Chamber Method' to EN ISO 5659-2 or 'Tube Furnace Method' to NF X 70-100-2.
- **In order minimize suffocation, all furnishing items have been mandated with "Toxicity" less than 1**. It will help in safe evacuation of passengers giving a time of approximately 25 to 30 minutes.
- For assessment of the Toxicity concentration, following gases are determined:

As Per EN 45545

SN	Name of the Gas	Toxicity concentrations in ppm
1	Carbon Dioxide (CO_2)	100000
2	Carbon Monoxide (CO)	4000
3	Hydrogen Fluride (HF)	100
4	Hydrogen chloride (HCl)	500
5	Hydrogen Bromide (HBr)	150
6	Hydrogen Cynide (HCN)	150
7	Nitrogen Oxide (NO, NO_2)	250
8	Sulphur Dioxide (SO_2)	400

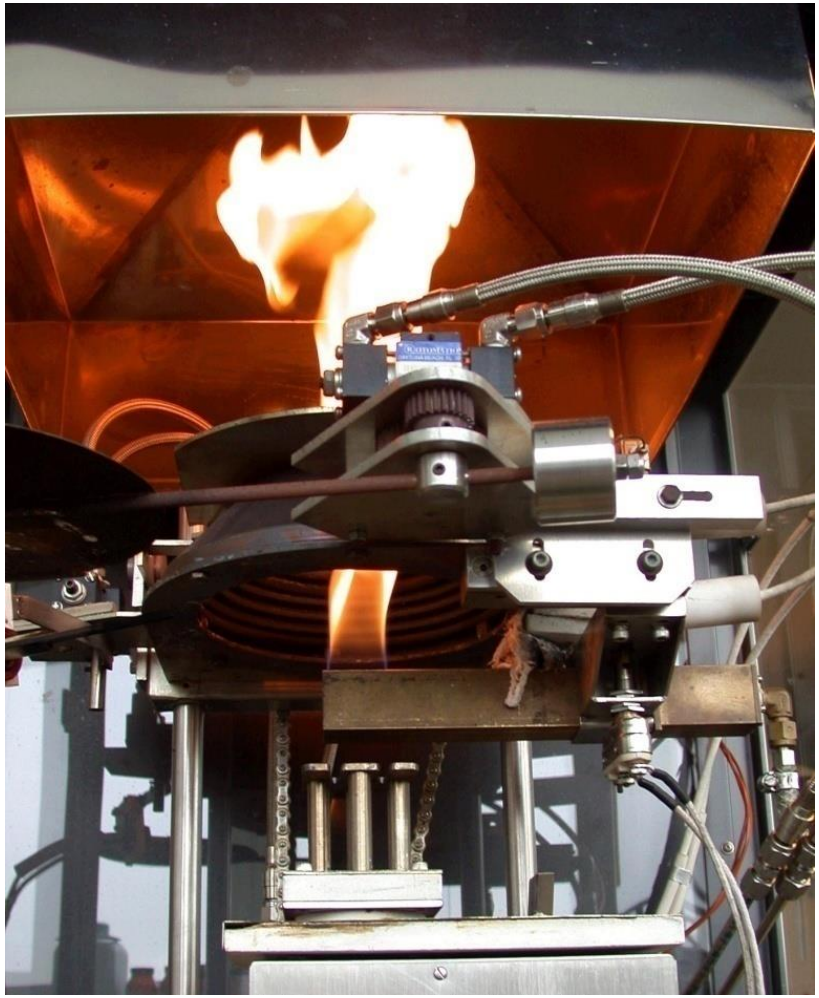
As Per NCD 1409

SN	Name of the Gas	Toxicity concentrations in ppm
1	Carbon Dioxide (CO_2)	100000
2	Carbon Monoxide (CO)	4000
3	Hydrogen Fluoride (HF)	100
4	Hydrogen chloride (HCl)	500
5	Hydrogen Bromide (HBr)	150
6	Hydrogen Cyanide (HCN)	150
7	Nitrogen Oxide (NO, NO_2)	250
8	Sulphur Dioxide (SO_2)	400
9	Formaldehyde (HCHO)	500
10	Ammonia (NH_3)	750
11	Acrylonitrile (CH_2CHCN)	400
12	Hydrogen Sulphide (H_2S)	750
13	Phenol (C_6H_5OH)	250
14	Phosgene ($COCl_2$)	25

Determination of heat released criteria

- The heat released is determined with a cone calorimeter test following the ISO 5660 standard. The material is placed under a constant radiant heat flux. Gases produced by the combustion are inhaled in an exhaust hood. The knowledge of the exhaust flow and of the oxygen concentration of smoke provides the possibility to calculate the heat release curve versus time for each material.
- The required criteria used is the MARHE (Maximum Average Rate of Heat Emission), a calculated parameter corresponding to a mix of the maximum heat released, the total heat released and the time to maximum. The incident heat flux is chosen according to the end use of the material; for walls, floors, electro-technical materials and mechanical pieces, the flux is 50kW/m². For seat materials, this flux is 25 kW/m². All materials must be tested with this method.

Cone Calorimeter Test Apparatus



FIRE RETARDANT FURNISHING MATERIALS USED IN IR COACHES:

S. N.	Material		Limiting Oxygen Index as per IS 13501/IS 13360 part-6 or Appendix- 7 of UIC 564-2		Deterioration of visibility due to smoke as per Appendix -15 of UIC 564-2 OR		Resistance of Spread of Flame as per respective Appendices of UIC 564-2 OR		Toxicity as per NCD 1409		Heat Release rate EN 45545
			Earlier value	Revised value	Earlier value	Revised value	Earlier value	Revised value	Earlier value	Revised value	
1	Fire Retardant Curtain Fabric to RDSO Spec C-9911 (Rev.3)		Min 28	Min 35	Class B	Class A	Class B	Class A	<1	<1	R1 (HL3)
2	Fire Retardant Upholstery to RDSO Spec C-9901 (Rev2)		Min 28	Min 35	Class B	Class A	Class B	Class A	<1	<1	R21 (HL3)
3	Stain Proof fire retardant Upholstery Cloth to RDSO Spec C-K610 (rev1)		Min 28	Min 35	Class B	Class A	Class B	Class A	<1	<1	R21 (HL3)
4	NAFTC Roof ceiling to RDSO Spec RDSO/2016/CG-02		Min 28	Min 35	Class B	Class A	Class B	Class A	<1	<1	R1 (HL3)
5	Wood Based Impregnated Compressed Laminates for use in Railway Coaches to RDSO Spec C-9407 (Rev.3)	Type-II	Min 28	Min 35	Class B	Class A	Class B	Class A	<1	<1	R1 (HL-3)
		Type-I	Min 28	Min 30	Class B	Class A	Class B	Class B	<1	<1	R1 (HL3)
6	UIC type elastomer flange connections for Intercommunication between Passenger coaches to RDSO Spec RDSO/2007/CG-05		Min 28	Min 35	Class B	Class A	Class B	Class A	<1.5	<1	R1 (HL3)
7	PVC Flooring to RDSO Spec RDSO/2006/CG-12		Min 35	Min 35	Class B	Class B	Class A	Class A	<1	<1	R-1(HL3)
8	Vinyl Coated Upholstery Fabric to RDSO Spec RDSO/2007/CG-07		Min 28	Min 32	Class B	Class A	Class B	Class B	<1	<1	R21 (HL3)
9	Decorative Thermosetting Resin Bonded Laminated Sheet to RDSO specification no. C- K514		Min 28	Min 32	Class B	Class A	Class B	Class B	<1	<1	R1 (HL2)
10	Prelaminated shaded comreg to RDSO Spec C-K513		Min 28	Min 30	Class B	Class A	Class B	Class B	<1	<1	R1 (HL3)
11	Densified Thermal Bonded Polyester Block to RDSO Spec C-K607.		Min 28	Min 30	Class A	Class A	Class B	Class B	<1	<1	R21 (HL3)
12	FRP Windows, Guides, Window Sills & Cross Members of BG Main Line & EMU Coaches		Min 28	Min 35	Class B	Class A	Class B	Class A	<1.5	<1	R1 (HL3)

Fire Detectors and Alarm

Heat Detectors: It gives an alarm when the detected temperature exceeds a fixed limits. Normally this will be between 54 -78 ^{0}C.

Ionization Smoke Detector: It work on ionization principles and senses invisible smoke particles and detects fire at incipient stage

Fire Detectors and Alarm

Optical Smoke Detectors: It uses light source to determine obscuration or light scatter caused by smoke particles entering the chamber. More advanced stage is to use laser beams for detection of fire.

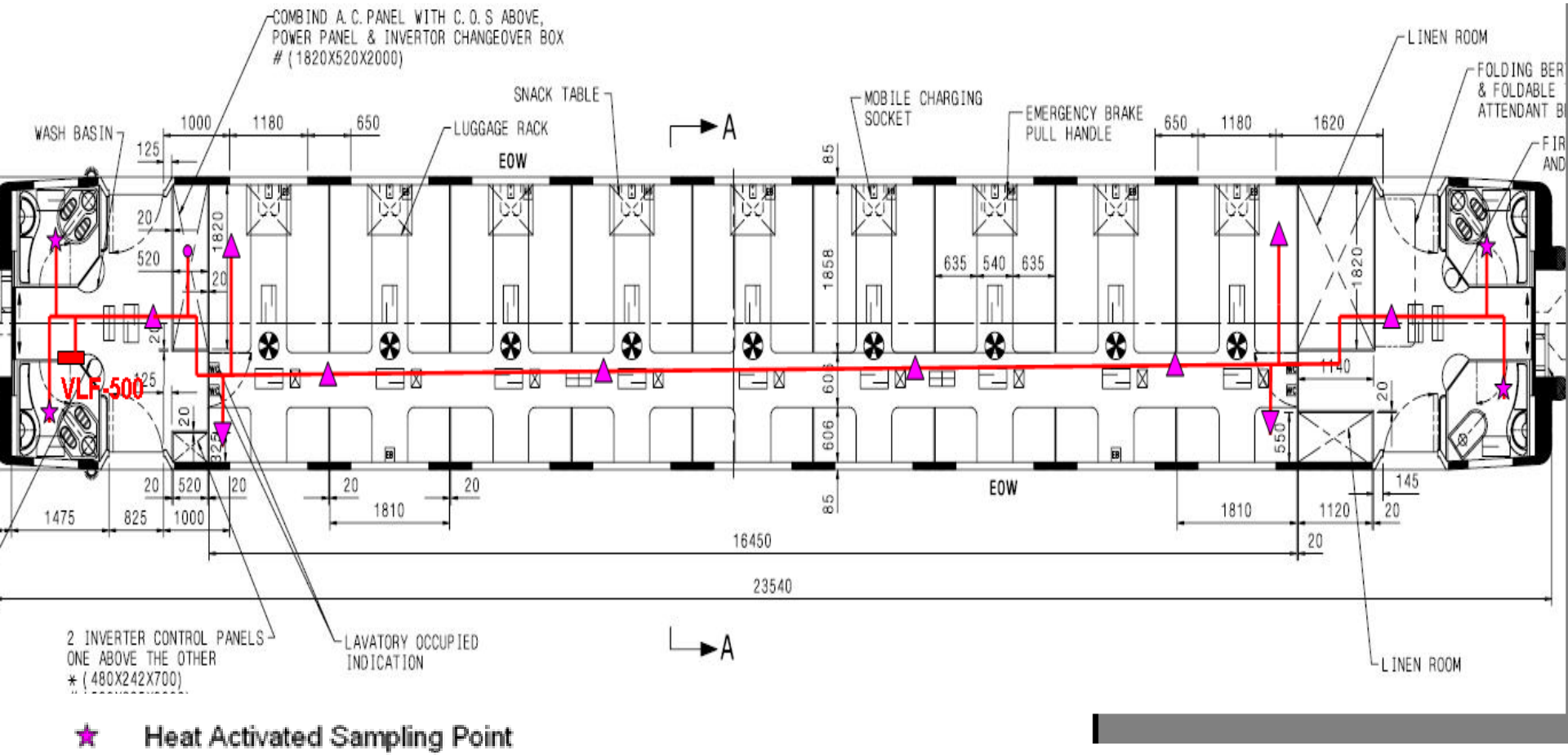
Photo Thermal Detector: In this type of detector the status of the optical (smoke detecting) chamber is monitored and compared with the heat sensing element. The alarm signal is sent when the comparison indicates a fire situation. The system is able to discriminate between smoke and other aerosol particles to avoid false alarms.

Fire Detectors and Alarm

Flame Detectors: Infrared Detectors responds through electromagnetic radiations resulting from burning of carbon and hydrogen material and to the flame flicker frequencies. Units to be immune false alarm caused by solar rays.

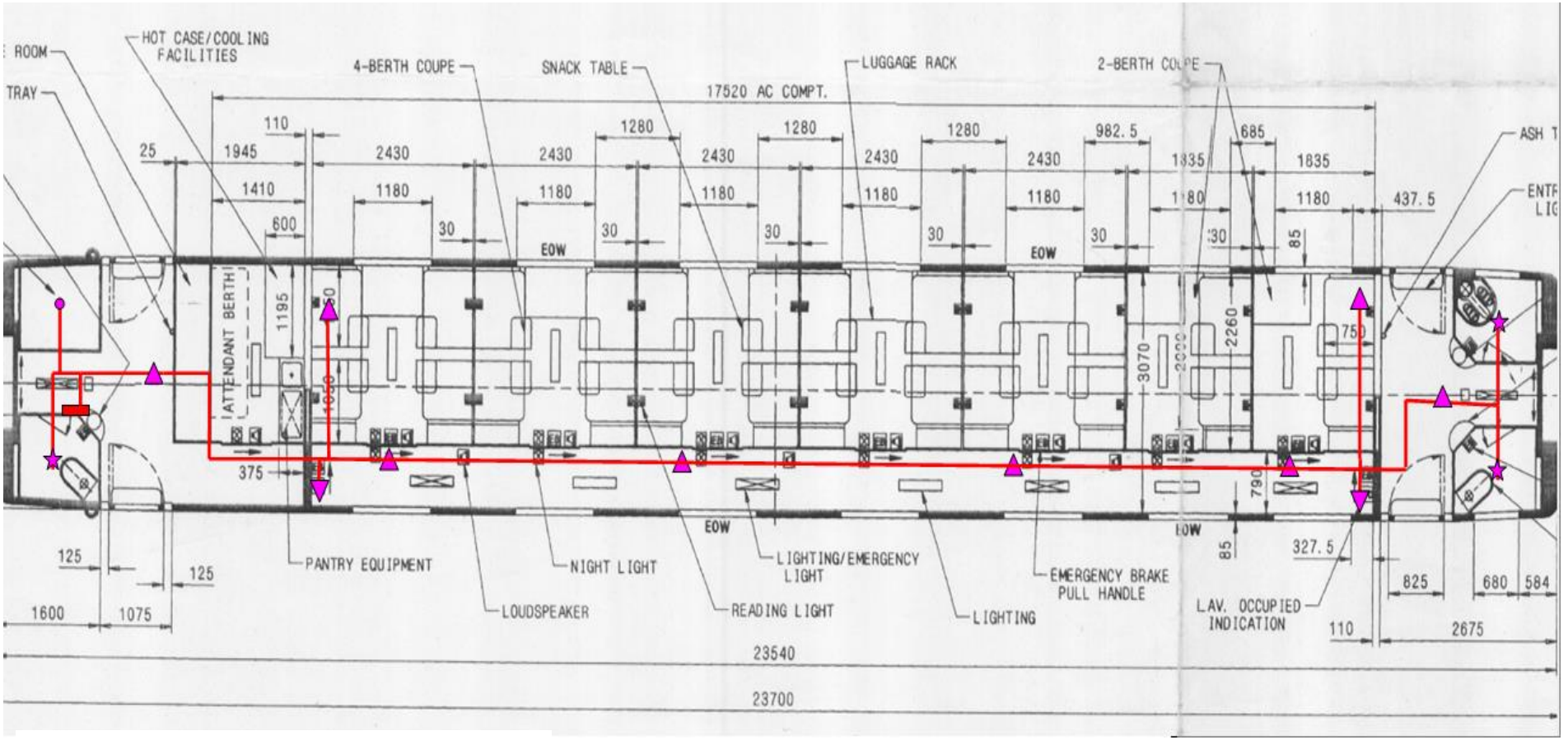
Linear Heat Detector: These type of line heat detectors includes pressurized tubing, cables that contains die-electric materials, fibre optic cables and other system linear heat detection may be found on cable trays and environments.

PIPE LAYOUT – 3 Tier & 2 Tier AC Coaches



- Heat Activated Sampling Point
- Capillary Sampling Point
- Sampling Hole
- Sampling Pipe
- VESDA Detector - VLF 500

PIPE LAYOUT – AC FIRST CLASS



- Heat Activated Sampling Point
- Capillary Sampling Point
- Sampling Hole
- Sampling Pipe
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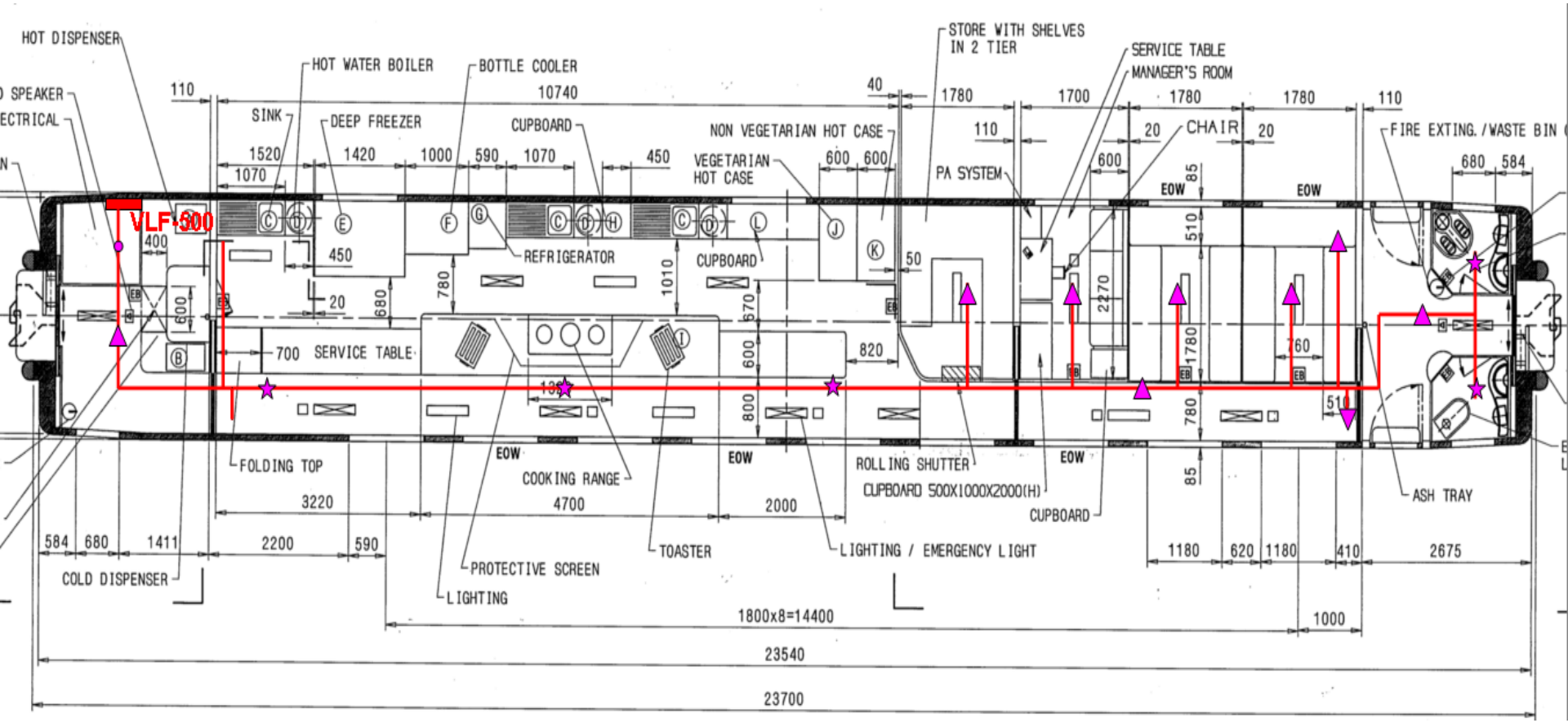
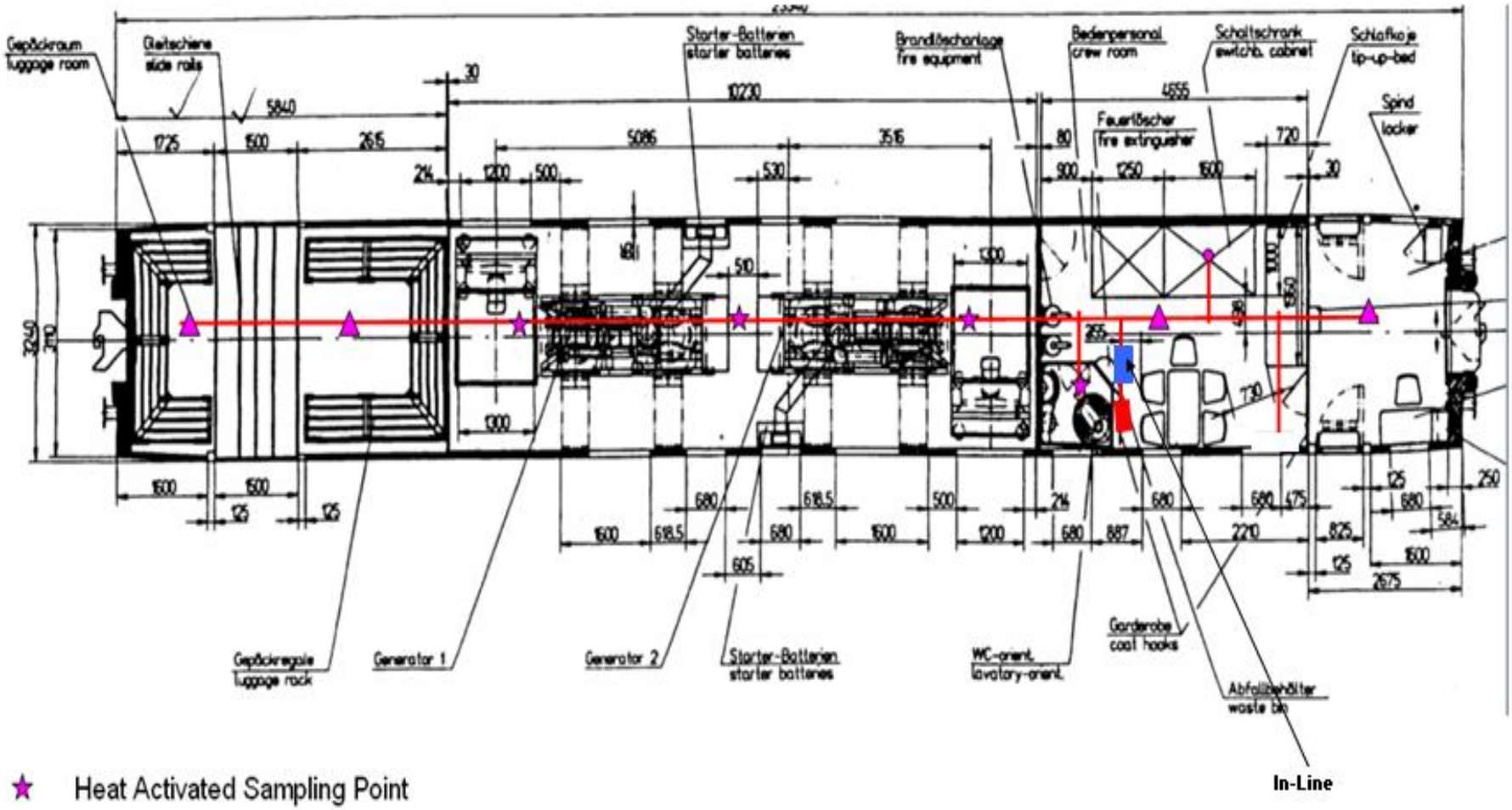
PIPE LAYOUT – PANTRY CAR



- Heat Activated Sampling Point
- Capillary Sampling Point
- Sampling Hole
- Sampling Pipe
- VESDA Detector - VLF 500

VESDA FOR BRAKE VAN



★ Heat Activated Sampling Point

▲ Capillary Sampling Point

● Sampling Hole

— Sampling Pipe

■ VESDA Detector - VLF 500

SMOKE THRESHOLD SETTINGS FOR AC COACHES

1. The System is designed for multi-level alarm.

2. The System's design also allow user to program & logic these levels as per requirements.

3. The system designed to show smoke level reading in % Ob/m (percent Obscuration/meter***)*** as well as in % Ob/ft (percent obscuration/foot)

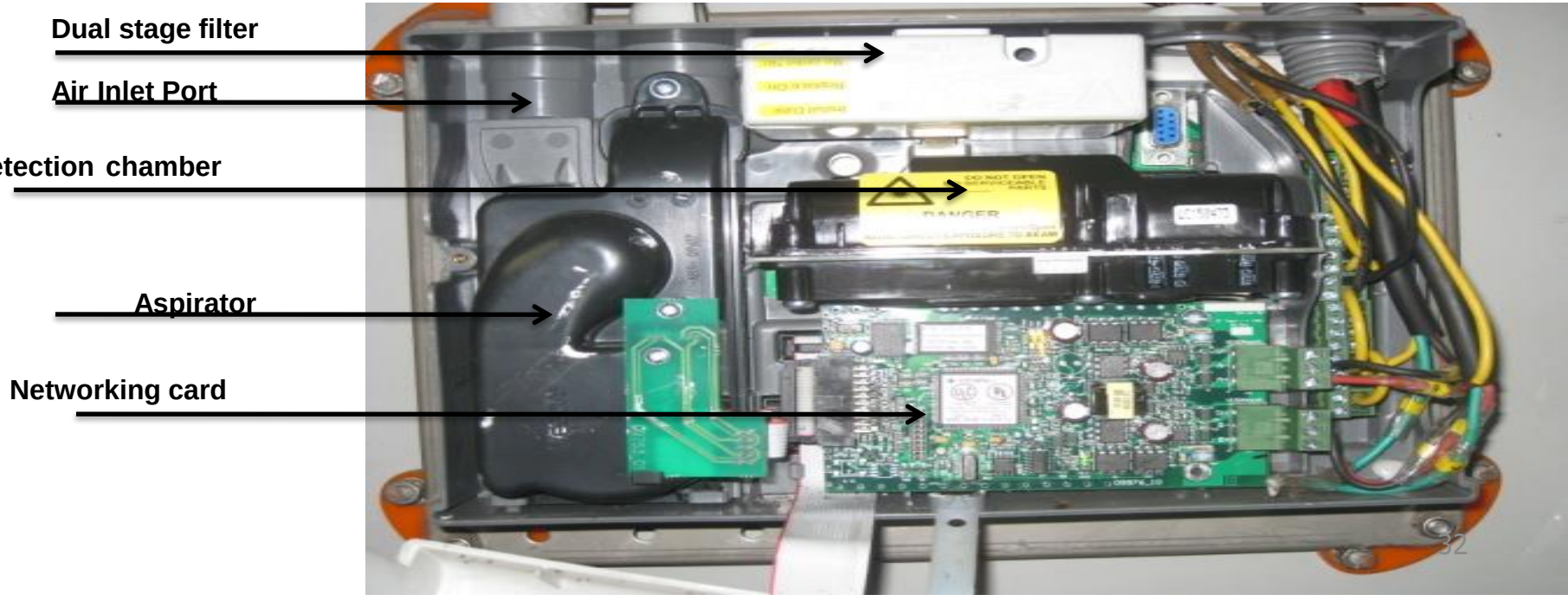
		Threshold Settings for AC Coaches	
Stage	Alarm	**Threshold (% obs/m)**	**Delay Period (Sec.)**
1	Alert	**0.35±0.05**	**20**
2	Action	**0.6±0.05**	**30**
3	Fire	**1.6±0.05**	**45**

Quick Detection of Smoke/Fire in Coaches

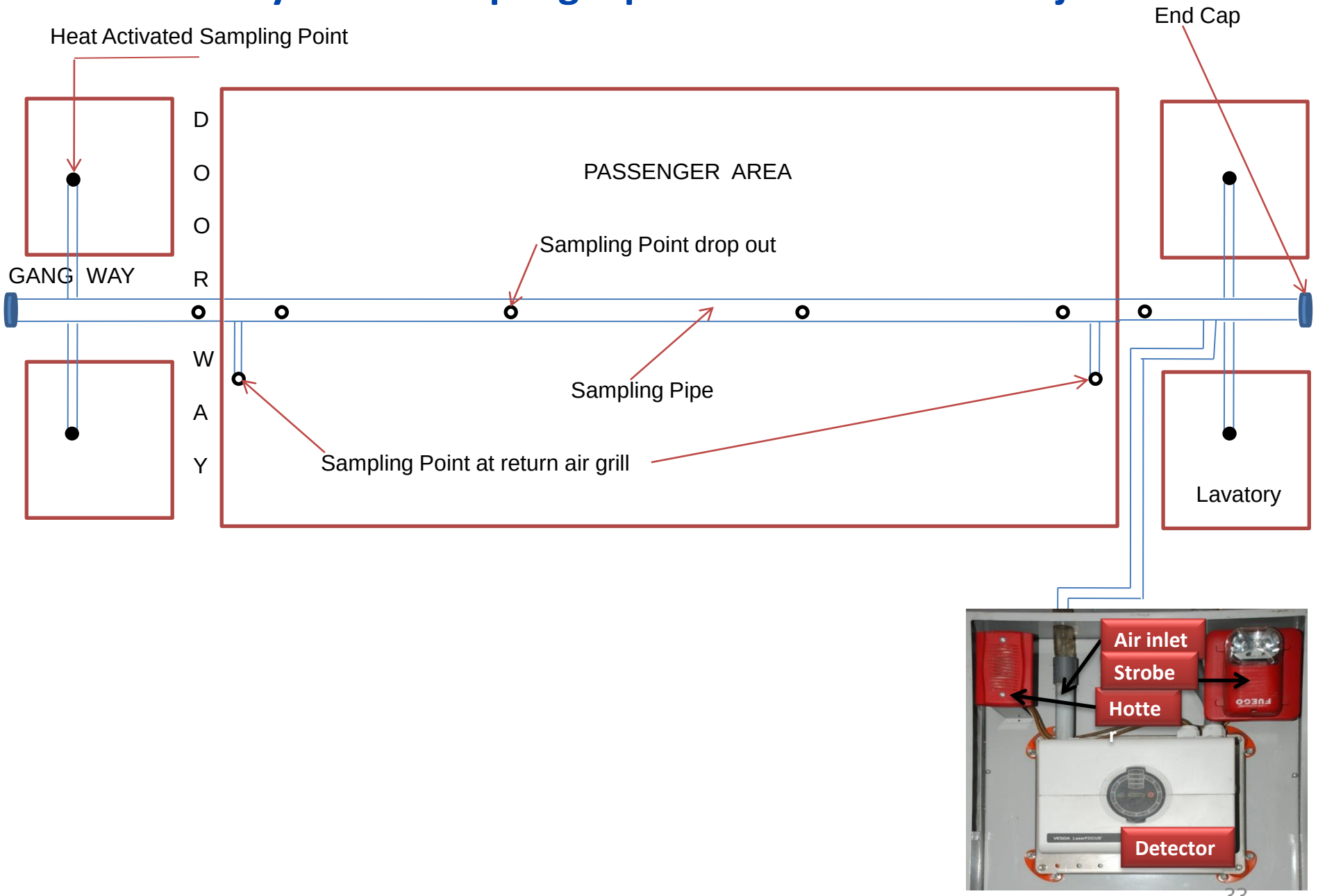
AUTOMETIC SMOKE/FIRE DETECTION WITH ALARM SYSTEM IN LHB RAJDHANI COACHES

PRINCIPAL OF WORKING:

Air is drawn into the pipe network through the sampling points from a close surrounding and onward to a very sensitive smoke detector consisting of an aspirator, detection chamber, dual stage filter and necessary networking card. The negative pressure of an aspirator send ambient air to a detection chamber where scattering of light occurs and detection of smoke took place.



Schematic Layout of Sampling Pipe Network in a LHB Rajdhani Coach



SMOKE AND FIRE DETECTION SYSTEMS

FEATURES

- Highly sensitive
- Can give very early warning.
- More response time available for rescue and other counter measures.
- Four programmable levels of alarms .
- Central monitor in pantry car/ SLR which can give status of all coaches.
- Less probability of false alarms.
- Self diagnostics of any fault within the system

LIMITATIONS

- Exact location of the fire event with in a coach is not possible.
- Suitable for controlled environment i.e. for AC coaches only.
- Not suitable for the fire caused due to Miscreant and vandalism activities in the coach.
- Not suitable for fire in coach due to highly flammable liquid, gas or other explosive materials.

Limitations of Fire Detection Systems India Specific

- Mixed trains – Air conditioned and non AC
- Open coaches have varying inside temperatures – as caused by the weather
- Seasonal variation – 1^0C to 50^0C – defeats temperature based detectors – false positives/negatives defy solution.
- Smoke gets blown away in open (non-AC) coaches – detection is late.
- Air conditioned coaches have controlled environment, but need a different scale of sensitivity of equipment

Specifications issued by RDSO to PUs/Railways for detection of fire on board at incipient stage of fire and fire fighting arrangements

SN	Spec No.	Description	Status
1.	**RDSO/2008/ CG-04 (Rev.-5)**	Schedule of technical requirement for design, supply, installation, commissioning & maintenance of aspiration type automatic Smoke / Fire detection with alarm system for Indian Railway AC coaches	Railways/PUs are procuring the system
2.	**RDSO/2013/ CG-06 (Rev.-2)**	Schedule of technical requirement for Design, Supply, Installation, Commissioning & Maintenance of Automatic Smoke / Fire detection cum Manual Suppression System for Pantry Car & Generator Cum Brake Van of Indian Railway Coaches (ICF and LHB Design) (Tentative for Trial)	Zonal Railways /PUs are procuring the system.

OTHER MEASURES TAKEN BY RDSO

- With the introduction of International PU foam, provision of ‘Fire Barrier Cloth’ have been proposed in these coaches.

- In order to avoid insertion of material in the ceiling, alternate material GFRE having improved fire retardant properties and sufficient strength to restrict insertion of garbage have been proposed to Rly Bd.

- Modification of body side doors has been done by eliminating Bottom latch.

- Specification for Fire Retardant Linen has been developed and has been sent to Rly Bd.

OTHER MEASURE STEPS TAKEN FOR SAFETY AGAINST FIRE: QUICK & SAFE EVACUATION

Provision of Bi-directional swing door:

- Bi-directional swing door openable on both sides (compartment doors) to facilitate passengers exit

Provision of fluorescent signage:

- During emergency, it helps passengers for safe evacuation even in low light.

EMERGENCY EXITS

To enable safe escape of passengers from a fire affected coach provision of emergency windows of size 1220MM x 610MM for AC coaches & 590 MMx610MM for non-AC coaches have been provided as under:

S. N.	Type of Coach	No. of Emergency Exit/ Emergency Windows
1.	GS Coach	4
2.	SCN coach	4
3.	ACCN coach	4
4.	ACCW coach	4
5.	FAC	all coupe

Multi-faceted approach on Fire Protection of Rail Transport

- Vehicle design
- Material control
- Fire Detection System
- Innovative Suppression system
- Evacuation to be improved further
- Fire barriers and doors
- ***Redefining Role of On Board staff***
- ***Limiting soft luggage***
- ***Awareness among passengers***

The Road Ahead

- Up-gradation of specifications of coach furnishing materials used in IR coaches to European specification EN45545-2:2013

- Setting of fire labs at RDSO/ZR/PU/Training Institutes with facilities to test the materials as per International norms

- Development of comprehensive fire safety plans for Indian Railways.

THANKS