INDIAN REAL DRIVING EMISSIONS [IRDE]

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ICAT

ABOUT ICAT

The International Centre for Automotive Technology (ICAT), Manesar is a centre under NATRIP (**N**ational **A**utomotive **T**esting and **R**&D **I**nfrastructure **P**roject), Govt. of India.

ICAT provides services for

- ❖ Test
- ❖ Validation
- ❖ Design
- ❖ Homologation

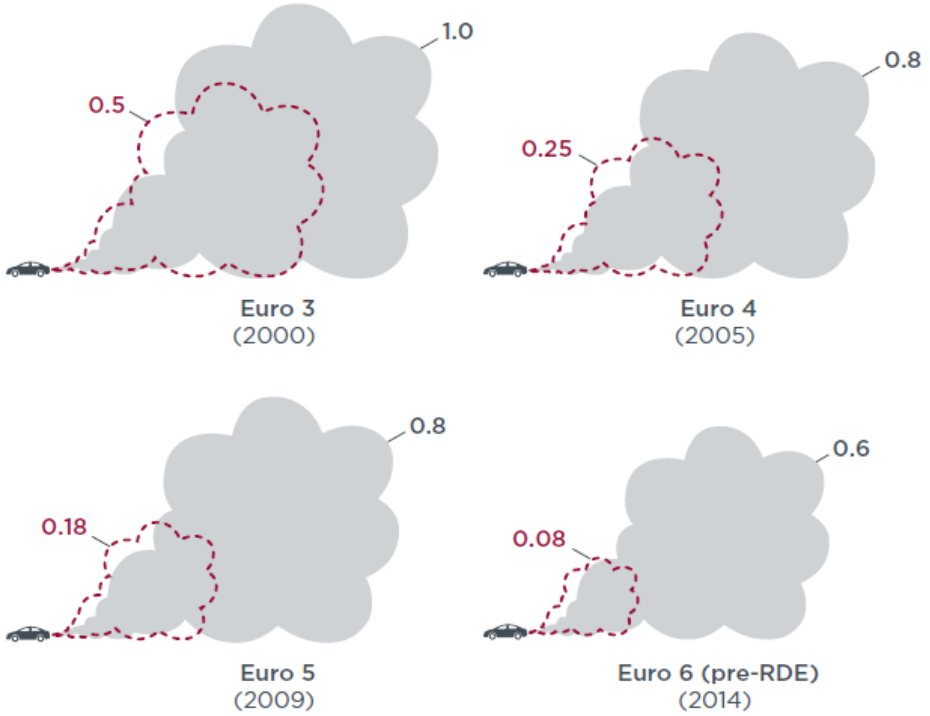
- ➢ Established : 2006
- ➢ Human resource : 535+
- ➢ Location : Manesar, Haryana (38 km from Delhi Airport)
- ➢ Area : Centre I - 8 Acres & Centre II - 46.6 Acres

THE NECESSITY OF RDE

- Real Driving Emissions (RDE) methodology has been proven to be an excellent way to ensure low emissions in real world conditions
- Emissions should be kept below the emission levels not only in the laboratory but in normal conditions of use as well

RDE BACKGROUND

Illustration of the evolution of real world NOx from European cars in the relationship to the regulated emission limits



RDE DEVELOPMENTS IN EUROPE

2011-2015:

- Kick-off: Working group on RDE
  - Complementary procedure for type approval and in-service conformity testing of LDVs
  - Covering a wide range of normal operating conditions; limiting defeat strategies
- Evaluation of candidate procedures by EU stakeholders (JRC report)
- Development of a PEMS testing protocol;
- Pilot program to assess the feasibility of PN-PEMS

2016:

- Development of RDE Regulations 2016/427 and 2016/646 as first on-road test procedure worldwide
  - NOx Conformity factor 2.1 – applicable from Sept. 2017/2019 (new types/all new vehicles)
  - NOx Conformity factor 1.5 – applicable from Jan. 2020/2021(new types/all new vehicles)
  - Compliance during urban driving and the entire RDE trip

RDE DEVELOPMENTS IN EUROPE

2017:

- RDE 3rd Package in Regulation 2017/1151
  - Testing of hybrid vehicles, coverage of cold-start and regeneration events, particle number emissions
  - PN Conformity factor 1.5 – applicable from Sept. 2017/2018 (new types/all new vehicles)

2018:

- RDE 4th Package:
  - Provisions for in-service conformity /
  - Reviewing RDE procedure
  - Adapting provisions to ensure practicality and effective emissions testing
  - New Validation criteria that work with hybrids
  - New simple and transparent evaluation method

- RDE 4 was voted positively in the Technical Committee and will become EU law by the end of the year

RDE DEVELOPMENT STAGES IN EUROPE

In 1990

EU followed Lab Testing.

For Emission Certification Purpose.

NEDC cycle.
Avg. Speed = 32 kmph.

Max. Acc. = 1.2 m/s^2.

In 2011

Joint research Centre (JRC) published a report.
Claimed discrepancies between lab testing and on road emissions.
Mainly for NOx emissions from Diesel cars.
Consequence: Formation of working group on RDE under the supervision of EU Commission.

In 2016

New Complementary Procedure Introduced.- WLTP

The new complementary test procedure was published.

New legislative text was split into 4 "packages"(discussed in subsequent slides)

In 2017

RDE test implemented for **new model** approvals from Sep 2017

NOx limit = 2.1 (CF) x Euro 6 Limit.
(= 2.1 X 80 mg/km = 168 mg/km).

In 2019

RDE test will be applicable for **all model** TA from Sep 2019.
From 2020
CF will be changed from 2.1 to 1.5 for new models
From 2021
CF will be changed from 2.1 to 1.5 for **all models**

RDE IN JAPAN

Scope

•Diesel vehicles having a gross weight of 3.5t or less

•Diesel powered passenger cars having a capacity of 9 or less people

Schedule of Introduction for RDE in Japan

•New Type Approval Vehicle : October 2022

•Continuous Production Vehicle : October 2024

JAPAN'S RDE METHOD

- RDE method shall be able to check whether result of chassis-dynamometer test has effect on real driving correctly as well or not.
- The Japan's RDE method is based on EC's RDE method, but it is slightly modified by taking into consideration difference of real world driving conditions and adopted different phase of WLTC between Japan and Europe .
- Especially driving condition and speed threshold of Moving Average Window(MAW) and CF value under EC's RDE method are developed based on chassis-dynamometer test (WLTC) and real world driving conditions.
- Only measures NOx on Chassis Dyno test and RDE test and do not measure PN while Europe measure NOx and PN for Diesel Vehicle .

JAPAN RDE V/S EUROPEAN RDE

- Based on difference of WLTP phases, Japan modified some of factors slightly as below.

	J-RDE			E-RDE		
Vehicle speed and Consist	Routes	Speed [km/h]	Consist [%]	Routes	Speed [km/h]	Consist [%]
	Urban/Rural	V≦60	40-65	Urban	V<60	29-44
				Rural	60<V<90	23-43
	Motorway	60<V	35-55	Motorway	90<V	23-43
Window speed characteristics	V<50:urban/rural speed 50≦V:motorway speed			V<45 : urban speed 45≦V<80:rural speed 80≦V<145:motorway speed		
CO_2 characteristic curve reference points	P1 : Same as E-RDE P2 : Same as E-RDE P3 : —			P1:v_{p1}=18.882km/h (Average Speed of the Low Speed phase of the WLTP cycle) P2:v_{p2}=56.664km/h (Average Speed of the High Speed phase of the WLTP cycle) P3:v_{p3}=91.997km/h (Average Speed of the Extra High Speed phase of the WLTP cycle)		

JAPAN RDE V/S EUROPEAN RDE

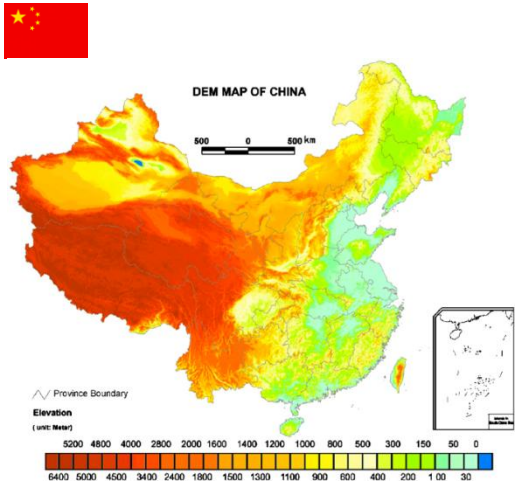
- Based on difference of real driving condition, Japan modified some of factors slightly as below.

	J-RDE	E-RDE
Order	1.Urban/Rural 2.Motorway	1.Urban 2.Rural 3.Motorway
Ambient conditions Altitude	0~1000m(700m) (Moderate altitude)	0 ~1300m(700m) (Moderate altitude)
temp	-2℃(0)~38℃(35) (Moderate temp)	-7 ℃(0)~ 35℃(30) (Moderate temp)
Average speed (urban driving part)	—	15 ~ 40 km/h
Max speed	—	145km/h
Motorway speed	—	Cover range : 90 ~ at least 110 km/h Velocity : Above 100 km/h for at least 5 minutes.
Test track	Available	—

CHINA RDE METHOD

China RDE reference to EU RDE ,but make some changes according to own conditions.

Items		Requirements
Test procedure & PEMS requirements		Package 1,2
Boundary Condition	Altitude	Moderate: [0m, 700m]
		Extended: (700m, 1300m]
		Enhance extended: (1300m~2400m]
	Temperature	Moderate: [0℃, 30℃]
		Extended: [-7℃, 0℃) or (30℃, 35℃]
Data post-process	ICE, NOVC-HEV	Package 2 Moving Average Window Method
	OVC-HEV	Package 3
Conformity Factors	NOx, PN	2.1



* Extended factor: 1.6 Enhanced extended factor: 1.8

Korea RDE-LDV in

- Korea implemented EU RDE-LDV to diesel vehicle's emission regulation with same technical requirement and same enforcement schedule
  * under amendment for RDE package 4

EU RDE-LDV stage	contents	EU (enforcement)	Korea (enforcement)
Package 1	methodologies measuring on-road NOx emissions and performance requirement of PEMS equipment	EU 2016/427, 646 (Sep. 2017)	CAA amend. in 2016 (Sep. 2017)
Package 2	on-road NOx emission limit		
Package 3	methodologies measuring on-road PN emissions and emission limit including cold start provision	EU 2017/1151, 1154 (Sep. 2017)	CAA amend. in 2017 (Oct. 2017)
Package 4	reviewing performance of PEMS equipment and revising on-road NOx emission limit with improved data analysis method	EU 2018/1832 (Jan. 2019)	Under amend.

KOREA RDE-LDV Regulations

- **Pollutants(NOx, PN) measured in on-road driving should be below emission limits**

  - **Measured with PEMS (Portable Emission Measurement System)**



  - **On-road emission limits (NOx, PN, diesel passenger vehicles)**

	New types	New vehicles	Emission limits (M1)	
NOx	Sep. 2017	Sep. 2019	0.168 g/km	Euro6d temp
	Jan. 2020	Jan. 2021	0.114 g/km	Euro6d
PN	Sep. 2017	Sep. 2018	9.0×10^{11}#/km	

* Urban and composite(urban+rural+highway) emission should be below limits

KOREA RDE-LDV

- **Route**
  - Urban(0~60km/h) : 34%, Rural(60~90km/h) : 33%, Highway(90km/h~) : 33%
  - each distance should be over 16km
  - maximum speed: 145km/h, averaged urban V.S : 15~40km/h, driving time : 90~120min.,
  - stop ratio : 6~30% of urban driving, Slope : 1200m/100km
- **Ambient temp. and altitude**

		moderate	*extended
ambient	~ Jan. 2020	3~30℃	-2~3℃, 30~35℃
	Jan. 2020 ~	0~30℃	-7~0℃, 30~35℃
Altitude		Below 700m	700~1300m

* Measured emission values under extended conditions are divided by 1.6

US IN-USE COMPLIANCE

- FTP City cycle
- HWFET Highway drive cycle
- US06 high speed drive cycle
- SC03 Air-conditioning drive cycle
- 20 deg F Cold city drive cycle

Use of PEMS testing on road compliance is part of EPA Compliance verification process.

BS VI INTRODUCED RDE IN INDIA

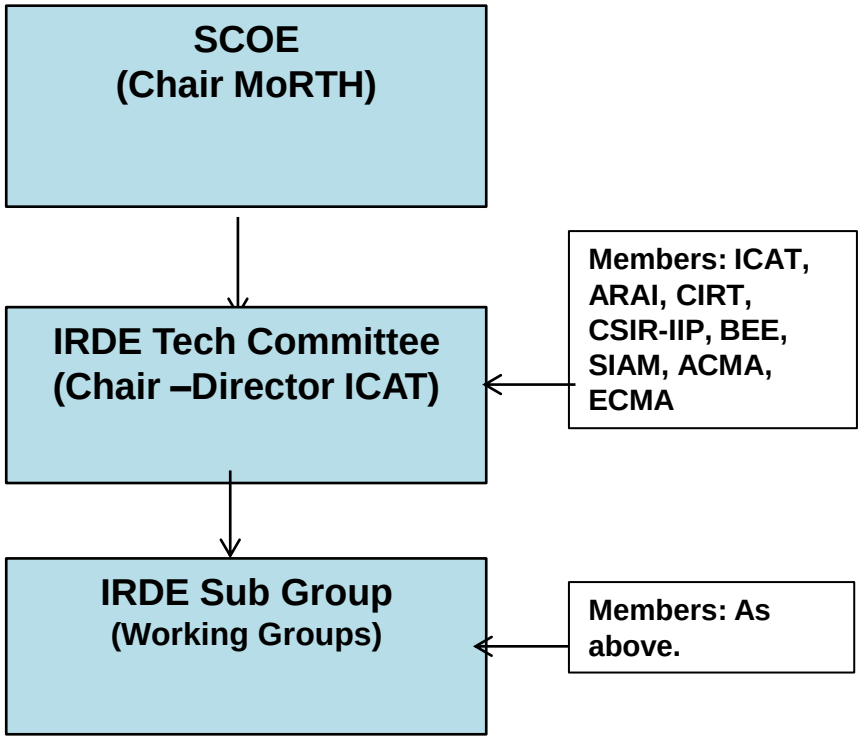
BS VI NOTIFICATION

Govt. Gazette Notification No G.S.R. 889 (E) dated 16th Sept 2016 notified implementation of BS VI with effect from April 1, 2020. BS VI included :

- RDE monitoring phase from April 1, 2020
- CF from 1 April 2023

IRDE – DEVELOPMENT

- ✓ IRDE Tech Committee under Chairmanship of Director ICAT was constituted by MoRTH direction on 26th Dec 2016.
- ✓ Mandate: To define IRDE Test Procedure for Light Duty Vehicles.



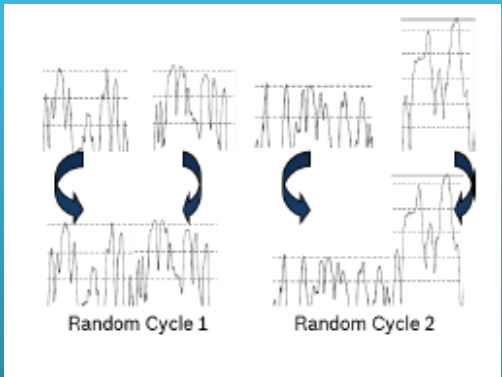
1st Meeting of IRDE Committee was held in Feb 2017.

INDIAN RDE DEVELOPMENT

Both lab based an on road test methodologies were evaluated by IRDE committee

Initially two test procedures were proposed:

Laboratory based testing – Random Cycle (RC)



On road emission testing – PEMS

In 2012 Europe also evaluated two methods to evaluate real world driving emissions :

- JRC evaluated PEMS based testing
- Vehicle manufactures evaluated Lab based testing using random cycles

Finally European Commission approved golden" method of PEM based testing on road and RC were kept as backup

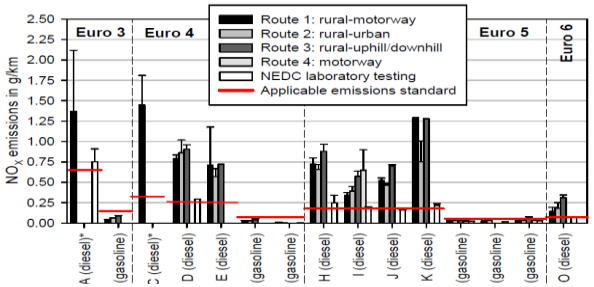
NEED FOR IRDE

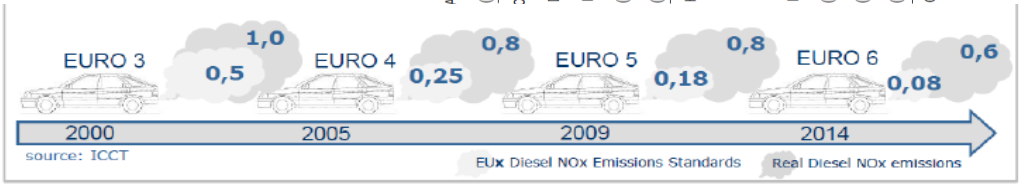
Global Influences

- Differences in Test Lab vs Road Results
- The issue of Test Cycle Recognition / Defeat Devices.
- Ambient Air Quality Issues (NOx Hotspots in EU Cities)

RDE Test Procedure Formulation in EU / Other Countries

(Source: Air quality in Europe - 2015 report, EEA & EUR 25572 EU-2013 report, JRC)





Drivers in India

- Indian climate, ambient conditions, traffic conditions, vehicle category mix and MIDC.
- To ensure that Real Drive Emissions remain within Compliance Limits with reference to Lab Emissions.
- To improve Ambient Air Quality in Major India Cities by achieving National Air Quality Guidelines.

A Need to have a Test Protocol for evaluating Emissions in Real Driving Conditions in India

METHODOLOGY – IRDE

EU Model (3rd Package) ± **Adaptations - India Specific Items** = **Indian RDE**

Key India Specific Adaptation

Ambient Temperature

Test Fuel option reference/commercial.

Speeds (Trip Share Distance)

- Low Speed in Indian Cities / Highways.
- Maximum Speeds Lower in India
- Typical Indian Vehicles (Small Engines / Low PMR)

Driving Dynamics (V*apos_95 & RPA)

- Typical Traffic Conditions in India Cities / Highways
- Typical Indian Vehicles (Small Engines / Low PMR)

Data Post Processing

- Based on Type-1 Test (MIDC); Reference CO_2.
- Adaptation of other Factors for Post Processing; Speed Bins, Normality, Completeness and multiplication factor.

Methodology Adopted

Data Survey.

- Indian Climate Data (15 Year Monthly Avg. Data with correction for Regional & Seasonal Extremes)

Data Collection by Experimentation.

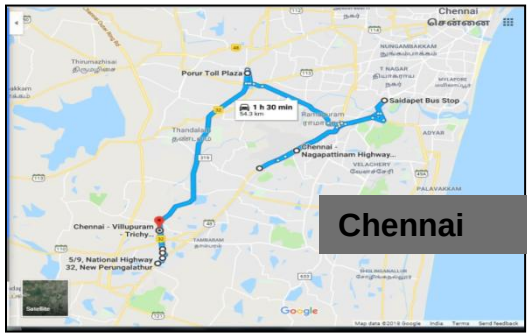
- Data Collection on Indian Roads in different Cities & Speed Distribution Analysis
- V*Apos & RPA Scatter based on Data Collection on Indian Roads considering Usable Acceleration Potential.
- Adaption using MIDC (2-Point Post Processing & Validation for CO2 Correction Factors, Normality and Completeness)

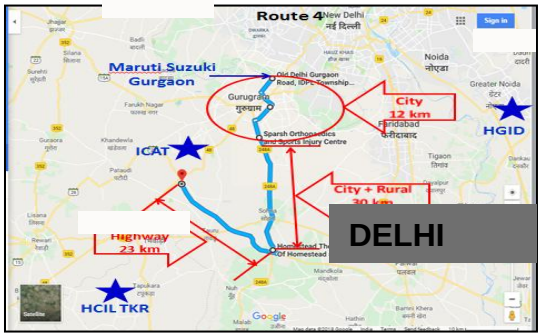
IRDE is mainly based on EU 3rd Package with Adaptations for India

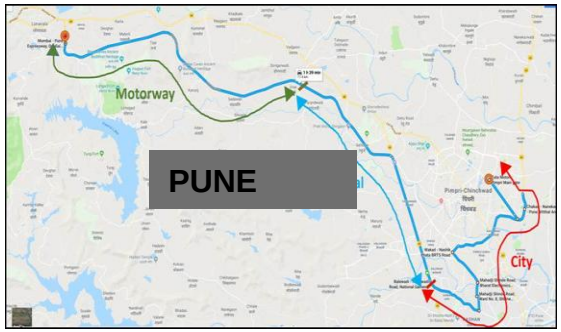
IRDE DEVELOPMENT : SNAPSHOT

- Over 60 vehicles Evaluated across various categories(M1, N1 & Low powered M1 & N1)
- Across Various Regions (North, West and South India) in different seasons
- Approx. 10,000km of Road Tests done.
- 12 IRDE Committee Meetings and Over 50 Expert Group Meetings & Telecoms
- Around 2 years of Work since commencement of activities from Jan 2017

Examples of Test Routes







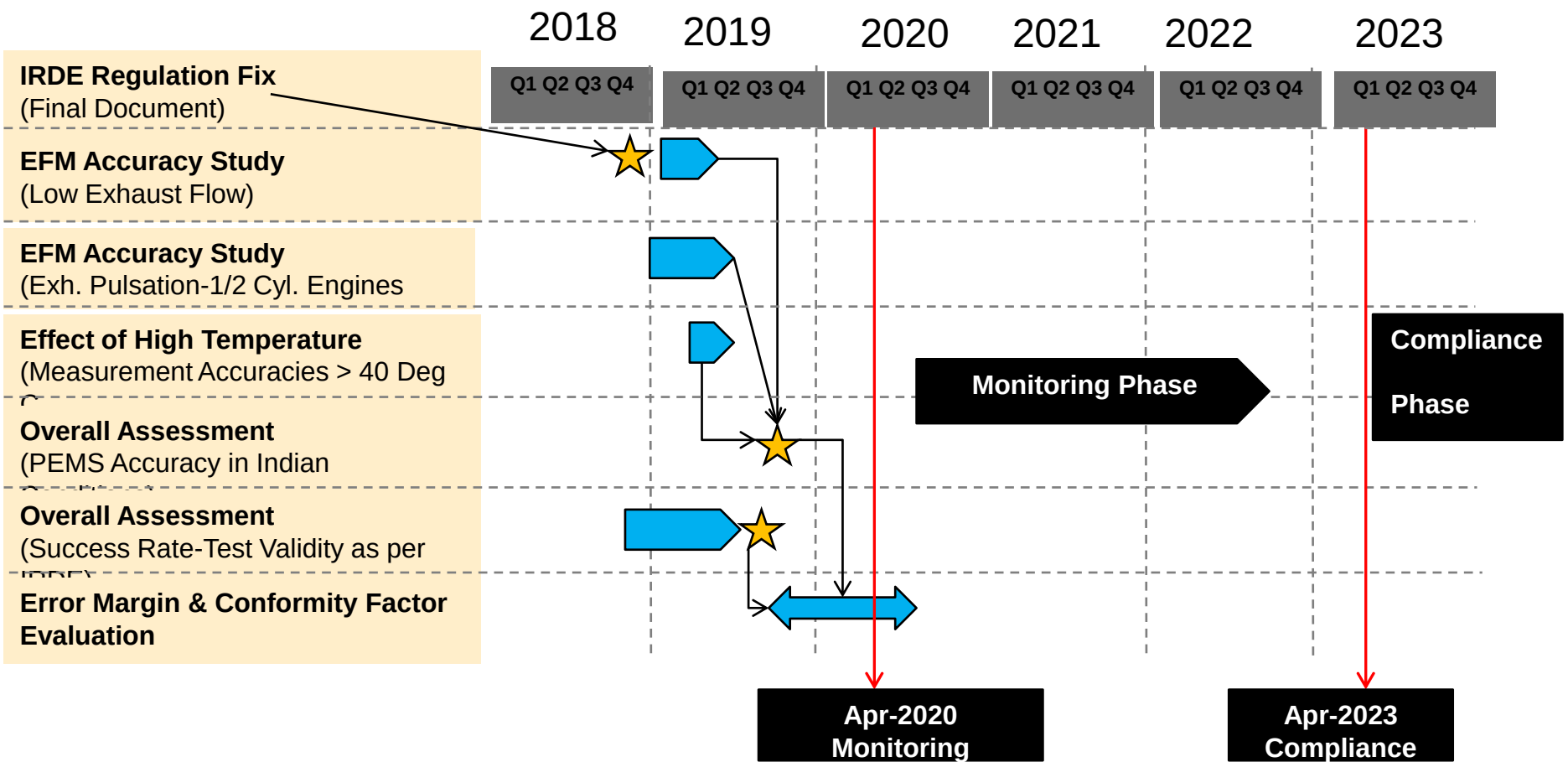
INDIAN RDE REGULATION : HIGHLIGHTS

#	Items	M Category	N1 Category	M1 & N1 (Low Power) (PMR < 22kw/ Ton & Max. Designed Speed ≤ 70 kmph)
Environment Boundary Conditions				
1	Temperature	Moderate: 10 ≤ T ≤ 40, Extended:40 < T ≤ 45 ; 8 ≤ T < 10		
2	Altitude	Moderate: A ≤ 700 m , Extended: 700 < A ≤ 1300 m		
Trip Requirements				
1	Speed Ranges	Phase1: V < 45 km/h Phase2:45 ≤ V <65 km/h Phase3: V ≥65 km/h V>75km/h for min 5 min	Phase1: V < 40 km/h Phase2:40 ≤V <60km/h Phase3: V ≥ 60 km/h V>70km/h for min 5 min	Phase1: V < 45 km/h Phase2: V ≥ 45 km/h V>55km/h for min 5 min
2	Trip distance share	Phase 1: 34 % (±10%) Phase 2: 33 % (±10%) Phase 3: 33 % (±10%) (Same for M1 / N1)		Phase 1: 50 % (±10%) Phase 2: 50 % (±10%)
3	Maximum vehicle velocity	For M1: Wherever **legal max speed limit permits**, the vehicle velocity **can exceed 100 km/h** for not more than **3 % of the time duration of the Phase 3 driving, maximum up to 120km/hr.** **For N1: Restricted to 80km/h.** **For LP M1/N1: Restricted to 70 km/h**		
4	Phase 1 Average Speed	15-30 km/h		
5	Total trip duration	90 – 120 min		

INDIAN RDE REGULATION : HIGHLIGHTS

Sr. No	Points	M Category	N1 Category	M1 & N1 (Low Powered) (PMR < 22kw/ Ton & Max. Designed Speed ≤ 70 kmph)
6	Minimum Distance	16km for each Phase (Phase 1, Phase 2, Phase3) (Same for M1/N1)		24 km for each Phase (Phase 1, Phase 2)
7	Stop periods	• 6 to 30% of Phase -1 duration • May contain several stop periods of 10 seconds or longer. • Single stop period must not exceed 5 Mins. • Vehicle should not be driven continuously below 20 km/h for more than 20 minutes.		
	Trip Dynamics			
8	Number of Acceleration points	Minimum 150 for each for Phase1, Phase2 Minimum 100 for Phase3		Minimum 150 for Phase 1 Minimum 100 for Phase 2
9	Relative Positive Acceleration (RPA)	(V≤55.9 km/h) Y = -0.001825 X + 0.1755 (V>55.9 km/h) Y = -0.0011 X + 0.1350	Y = -0.0016x + 0.1406	(V≤ 54.76 km/h) Y = -0.0022X + 0.1271 (V> 54.76 km/h) Y = 0.0066
10	V*Apos	(V≤56.9 km/h) Y = 0.0467X + 12.2490 (V>56.9 km/h) Y= 0.1665 X+ 5.4352	(V ≤ 51.40 km/h) Y= -0.0614X + 6.9439 (V> 51.40 km/h) Y= 0.0045X + 9.8664	Y = 0.0142X + 4.6214

FUTURE ACTIONS



IRDE Implementation Timelines are already fixed. Conformity Factor Decision expected at beginning of the Monitoring Phase – Plan under discussion.

CHALLENGES FACED WORLDWIDE

- Selection of a Driving Route to minimise void tests and compliance to route requirement for trip share.
- Set-up for each vehicle is unique and hence adaptations to be panned carefully to ensure EFM fit for each engine size.

- Set-up to be made carefully to avoid damage to equipment due to exhaust temperatures.

- In India PEMS cannot be mounted outside the vehicle and hence needs to be accommodated inside the vehicle .
- PEMS is expensive equipment and subject to high risk of using on road.

- CO concentration increase inside the vehicle due to exhaust leakage and hence occupant at risk. Monitoring of CO levels required in the vehicle.
- Trip duration limited by battery capacity of the PEMS

CHALLENGES FACED WORLDWIDE

- Cycle mandates that all Trip share to be completed within set period of time, otherwise test might fail due to invalid result and be repeated.
- Trained drivers who have good knowledge of routes and driving style are required to maximize test validity are required.
- Confidentiality of vehicle prototypes to be maintained.
- Functioning of equipment in extreme hot conditions is a big challenge in India.
- High spread of results due to route selection, driver, traffic, results are not reproducible.
- Insurance of PEMS equipment is a big challenge due to its inherent usage.
- Customisation of software to suit local regional requirements.

GLOBAL TECHNICAL REGULATION (GTR) ON RDE

- In its June 2018 session, WP.29 decided to set up an informal group under GRPE to prepare, within the coming years, a GTR on Real Driving Emissions procedure.
- The goal of the informal group is to prepare and propose to GRPE, for its June 2020 session a draft text of an RDE GTR, including suggestions for the organization of the future work.
- The mandate for the informal group will be limited, in a first step, to June 2020, but may need to be extended to work on additional items.
- 7 informal group meetings held where contracting parties are sharing country specific data for evolving Global RDE.

THANKS

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Summit Dates: 27th Nov'2019 to 29th Nov'2019
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