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Car development and global working experience in the automobile industry

S. Khim WONG

siowkhim@yahoo.ca

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JAS4QoL

Mini Review

Car development and global working experience in the automobile industry

Wong, S. Khim

siowkhim@yahoo.ca

Summary

This presentation aims to provide a glimpse of an Automotive Engineer's view in the development of a motor vehicle and what it was like to work in the North American and Global automotive industry. Focus is given on the engineering of the fuel tank system and how evaporative emission regulations were met. A brief look at air pollution and the challenges facing the automotive industry and electric car were also presented. A review on the decline, transformation and rise of China concludes this presentation.

About the Author

S. Khim Wong earned his bachelor degree in Mechanical Engineering from North East London Polytechnic, England. His professional work experience includes working in the automotive industries in Britain, Malaysia, USA/Canada and China. He has written a number of technical specifications including one for The Society of Automotive Engineers International, SAE J2587 Optimized Fuel Tank Closure, where he was chairman and co-author. His interest in history and world travel gives him a Global prospective of world politics, work ethics and social cultures.

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1. About Cars

1.1 Assembly of a car

An automobile has about 30,000 parts. A typical production line assembles about 250,000 cars a year, or about 1000 a day in 2 work-shifts. Modules/Parts are delivered to an assembly station on a just-in-time basis. Cycle time or Takt time is about 40 to 80 secs. Takt time is the maximum amount of time in which a product needs to be produced or assembled in order to satisfy customer (the next assembly station) demand. This is usually the speed of the moving assembly line for one vehicle length. Every part must meet ALL quality requirements. Any hiccup will cause a delay and potential production line stoppage.

1.2 Different modules of a car

An automobile is made up of many modules including the body, power train, suspension, exterior, interior, passenger protection system, electricals, and electronics. The automotive industry is highly regulated for safety, environmental factors (such as noise, tail pipe emissions, and evaporative emissions), and fuel economy requirements.

1.3 Power train and the future of Electric cars and the Automotive Industry

The power train of an internal combustion engine (ICE) vehicle consists of the air intake, fuel storage, and delivery system, the air/fuel mixture, engine, exhaust, radiator and other control systems.

The power train of an ICE has about 2000 parts compared to that of an electric power train, with less than 100 parts. The electrical power train is less complicated to build, lasts longer, and is cheaper to operate and maintain. In 10 to 15 years (about 2030), Electric cars will be cheaper to build than gasoline engine cars. Coupled with autonomous (self-driving) technologies, the entire automotive industry will see a major shift towards a shared economy such as (Grab Car, Uber etc.) and there will be less necessity for personal car ownership.

Electric cars face several challenges. The lack the economy of scale results in the higher cost of development and production per vehicle. Currently, sales of new electric cars rely on government subsidies. As a result, used electric cars lose their value very quickly. For example, a Nissan Leaf in Japan loses about 90 percent of its value after seven years; within the same amount of time, the battery range degrades from 160km when new to 100 km. As newer electric cars begin to come with improved batteries that require less time to charge and have a longer range, older electric cars become less attractive to buy and own.

1.4 Plastic fuel tank system

The fuel-tank has changed from a simple fuel storage unit to a complete fuel system. It is a highly regulated part of the vehicle. Like the rest of the vehicle, the first fuel-tanks were made of steel. Plastic fuel-tanks were first introduced in Germany in the prototype 1962 Ford Consul using PA (Nylon). High density polyethylene (HDPE) fuel-tanks was first introduced in the 1971 Alpine A110 – rally racing car, and used for production of 1974 VW followed in 1978 by Citroen 2CV. HDPE is now the industrial standard. This is a very specialized sector within the automotive industry and there are only 4 major companies in the plastic fuel industry world-wide. There is a small circle of people working in this fuel-tank industry, and they tend to know each other. In 2016, of the 95 million new vehicles worldwide, 80% were made of plastic and 20% of steel

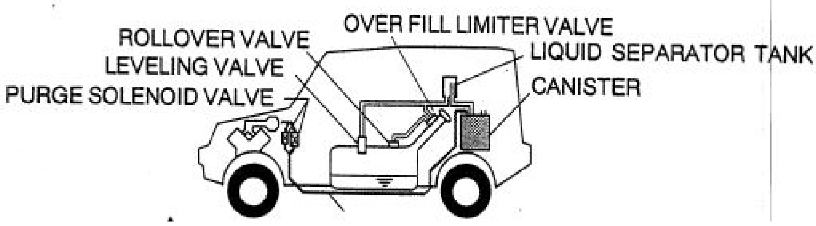
1.5 Functions of a fuel tank system

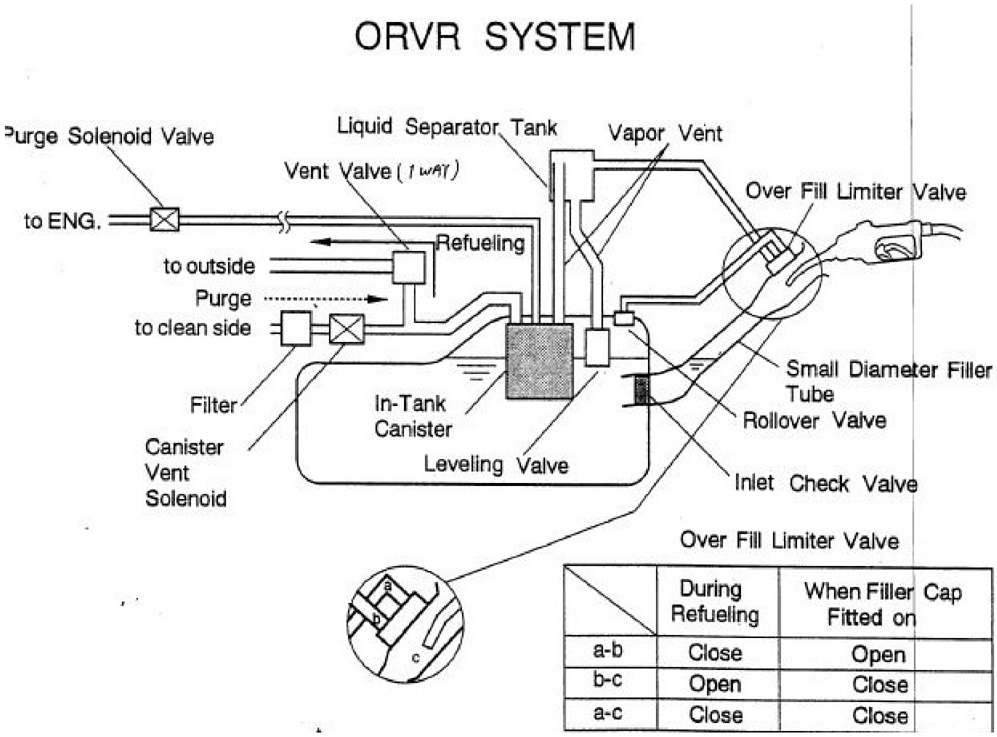
A fuel-tank system must perform several functions, such as receiving fuel (i.e. filling, storage, gauging), indicating the amount of fuel, venting, delivering fuel to engine, regulating vapor management, and last but not least, ensuring safety.

1.6 Filling a fuel-tank and vapor management

Since 1971, fuel vapor is not allowed to be vented to the atmosphere during refueling. Therefore, filling a fuel-tank is like filling a bottle with a straw with flammable/volatile liquid with the cap on. The OnBoard-Refilling-Vapour-Recovery (ORVR) system stops the vapor from being vented into the atmosphere (see Fig. 1).

1.7 On-board Refueling Vapour Recovery (ORVR) System





	During Refueling	When Filler Cap Fitted on
a-b	Close	Open
b-c	Open	Close
a-c	Close	Close

1.8 Fuel-filling

Without proper control up to one full tank of fuel vapor can be lost in the atmosphere during refueling during the life time of a vehicle (15 years or 150,000 miles).

NO VAPOUR ALLOWED INTO ATMOSPHERE

1.9 Dos and Don’ts when filling a fuel tank

- DOs:
  - **i.** Shut off your car engine completely.
  - **ii.** Close doors and windows if people are in car.
  - **iii.** Insert fuel-filling nozzle all the way into the fill-head.
  - **iv.** Start at full throttle (3rd Clip).
  - **v.** Fuel-nozzle will automatically shut off.
  - **vi.** Trickle fill for round-up or top-up.
  - **vii.** Close cap properly.
- DON’Ts:
  - **i.** When fueling, do not get in or out of the car: your pants/skirts rubbing on the car seat may generate static electricity and has the potential to cause a fire.
  - **ii.** For the same reason, do not use electronic devices in or near car that is being fueled.

1.10 Fuel Storage

A fuel-tank filled with fuel is like a bomb. A fuel-tank must not leak fuel under any of the following conditions:

- **i.** During impact
- **ii.** During Front, side, and rear crash
- **iii.** During Rollover

iv. When "fesistance to fire" is needed (ECE R34.01, Annex 5 Section 5.0)

v. At high temperatures > +70°C

vi. At low temperature < -40°C

vii. During fluctuations of ordinary daily temperature cycles: +20 to -20°C

A fuel-tank goes through more than a million pressure-vacuum cycles (expansions and contractions) over its lifetime, which can cause material fatigue and cracks on the fuel-tank. Copper electric wires attached to the fuel level sensor and fuel pump can break due to metal fatigue.

Pressure-vacuum changes are caused by:

i. temperature changes – due to weather and fuel expansion and vaporization

ii. fuel delivery to the engine reducing volume of liquid fuel and increasing vapor in the tank

1.11 Fuel storage and pressure/vacuum cause material fatigue and failure

Metal fatigue from pressure-vacuum cycles caused the crash of the first jet airliner, the de Havilland Comet, in 1954. This was due to material/metal fatigue caused by a pressurized cabin.

1.12 Plastic fuel-tank material (HDPE) and problem with permeation

A special grade High Density Polyethylene (HDPE) is currently the standard material for plastic fuel-tanks. HDPE is petroleum-based, and hydrocarbon (HC) molecules from petrol/gasoline can permeate through the HDPE material into the atmosphere. An untreated HDPE fuel-tank can emit as much as 20 g of fuel vapor in 24 hr due to permeation. To meet evaporative emission regulations, barrier layers were introduced on to the fuel-tanks.

1.13 Barrier Layers to prevent permeation

a) *Fluorine*

Fluorine (F_2) was first introduced in 1978 for the Renault 21 – this can achieve the 2 g/24-hr requirements. Fluorine is a very toxic chemical. It can be deadly and welds contact lenses to the eye.

b) *Ethylene vinyl alcohol (EVOH)*

Plastic fuel-tanks with EVOH as a barrier-layer were made of 6 layers: 1) HDPE virgin, 2) HDPE regrind, 3) adhesive, 4) barrier – EVOH, 5) adhesive, and 6) HDPE. EVOH was first introduced in the 1995 Jeep Grand Cherokee. A fuel-tank with EVOH as a barrier can meet the 0.2 g/24-hr requirements.

c) *Sulphurnation (SO3)*

Sulphurnation (SO_3) is used mainly on components for the fuel tank.

1.14 Venting of a fuel-tank system

Reasons that require fuel-tank venting include:

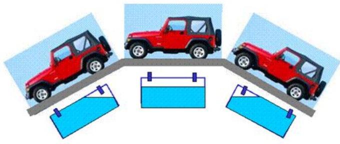
i. RE-FUELING – without venting will cause back pressure causing spit back and no-fill

ii. FUEL STORAGE – atmospheric temperature variations cause areas of pressure and natural vacuum inside the fuel tank

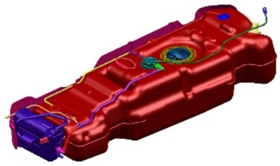
iii. FUEL DELIVERY – natural vacuum inside the fuel tank can suck the fuel back into the fuel tank and reduce the ability of the pump to deliver fuel to the engine

Without proper venting, a fuel-tank can expand and/or collapse. The fuel tank goes through more than one million pressure–vacuum cycles which can result in the fuel-tank material failure, resulting in cracks, collapse and fuel leakage.

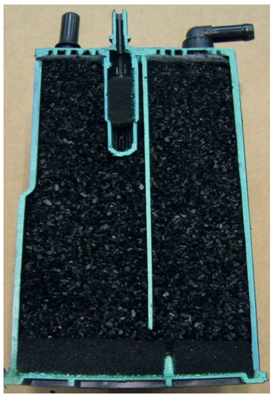
A fuel-tank must vent during all-weather and driving conditions. Since 1971, regulations in the United States (US) do not permit fuel vapor to be vented into the atmosphere.



1.15 Carbon canister-filter absorbs fuel vapour and then purge to the engine.



The carbon canister-filter absorbs the fuel vapour and at certain designated condition, purged the fuel to the engine to burn as fuel. Activated carbon in the carbon canister-filter must stay dry to work properly. A trap prevents fuel liquid from entering the carbon chambers. WATER MUST NOT ENTER THE CARBON CANISTER FILTER. Driving over water can risk damaging the carbon canister and the fuel system. The production of activated carbon is an environment-unfriendly industry. The manufacturing process emits toxins and cause major air pollution and health problems.



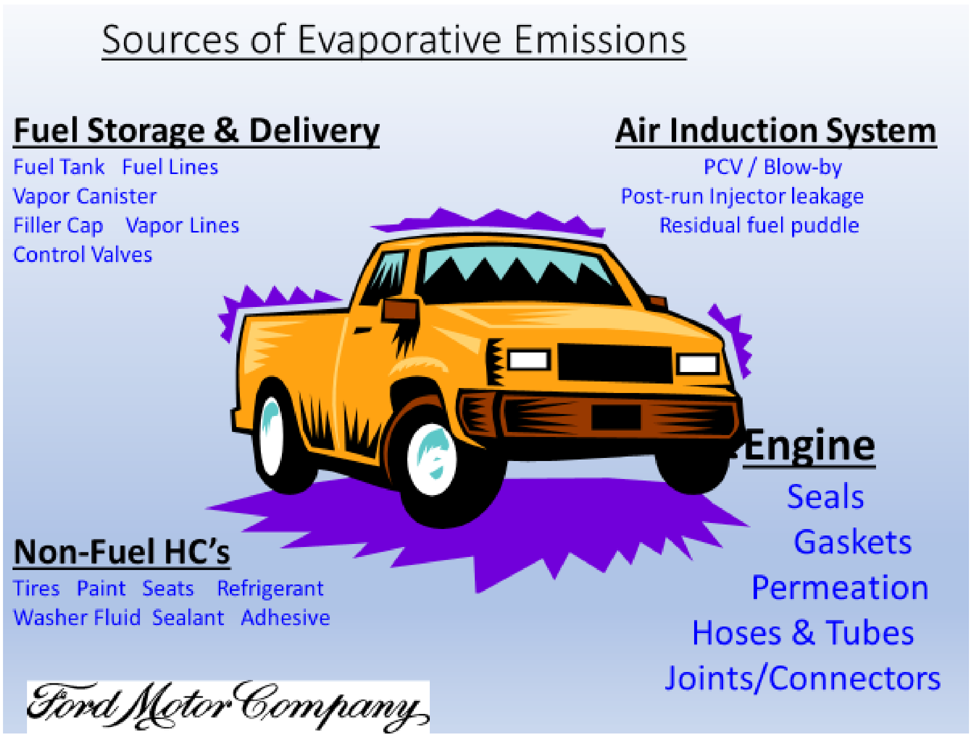
1.16 Air pollution, water and soil contamination

Some facts about air pollution are presented. According to the WHO, 92% of the world's population lives in places where air pollution exceeds the safe limits. Air pollution is the 4th largest threat to human health behind high blood pressure, dietary risk, and smoking. About 6.5 million deaths worldwide were registered from air pollution-related diseases in 2012, causing US$ 225 billion loss in labour income.

1.17 Air pollution from motor vehicles

Every vehicle on the road contributes to air pollution – including electric vehicles. Two types of pollution result from the use of motor vehicles: 1) tail pipe or exhaust emission; and 2) evaporative emission.

1.18 Source of Evaporative Emissions from a motor vehicle



1.19 Effects of air pollution on soil and water contamination

Rain 'cleans the air of pollution' but water run-off contaminates rivers, lakes and seas, killing fish and wildlife and affecting human health. Polluted rainwater also contaminates soil in the ground and harm plants and trees around us. Fuel solvents such as methyl tert-butyl ether (MTBE) contaminate drinking water and causes cancer. MTBE is an additive to petrol/gasoline produced by US automobile companies. Although its use is banned in the US and many other countries, international trade agreements (dominated by the US) still allow MTBE and other banned substances to be used currently in many countries. If other countries attempt to ban MTBE, lawyers from the US will sue those countries to have them pay fines: Canada paid US$40 million fine due to North American Free Trade Agreement (NAFTA).

1.20 Emission regulations: CARB , EPA , EU, Japan

Emission Standards Specify Limits for:

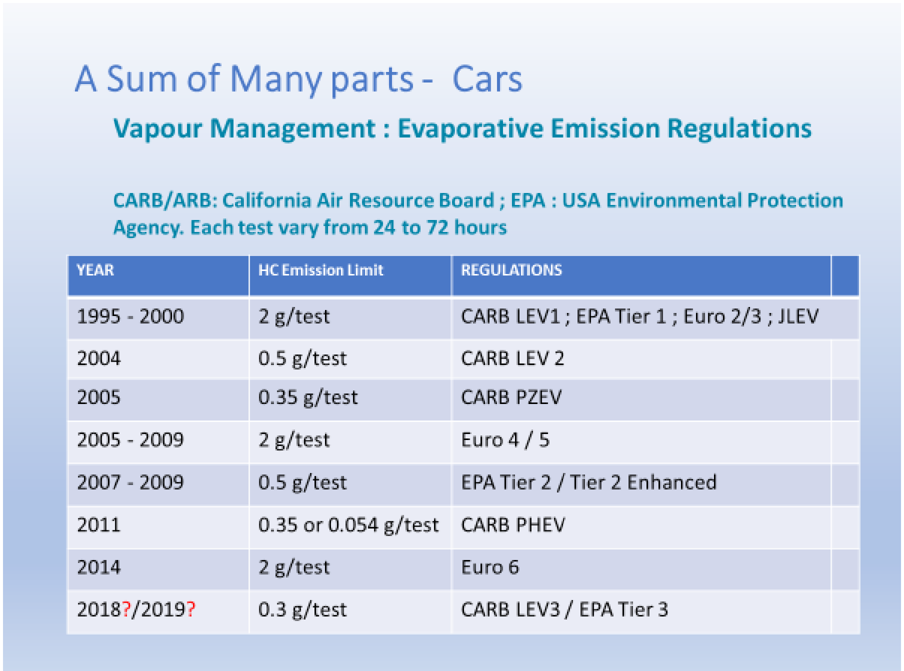
Pollutants

- **i.** Carbon monoxide (CO)
- **ii.** Hydrocarbons (HC)
- **iii.** Nitrogen oxides (NO_x)
- **iv.** Particulate matter (PM)

Other Chemicals

- **i.** Non-methane organic gases (NMOG)
- **ii.** Formaldehyde (HCHO)
- **iii.** Carbon dioxide (CO_2)

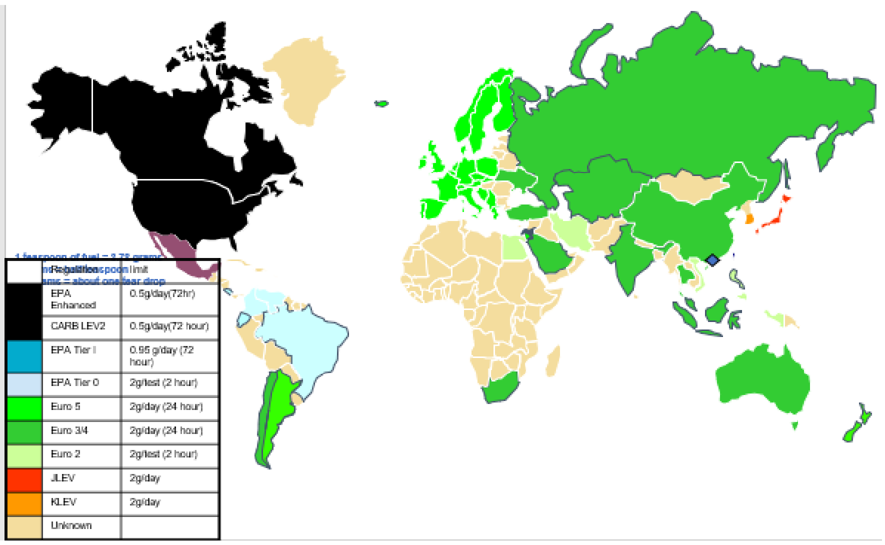
1.21 Evaporative emission regulations

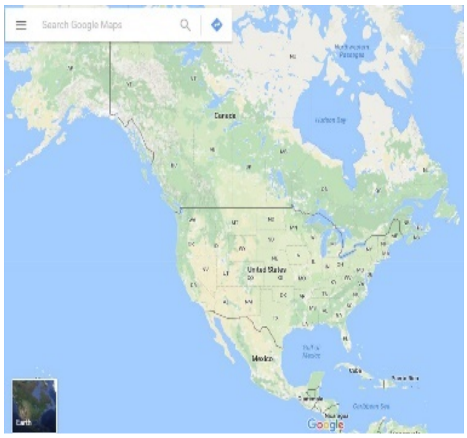


YEAR	HC Emission Limit	REGULATIONS
1995 - 2000	2 g/test	CARB LEV1 ; EPA Tier 1 ; Euro 2/3 ; JLEV
2004	0.5 g/test	CARB LEV 2
2005	0.35 g/test	CARB PZEV
2005 - 2009	2 g/test	Euro 4 / 5
2007 - 2009	0.5 g/test	EPA Tier 2 / Tier 2 Enhanced
2011	0.35 or 0.054 g/test	CARB PHEV
2014	2 g/test	Euro 6
2018?/2019?	0.3 g/test	CARB LEV3 / EPA Tier 3

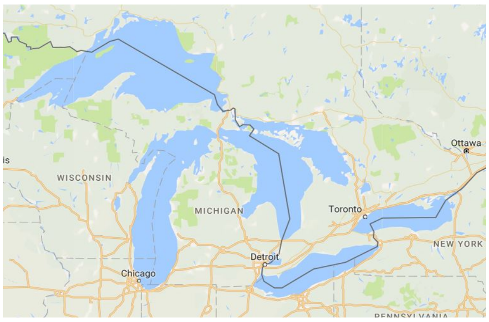
Useful note: i) 1 teaspoon of fuel = 3.8 g; ii) 2 g = half teaspoon; and iii) 0.2 g = about one teardrop

1.22 World map of evaporative emission regulations in 2012 – Light-duty vehicles





1.23 Effects of air pollution on water resources of the Great Lakes region of North America



The Great Lakes region of North America holds 20% of the world's fresh water. It is a very important source of fresh water. However, nearby chemical plants, industries, and acid rain have contaminated the water. When I took my first gulp of water in Toronto – I had to spit it out instinctively. There are fish consumption advisories related to mercury, PCB, and other pollutants.

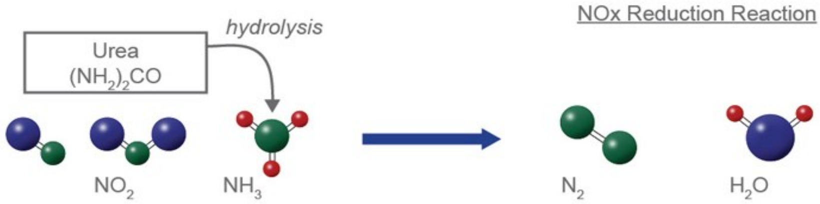
1.24 Management of air pollution derived from vehicles

There has and still is a lot of engineering work being done in managing air pollution in vehicles. There are limits for internal combustion engines (ICE). Major changes in the auto industry are happening now:

- **i.** Hybrid Electric and Alternate fuel vehicles
- **ii.** Electric vehicles
- **iii.** Fuel Cells
- **iv.** Autonomous vehicles

1.25 Evaporative emission does not apply to diesel fuel

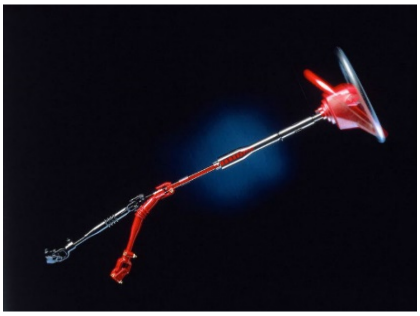
Fuel vapor management does not apply to diesel fuels due to its lower volatility: however, diesel engines emit more particulates (soot) and NO_x and therefore need exhaust treatment systems such as Selective Catalytic Reduction (SCR). Diesel exhaust treatments such as SCR require injection of AdBlue/DEF into the exhaust gas to reduce particulate emission. Although AdBlue/DEF is a non-toxic fluid, it is highly corrosive due to its composition as purified water and urea $[NH_2]_2CO$]. AdBlue/DEF sets off a chain of chemical reactions that eventually converts nitrogen oxide (NO_2) into nitrogen, water and carbon dioxide (CO_2).

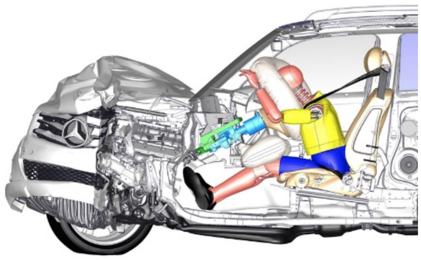


1.26 DRIVER and PASSENGER PROTECTION – Dynamics of a car crash

There are three ways of inflicting personal injuries in a car during a crash:

- **i.** Person hitting part of car
- **ii.** Part of car hitting person
- **iii.** Sudden deceleration/stop causes the steering wheel to press against external and internal organs and to hit skeletal structures, causing injury and possible death – this last way is the most deadly.





Collapsible steering columns (right) prevent the steering wheel from crashing into the driver. The crumpled zones absorb the force which would otherwise be transferred to the body systems of occupants. With recoiling seat belts and air bags protection (right), the safety cage protects the occupant.

1.27 Development of a fuel system

Validation/Testing of the fuel system includes verification of the following:

Validation:

- **i.** Drop test
- **ii.** Crash test
- **iii.** Filling
- **iv.** Burst
- **v.** Aging
- **vi.** Deformation
- **vii.** Volume
- **viii.** Gauging
- **ix.** Noise
- **x.** Fire
- **xi.** Venting

Testing:

Hot Trips + 60 degree C = 140 degree F

- **i.** Filling
- **ii.** Low fuel
- **iii.** Vapor lock
- **iv.** Up-hill/ Down-hill

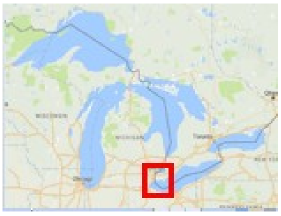
Cold Trips minus 40

- **i.** Filling
- **ii.** Low fuel
- **iii.** Ice pack
- **iv.** High altitude testing
- **v.** Crash test

2. Life as an Automotive Engineer

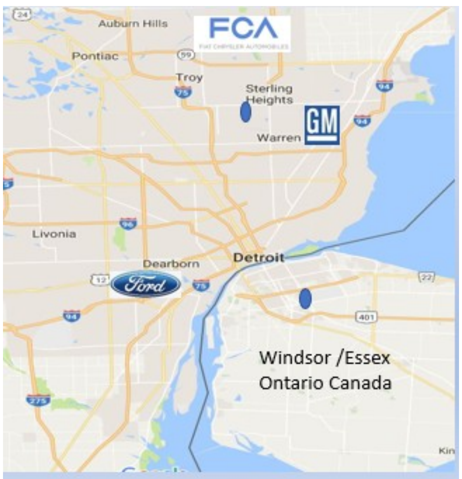
2.1 The North American Automotive industry is centered around Detroit, Michigan, USA

The development centers of the three major American automotive companies, Fiat-Chrysler, Ford and General Motors are within one-hour drive from each other. Other original equipment manufacturers (OEMs), such as Toyota, Nissan, Hyundai etc. and major suppliers, have their development centers in this region as well.



2.2 About working conditions and benefits of the US automotive industry

- **i.** 2016: 20 million vehicles USA/Canada/Mexico
- **ii.** 8:00 am to 5:00 pm, 5-day week (40 hr/week)
- **iii.** 48 work days/year
- **iv.** 13 public holidays a year – inclusive of 10 days Christmas-New Year 'shut down'
- **v.** First Public holiday after New Year day is in May, followed by other holidays in July, September, November
- **vi.** 10 days/1st 5years paid holidays to 20 days after 10-year service
- **vii.** Employer-based healthcare provided
- **viii.** No maternity leave
- **ix.** Limited long-term paid sick leave
- **x.** Job security - unlike that of British/European labor laws
- **xi.** Engineer's salary: US$65,000 - 120,000 per year
- **xii.** Social security contributions – 6.2% each employee/company and 1.45% medicare tax
- **xiii.** Some get company pension



xiv. Other retirement savings (401K) are voluntary. Company matches up to 3-5% of gross pay

xv. Generally – good work support system

xvi. Can be fired if cannot perform or too sick to work

xvii. For serious sickness – option to keep job and not retire or go bankrupt

2.3 Work experience in China

I had the opportunity to work in China from 2005 to 2010. As a person of Chinese heritage and a history-loving student, working in China gave me the opportunity to discover and have a better understanding of China.

2.4 China Review

China is a country of many 'nations'. There exists a common sense of culture and social responsibility as described in " Three Character Classic" 三字經 Chinese are very keen to learn and explore new things. They are quick to accept new technology – compared to India and Indonesia. Its large market creates opportunities for personal growth. China faces many challenges such as 1) combating air pollution, 2) finding abundant sources of food and water, 3) serving the 15 million people who join the work force each year, and 4) developing a better sense of social responsibility within the populace.

2.5 A brief historical account of the decline of China: struggles and failure to modernize

i. 1800 – as Industrial Revolution was taking shape in England/Europe, China was the largest economy of the world.

ii. Agriculture Society: Every 5 to 10 years – Drought, Flood, Locust – result in famine.

iii. 1834-1870: Opium trade and war followed by unequal Treaties with Britain, France, USA,– drained China of her Silver and thus remain bankrupted and hungry for next 150+ years (about 1 in 4 was addicted to opium: i.e. 100 million people)

iv. 1870-1945: Invasions and Concessions by Britain, France, Germany, Russia, Italy, USA, Austro-Hungarian, Belgium, Netherlands and Japan – starvation of local population.

v. 1910-1949: End of Manchu rule, China Internal rivalries – War Lords, Civil War, opium addiction and the unification of China.

vi. 1940 40 million opium addicts and starvations – rice for Japanese army only.

vii. 1950-1953: China fought USA in Korea War.

viii. 1955 : Taiwan Crisis. USA President Eisenhower's Secretary of State John Foster Dulles, threatened Nuclear attack on China – thus the population explosion in China.

ix. 1949 –1972: Bamboo Curtain- Self Isolation and West containment.

x. 1958-1976 – Great Leap Forward and Cultural Revolution –

xi. Failure to Industrialize and Drought resulted in Famine (1959-1961) 30-45m deaths

xii. 1979 – 27-day China-Vietnam War – Ill equipped army badly wounded by Vietnam who had defeated USA in 1976.

xiii. Chinese people had been living in hunger during these times.

2.6 Transformation of China

i. Modernization of Chinese Language:

ii. 1919 - abandonment of the classical Chinese written language. The Treaty of Versailles that ended WW1 in Europe gave German territories in China to the Japanese. This gave rise to the May 4th 1919 Movement. One of the declaration of this Movement was the abandonment of the classical written language

iii. 1958 – official adoption of Hanyu Pinyin - Romanized BoPoMoFo

iv. 1990s – personal computers – enable effective use of Chinese writing

v. 2000s – Mobile phones – SMS / Smart phones /

vi. 1972 – PRC Membership of United Nations

vii. 1977-1980 - present: many separate world study tours by senior officials

viii. Emulate Iwakura Mission (December 1871- September 1873) – 51 Meiji Government leaders' study-tour that started the industrialization of Japan.

ix. 1980s Investments by Oversea Chinese in Shenzhen, Xiamen, etc.

x. 1993: End of food-rationing in all of China

xi. 1994: beginning of Privatization of State owned enterprises

xii. 1995: China Project 211 – Aim: by the year 2100, 100 World Class Universities/Research Institutions

xiii. 2001-Dec: Membership of World Trade Organization – beginning of major foreign investments and the industrialization of China

xiv. 2014 – End of "…. Maintain a low profile. Never take the lead…"

xv. 2015 – Internet Plus and made-in-China 2025 – aims to redirect to high value-added products

Quote from Napoleon on China: "Let her sleep, for when she wakes, she will shake the World"

2.7 <u>China has awakened</u>

i. Technological advancements in 10 targeted industries:

ii. Electric vehicles, new materials, artificial intelligence, computer chips, aeronautics and space, Bio Med, robotics, quantum computing, 5G mobile communications

iii. In 2017 is already the world leader in Electrical vehicles, Financial Tech

iv. China's big advantages are due to its:

1. Scale
2. Growth momentum
3. Currency value
4. Work ethic (i.e. Chinese are very keen to learn and tend to explore new things)
5. Attitude
6. Eagerness to improve (chinese yearn to improve their living standards and life styles)
7. Belief that all can be taught and discovered

Despite suffering through many sad historical events, Chinese people have learned to harbor and cherish a common will and desire for peace, political stability, and a determination never to be invaded, robbed, bankrupted, or humiliated ever again.