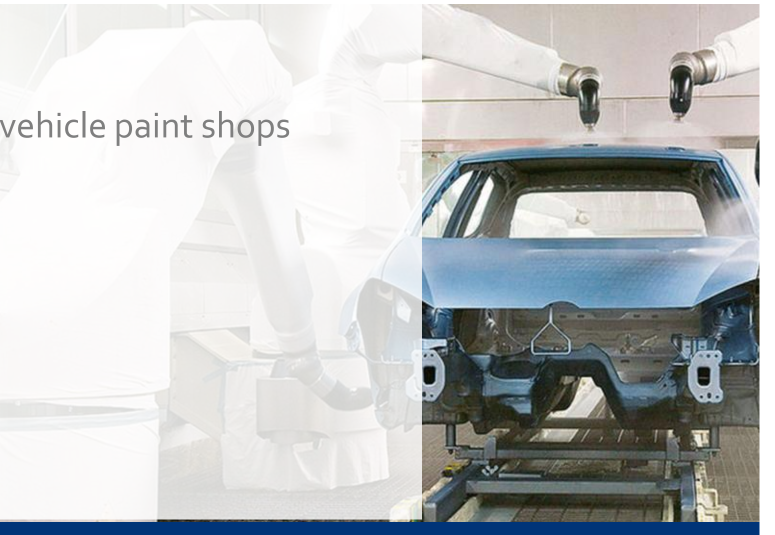
European Automobile Manufacturers Association

Vehicle coating

Solvent use and BAT in motor vehicle paint shops



TFTEI ANNUAL MEETING 2016

CATANIA (ITALY) 20/05/2016

Michael Mrowietz, Roman Meininghaus

ACEA

Saturday, 28 May 2016

IN THE NEXT 20 MINUTES…

- **Environmental relevance of vehicle paint shops**
- **What has been done in the last 10 years**
- **Rounded off by a 5 min crash course in vehicle painting**

MOTOR VEHICLES

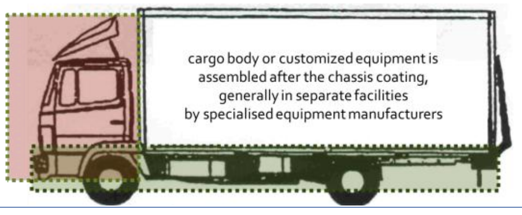
Passenger cars

© VW

Vans

© Renault

Trucks and truck-cabins



Buses

© MAN

MOTOR VEHICLE PAINTING OBJECTIVES

Customer requirements

Appearance

Design / Fashion:
- 2 tones
- metallic, pearlescent

Lightweight desing:
- multimaterial body

Quality:
- anti rust guarantee

Environmental protection

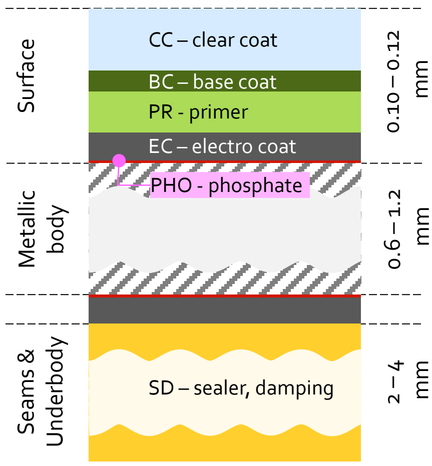
Manufacturing:
- cost efficiency

Workplace health & safety

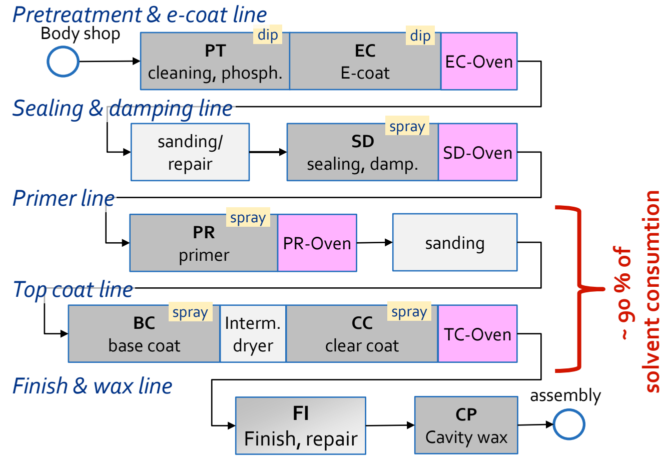
© FIAT

COATING PROCESS

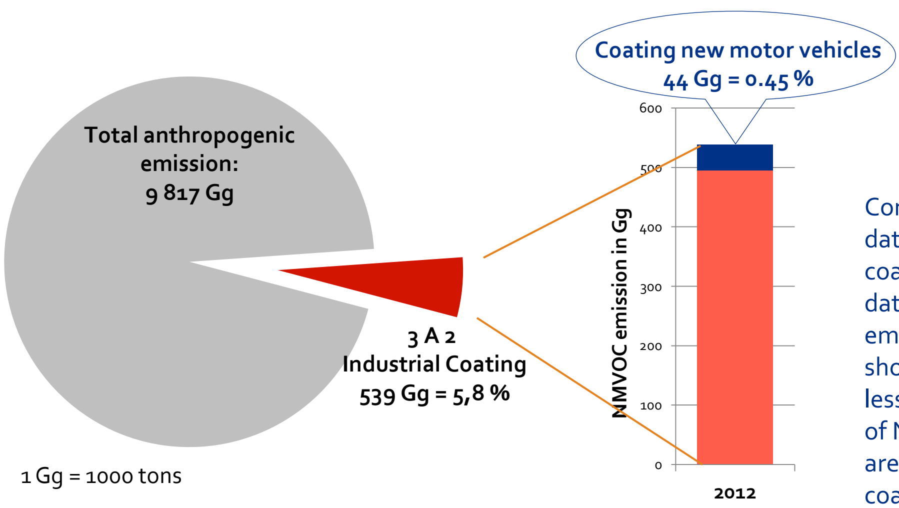
Coats



Processes



NM VOC EMISSIONS 2012 IN THE EUROPEAN UNION

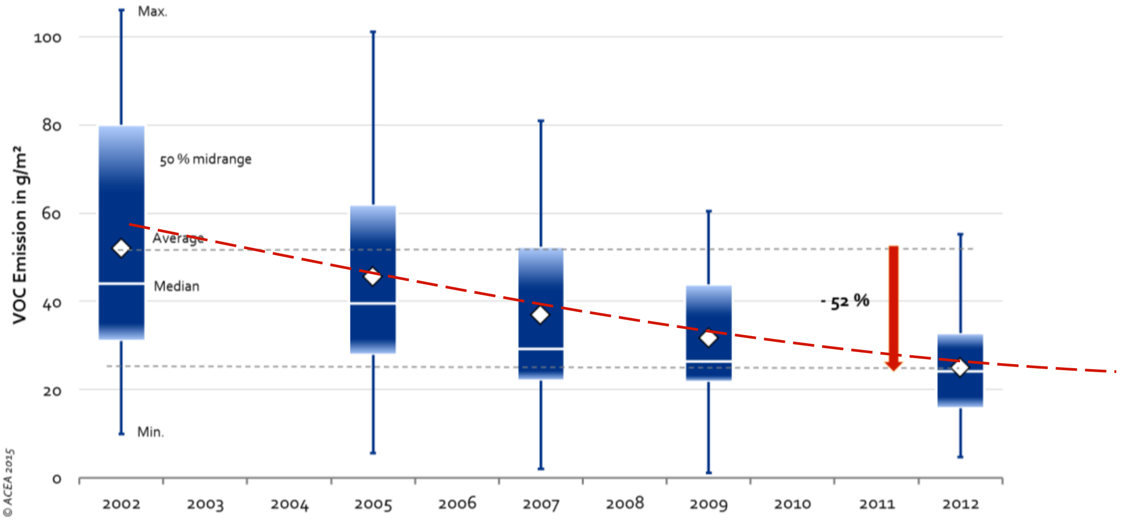


Comparison of ACEA data for motor vehicle coating and published data from national emissions inventories show, that less than 0.5 % of NMVOC emissions are caused by vehicle coating.

1 Gg = 1000 tons

http://www.ceip.at/ms/ceip_home1/ceip_home/webdab_emepdatabase/

VOC EMISSIONS OF EU PASSENGER CAR PAINT SHOPS



VOC EMISSIONS DETERMINATION

Determination of total emissions mass flow E_{mass} in kg/a:

direct method:
measurements at all fugitive and point sources

indirect method
Consumption of solvents
– VOC destroyed or transfered in waste

O1 + *Fugitive* = E_{mass} = *C – O5 – O6*

expensive, complex, inaccurate

moderate costs, use of available data , reliable.
Generally applied in the automobile industry

Determination of electro-coat surface A_{EC} in m²/a

$A_{EC,\,veh} \times n_{veh} = \mathbf{A_{EC}}$

A_{EC} surface is a reference surface (not the painted surface)

Calculation of total emissions in g/m²

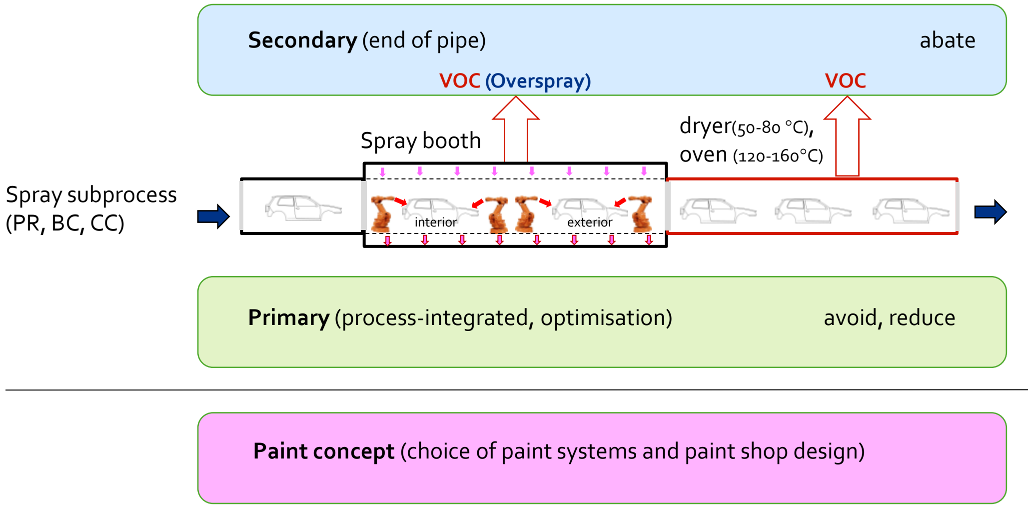
$E = E_{mass} / A_{EC}$

FACTORS THAT INFLUENCE SOLVENT CONSUMPTION AND VOC EMISSIONS

- **Product requirements**
  Painted surface, custom requirements on appearance and fashion (special effect colours, 2tone), availability of water based paints (fleet colours)

- **Paint shop design, application techniques and abatement measures**
  Consumption of solvents and emissions of VOC depend on the
  - application of many different techniques,
  - which might be different in each process step or paint shop line
  - and cannot be combined arbitrarily

VOC REDUCTION MEASURES



PRIMARY MEASURES (PROCESS -INTEGRATED)

Primary measures

- **High first run rate**
  - Clean room spray cabins
  - Air-locks with body dusting
- **High paint transfer efficiency**
  - Automation
  - Rotary atomisers (bells) with electrostatic charging
- **Low loss colour changers and cleaning techniques**
  - Capturing of cleaning solvents / paint at colour changes
- **Reduction of VOC content in coatings and solvents/cleaners**
  - High solid paints
  - Replacementv of solvent cleaners by detergents

PRIMARY MEASURES (PROCESS-INTEGRATED)

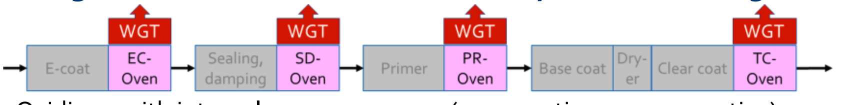
Primary measures

- **Driving forces: product quality, cost per unit**
- **Environmental benefit without or with acceptable additional cost**
- **Achieved VOC reduction in the last 10 years: (10 ± 5) g/m², depending on local conditions**
- **Can be retrofitted in existing paint shops, but limitations of applicability must be taken into account**
- **Standard for new installations**

SECONDARY MEASURES (END-OF PIPE)

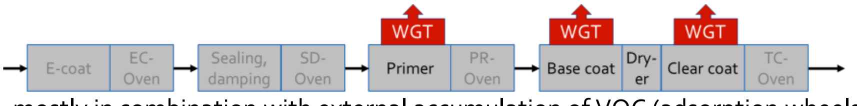
Secondary measures

- **Waste gas treatment (WGT) of VOC in dryer oven waste gases**



  - Oxidisers with internal energy recovery (recuperative or regenerative)
  - Low volume flows
  - Often used (if high VOC raw gas concentrations)

- **Waste gas treatment (WGT) of VOC in spray booth waste gases**



  - mostly in combination with external accumulation of VOC (adsorption wheels)
  - Mostly oxidisers with internal energy recovery (recuperative or regenerative)
  - Seldom used (very high waste gas volumes with low/medium VOC concentrations, high energy consumption)

SECONDARY MEASURES – END OF PIPE

Secondary measures

- **Driving forces: environmental protection**
- **Additional invest and running cost**
- **Achievable VOC reduction depends on raw gas mass flow**
- **Cross media effect: energy consumption, NOx and CO emissions**

- **Dryer oven waste gas treatment standard in new paint shops**
  (exceptions for low raw gas mass flows)

PAINT CONCEPTS: PAINT SHOP FAMILIES

- **In a paint shop usually 3 - 4 paint layers are applied in successive steps**
- **Depending on solvent composition three paint shop families have been evolved in the last 30 years**

Family	% EU	Primer		Base coat	Clear coat	
SB	15	SB	Oven (opt. *)	SB	Generally SB (not applied for unicoats)	Oven
SB-Mix	29	WB		SB		
		SB		WB		
WB	56	WB		WB		

SB = Solvent based (35 – 89 % VOC)
WB = Water based (5 – 17 % VOC)
*) = not for integrated processes (IP), IP is an umbrella term for several new paint processes introduced since ~2000 and actually used in ~18 % of all paint shops

SUBSTITUTION IS A FUNDAMENTAL CHANGE

	Solvent based	Water based	
Spray coating system:	Solvent based	Water based (except clear coat)	
Intermediate dryer between base coat and clear coat	Short flash-off zone (not in all cases)	Intermediate dryer (with T = 50 – 80 °C, t = 5 – 10 min) and in/out air-locks necessary, typical length: 35 – 55 m (+ 75 % of total length of a top coat line).	**Longer line**
Primer dryer oven heating curve	No temperature hold below 100 °C	5 – 10 min. temperature hold necessary to evaporate water before surpassing the boiling point temperature.	**Longer line**
Construction material for paint booths	Standard galvanised steel	Stainless steel for all parts in contact with paint	**Full renovation**
Use of electrically charged bells	Automatic application	Automatic application. Electrically disjoined paint supply system necessary	**Less efficient**
Paint window	Broader than for water based paints	Restrictions in range of humidity. Depending on local climate conditions additional equipment for air conditioning	**Larger air handling units**

CHOICE OF PAINT CONCEPTS

Paint concepts

- **The choice of the coating system entails fundamental and mostly irreversible differences in the design of the paint shop.**
- **In existing sites such a fundamental change can be done only if**
  - there is room to build a second paint shop (or paint shop line) in parallel without interrupting the existing one,
  - and where the new paint shop can be linked to the body and to the assembly shop.
  - if production can be interrupted for a longer time (> 4 weeks), which is normally not the case in the vehicle industry.
- **Each production line is normally dedicated to only one single model of the product range of a company.**
- **Due to these constraints such a transformation is very expensive and is rarely made.**
- **A decision for a certain paint concept is usually made for new paint shops.**

EVALUATION OF VOC REDUCTION MEASURES

Measure	Implementation time	Costs	Potential tradeoffs
Primary	Short - long	• High invest • long pay back	• Quality / Appearance loss • Run up difficulties
Secondary	Short	• High invest • high operational cost • no payback	• More energy use • more CO_2 emissions • additional emissions of dust, NO_x, CO
Paint concept	Long (new or major refurbishment)	• Can reduce operational costs	• Quality loss • Appearance loss • Run up difficulties • Longer interruption not acceptable • Production losses • Site layout constraints

SUMMARY AND CONCLUSION

- **VOC emissions have been halved in the last 10 years.**
- **The contribution of motor vehicle paint shop emissions to anthropogenic NMVOC emissions in the EU has been reduced to below 0.5 %.**
- **This has been achieved by a combination of**
  - Primary measures (process optimisation),
  - Secondary measures (waste gas treatment) ,
  - Introduction of paint concepts with low VOC paints (mainly in the context of startup of new plants).
- **The applicability of each measure has to be evaluated case by case.**
- **Achievable emission reductions are different for existing and new installations**
- **Further reduction of VOC emissions will be slow and very expensive.**

1991
2016

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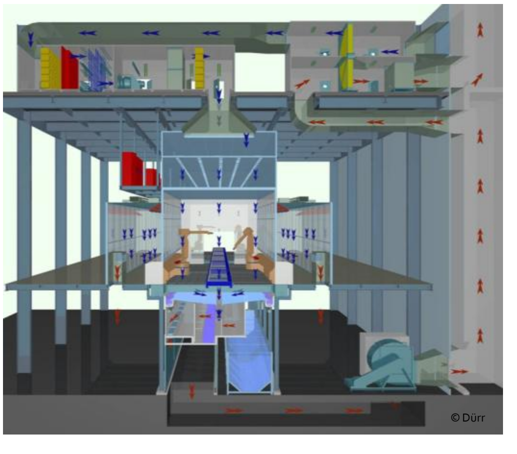
Supplementary information

PAINT SHOP FOR COATING OF PASSENGER CARS

Supplementary information



Typical line: 30 u/h, 85 000 m² floor, line lengh 1.5 km; processing time 6 – 11 h:

KEY ENVIRONMENTAL ISSUES

Supplementary information

Ressource consumption

Solvents / Paints
Energy
Water

Releases into air

VOC	volatile organic compounds
PM	particulate matter
NOx, CO	Nitrogen oxides, Carbon monoxide
CO2	Carbon dioxide

Releases into water

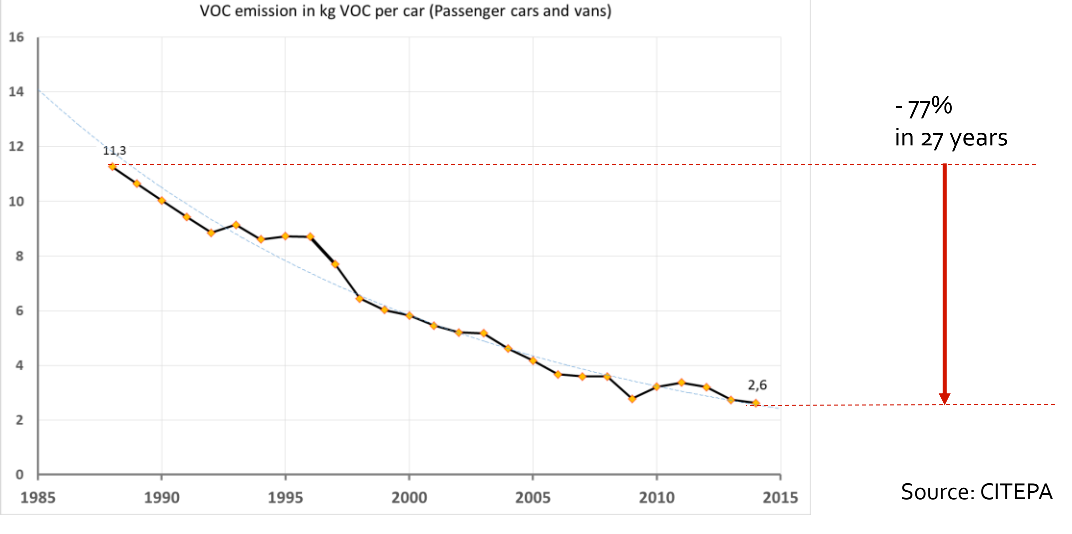
COD	Chemical oxigen demand
Metals	(Heavy) metals, Ni, Zn

Waste

Paint sludge / paint filter dust
Solvent
Phosphate sludge

EMISSION REDUCTION 1987 – 2014 - EXAMPLE FRANCE

Supplementary information



Source: CITEPA

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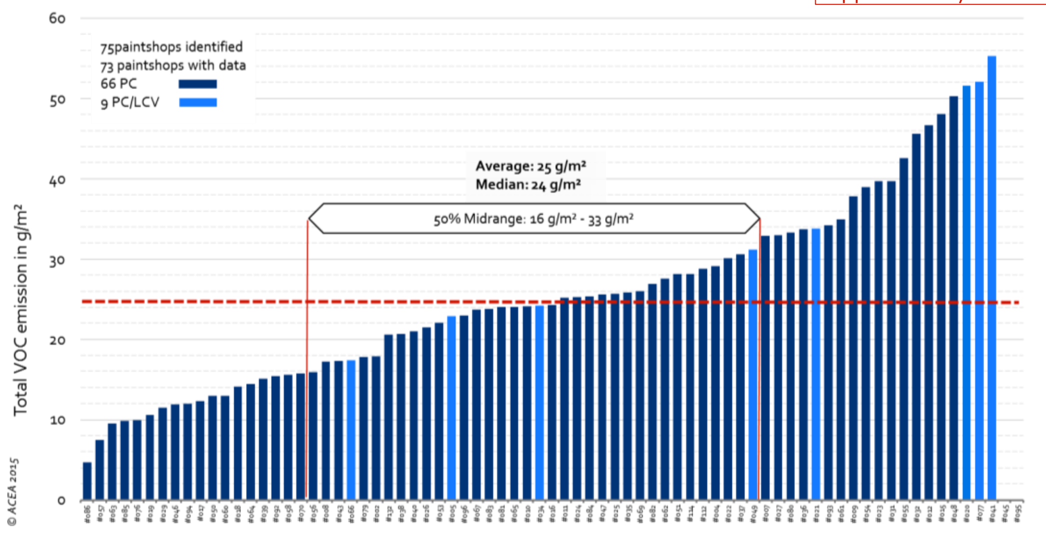
VOC EMISSIONS OF EU PASSENGER CAR PAINT SHOPS 2012

Supplementary information



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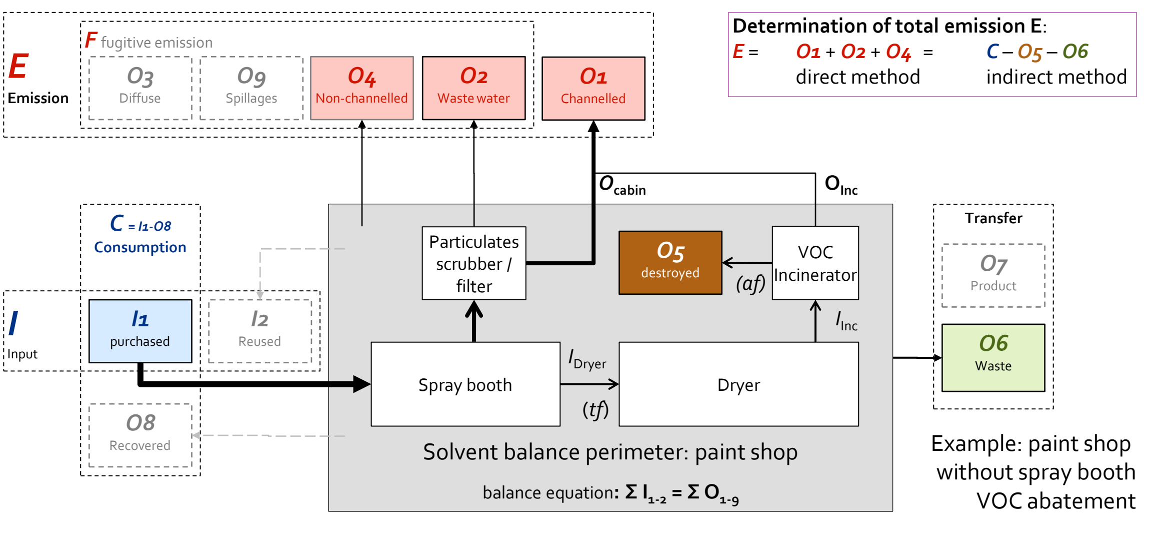
PAINT SHOP SOLVENT BALANCE (SOLVENT MANAGEMENT PLAN)

Supplementary information



Example: paint shop without spray booth VOC abatement

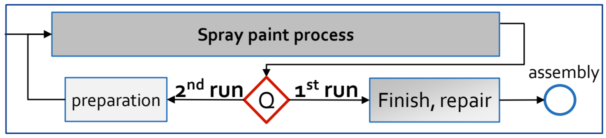
PROCESS OPTIMISATION, SHOP FLOOR MANAGEMENT

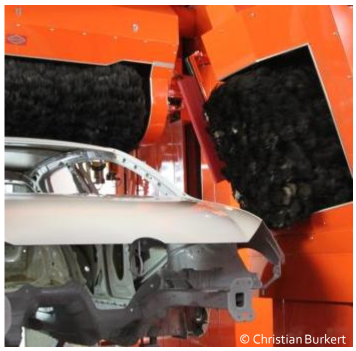
Supplementary information

Primary measures

High first run rate

- Dusting
  - **Airlocks at spray cabins with dusting equipment for bodies:**
    - ionised air blow-off stations
    - rotating feathers
    - robot-operated suction brushes
- Clean room conditions
  - **Particle filters in spray cabin AHU**
  - **Special work-clothes**
  - **Airlocks for operators and maintenance personnel**





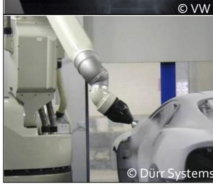
TRANSFER EFFICIENCY

Supplementary information

Primary measures

Manual application
Only with air-spray
Exterior until 2000
Hard to reach areas
Special cases

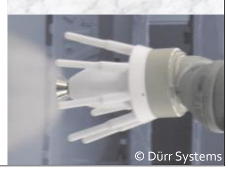
Paint machines
Air-spray or bells
Many spray-heads
Exterior: 1980 – 2000
Interior: not applicable



Robots
Mainly bell atomisation
Exterior: 2000 – 2005
Interior: 2010 - ongoing

Airspray (HVLP)
Automatic & manual
Exterior: until 2000
Interior: until 2012
Still applied in special cases
Transfer efficiency: 25 – 45 %

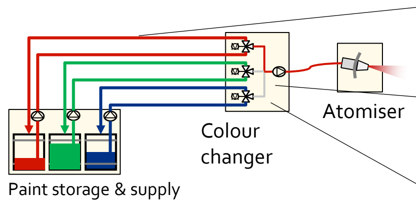
Rotary atomiser (Bell)
Only automatic
With internal or external electrostatic charging
Exterior since 2000
Interior: since 2012, ongoing
Transfer efficiency: 50 – 85 %



COLOUR CHANGE / PURGING

Supplementary information

Primary measures



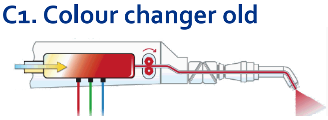
A. Pigging systems

B. Integration in robot arm

C. Low loss technology

D. Collection of purge solvents

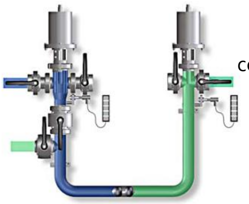
C1. Colour changer old



Paint reservoir must be purged at colour change

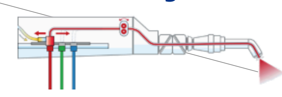
Loss: paint: 25 ml
solvent 250 ml

A: Pigging systems



Reclamation of color from piping systems at colour changes

C2. Colour changer new



Direct coupling of supply line to feed line with rotational or linear valve skid

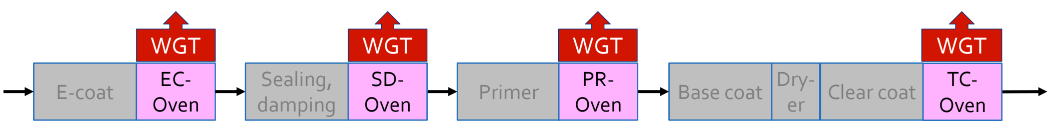
Loss: paint: <10 ml
solvent 150 ml

WASTE GAS TREATMENT - DRYER OVEN

Supplementary information

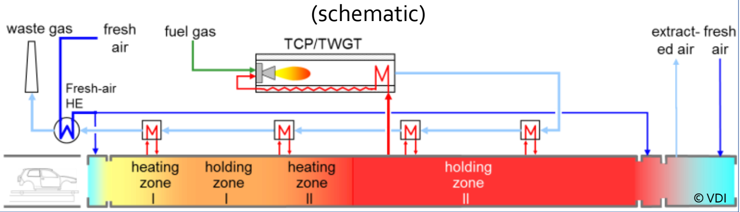
Secondary measures

Regenerative or recuperative thermal oxidation



- Raw gas volume from dryer oven: 8 000 – 20 000 Nm³/h
- Dedicated to each dryer oven or centralised waste gas treatment plant
- Reduction effect depends on raw gas mass flow
- Crossmedia effects: energy consumption, NOx, CO emission, ….
- Invest and running cost

Example: combined recuperative postcombustion with dryer heating (schematic)

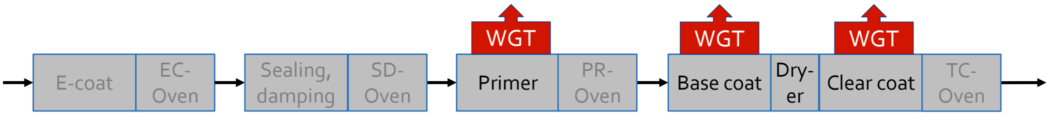


SPRAY BOOTH AIR WASTE GAS TREATMENT

Supplementary information

Secondary measures

VOC accumulation and incineration



- Raw gas mass flow:
  - **without cabin air recirculation: 80 000 - 300 000 m³/h (large adsorption wheels necessary)**
  - **with cabin air recirculation: 20 000 – 50 000 m³/h (not possible in combination with wet paint overspray scrubbers)**
- Reduction effect depends on raw gas mass flow
- Crossmedia effects: high energy consumption, Nox-, CO emission, ….
- Very high invest and running cost