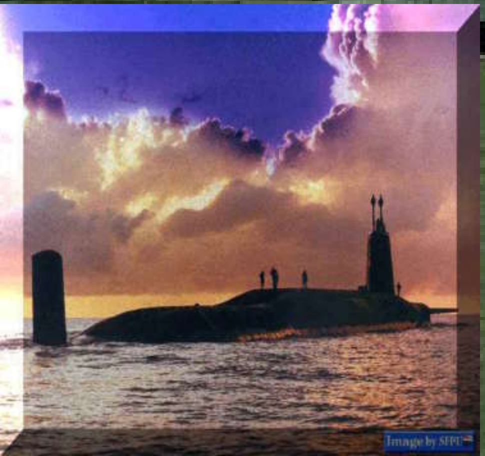
WARSHIP SUPPORT AGENCY
Defence Logistics Organisation
MPS IPT

MPS213

A Non-Thermal Plasma Application for the Royal Navy

MARINE PROPULSION SYSTEMS INTEGRATED PROJECT TEAM
M·P·S I·T



Lt Cdr Derek Hughes

- DIESEL DEVELOPMENT OFFICER -

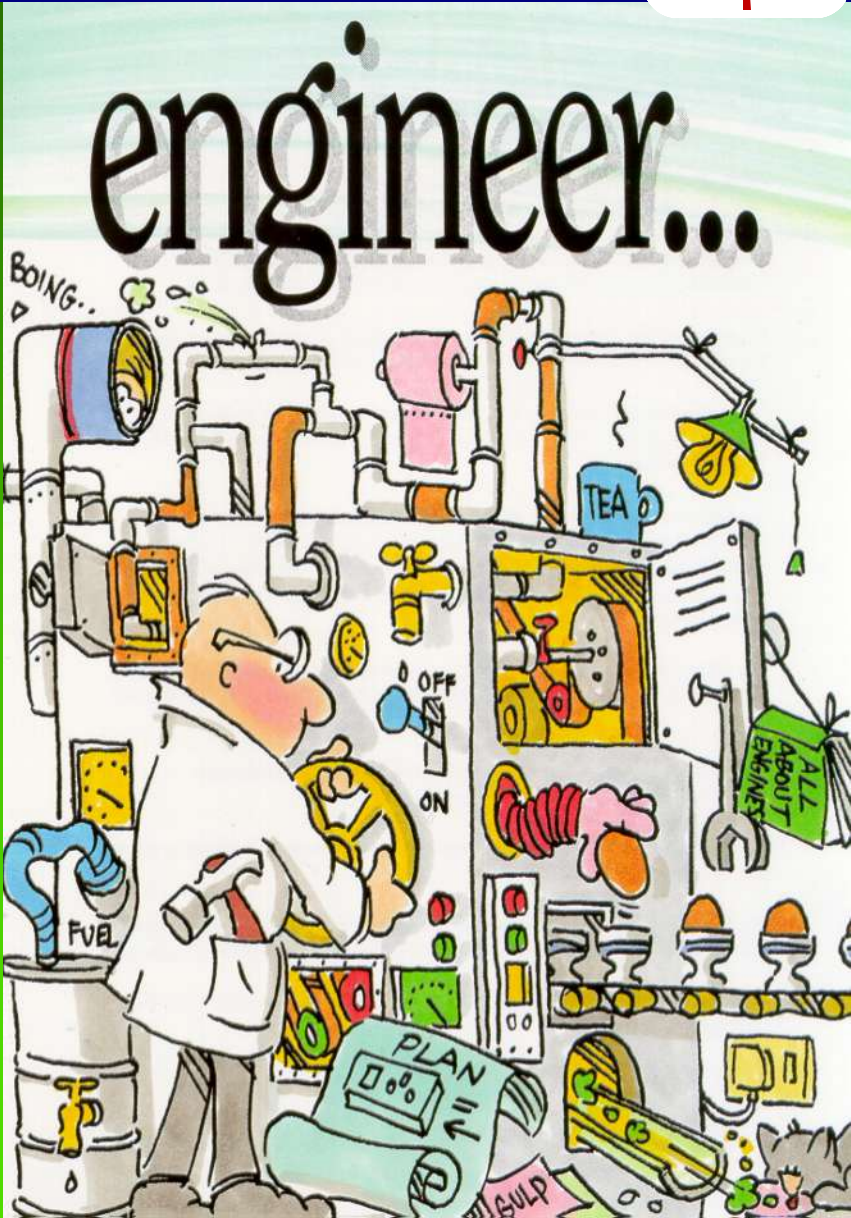
29 August 2002
DEER

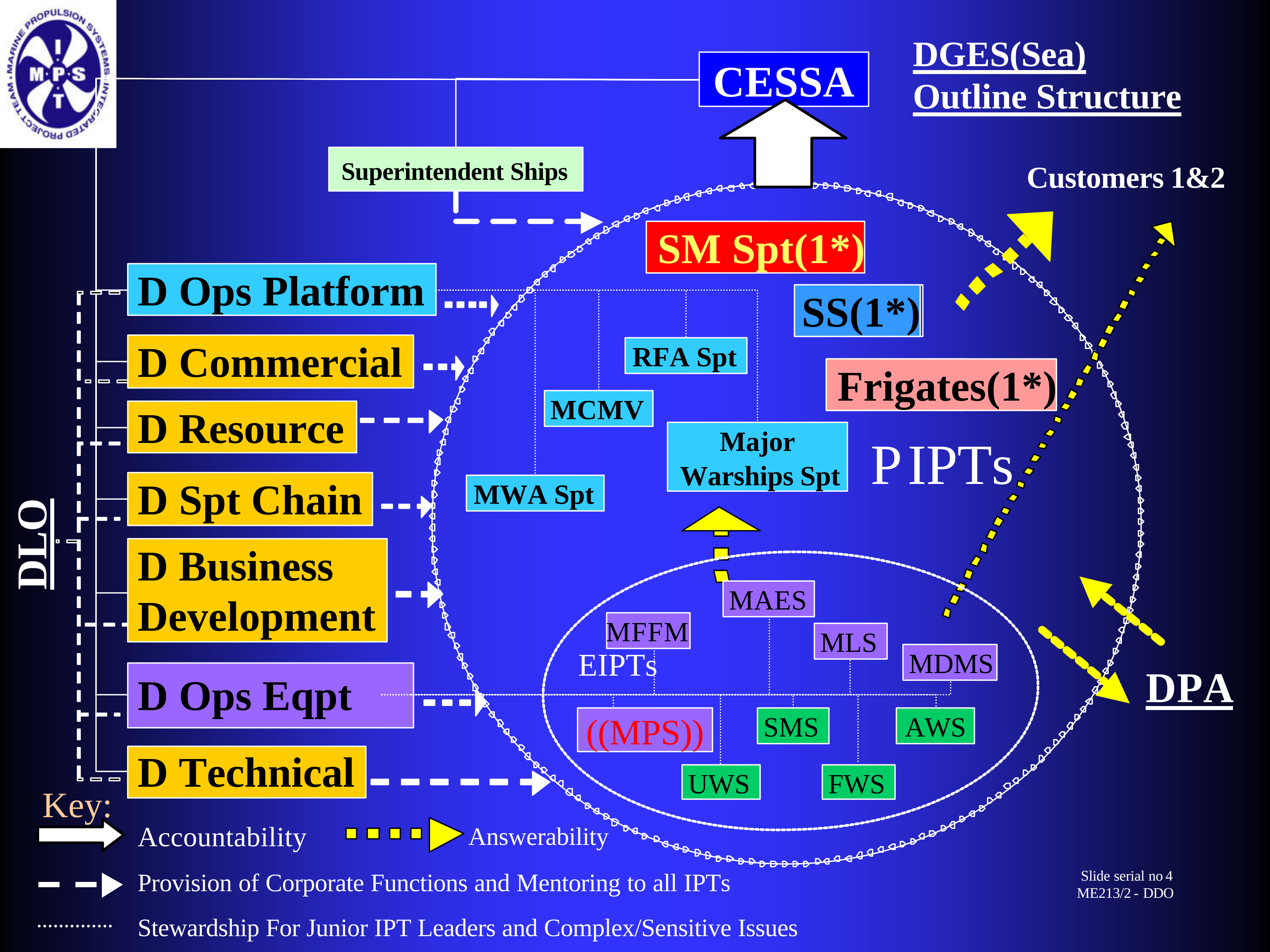
2000 and Beyond

- Introduction
  - MPS 213
- The Fleet
  - Existing Fleet
  - Future Fleet
- Trends
  - Marine Engineering Strategy
  - Diesel Emissions
- Summary

Lt Cdr Derek Hughes

- 1978 - 88 HMCS ONONDAGA
- 1988 - 92 RRMC/RMC BEng
- 1992 - 94 Naval trg
- 1994 - 96
  HMCS MONTREAL (Trg)
- 1996 - 97 CFNES (OT Div)
- 1997 - 98 MSEO
  HMCS ST. JOHN'S
- 1998 - 99 MSc UCL Marine Engineering
- 1999 - Wave 2 Upholder
- 2000 - MOD(N) Exchange




DGES(Sea)
Outline Structure
CESSA
Superintendent Ships
Customers 1&2
SM Spt(1*)
SS(1*)
Frigates(1*)
RFA Spt
MCMV
Major Warships Spt
MWA Spt
PIPTs
DLO
D Ops Platform
D Commercial
D Resource
D Spt Chain
D Business Development
D Ops Eqpt
D Technical
MAES
MFFM
MLS
MDMS
EIPTs
((MPS))
SMS
AWS
UWS
FWS
DPA
Key:
Accountability
Answerability
Provision of Corporate Functions and Mentoring to all IPTs
Stewardship For Junior IPT Leaders and Complex/Sensitive Issues
Slide serial no 4
ME213/2 - DDO

MPS - Organisation

Mr Mike Botley
Marine Propulsion Systems - Team Leader

Gearboxes
Cdr J Wood

Gas Turbines
Develop - Cdr English
In Service - Paul Denton

Diesels
Cdr Cummin

Shafting/Propellers
Cdr Wood

Fuels/Lubricants
Paul Maillardet

Cdr Mike Cummin
Head of Diesel Section

MPS MPS217b

MPS CB

MPS MPS213
Technical

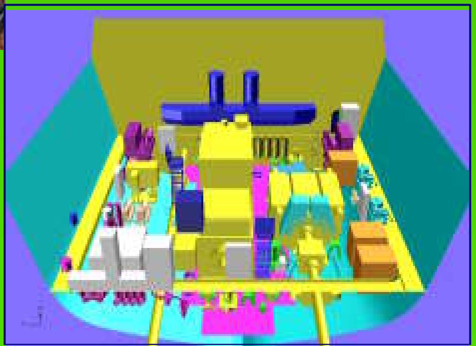
- **107 People (25 Navy / 82 Civilian)**

Diesel Future Strategies

Emissions

Engines

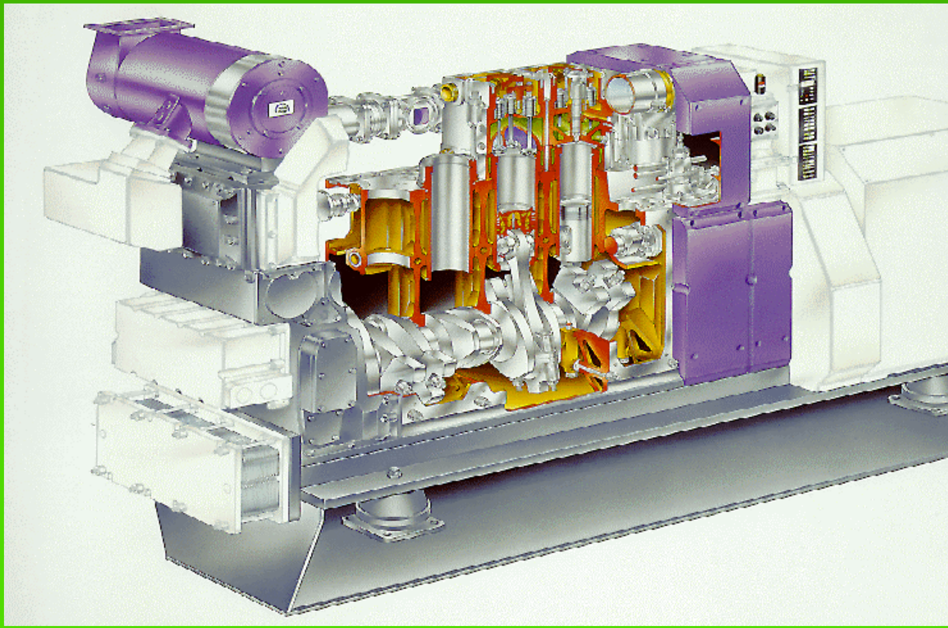
T45 Platform



- Emissions (MARPOL)
- Single Fuel (OBM)
- Commonality of Equip
- Condition Monitoring (Potmeter, Dr Diesel, etc)
- VMI, CLS, Pwr by Hour

Diesels at Work - UK!!

- 4 Vanguards
- 5 Swiftsure
- 7 Trafalgar
- 3 CVS
- 2 LPDs
- 1 LPH (HMS OCEAN)
- 12 Type 42
- 7 Type 22
- 16 Type 23 Duke Class
- 11 Hunt Class
- 12 Sandown Class (SRMH)
- 16 Archer
- 5 Island Class
- 2 Castle Class
- 2 OSV (Herald, Scott)
- 3 CSV (Beagle, Bulldog, Roebuck)



Diesel Proliferation

- ALLEN
- BERGEN(RR)
- CATERPILLAR(MaK)
- CROSSLEY
- CUMMINS
- DETROIT DIESELS
- DEUTZ MWM
- DORMAN
- ISOTTO FRASCHINI
- MaK
- LISTER PETTER
- MAN B&W
- MIRRLEES BLACKSTONE
- MTU
- ONAN
- PAXMAN DIESELS
- PERKINS
- RUSTON DIESELS
- SEMT PIELSTICK
- VOLVO PENTA
- WARTSILA NSD
- YANMAR

The Existing Fleet

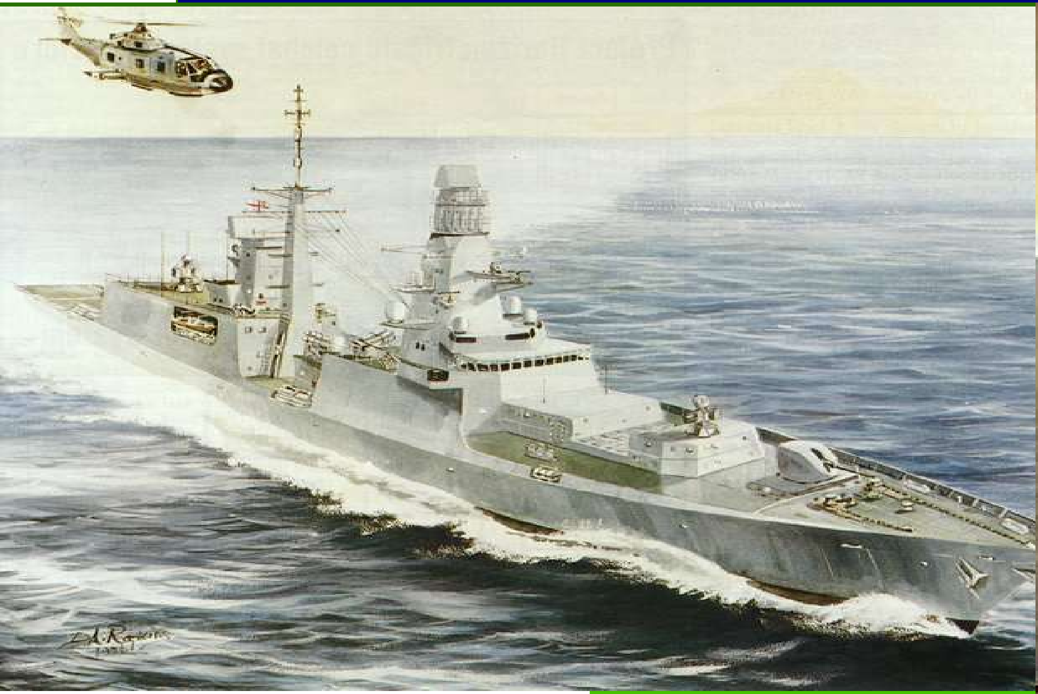
Reduce WLC

- RCM
- CM Tools
    - Trial COTS
    - Develop
- SM Challenge
    - low hours
    - low load
    - availability
    - manage risk

The Emerging Fleet

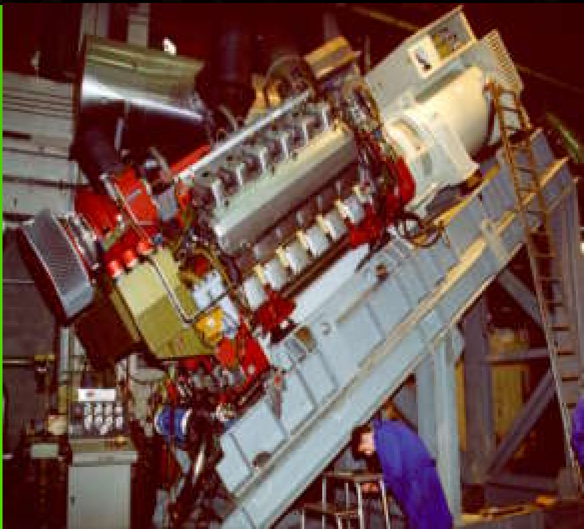
- LPH (OCEAN)
- OSV (SCOTT)
- 12 LCU MK10
- Trimaran
- 2+ A0
- 2 LPD(R)
- 3+ ASTUTE
- 12 T45 AAWD
- 4+ ALSL
- 2+ SV(O)
- 6 RO-RO

The Future Fleet - Type 45 Project



Main technical data

- **Bore** 200 mm
- **Stroke** 240 mm
- **Swept volume** 7,5 litr./cyl
- **Speed** 1200 - 1500 rpm
- **Weight** 13000 - 19000 kg



Potential Future Fleet (CVF, FSC) - Trimaran Frigate

The Electric Ship Programme

DSSC MARINE ENGINEERING

ME Development Strategy Paper

Advanced Cycle Gas Turbines

Integrated Full Electric Propulsion

Widespread Electrification

Diesel Beater?

Investment Appraisal

COTS?

Emissions

- Background
- Policy / Strategy
- Monitor
  - Legislation
  - Technology
- Evaluate
- Development
  - SCR
  - NTP

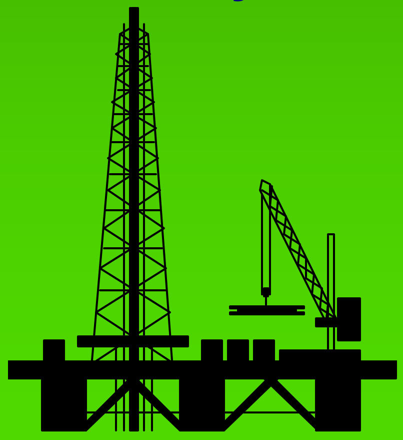
Background

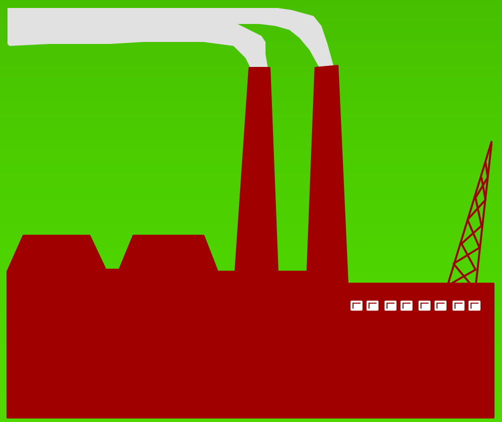
" We as a species, as a planet,

are teetering on the edge,

living unsustainably and perpetuating inequity,

and may soon pass the point of no return."





MOD - Policy/Strategy

- the MOD must comply with UK legislation
- the MOD must comply with international conventions to which the UK is a signatory
- the MOD cannot invoke Crown immunity unless operationally necessary
- regulations of host nations must be respected
- the MOD is to take a lead in addressing environmental issues and to enhance the natural environment
- the specific RN policy on engine emissions is derived from general MOD policy

Survey on Measures to Reduce the NO_x Emissions

MEASURES

Engine internal (Primary)

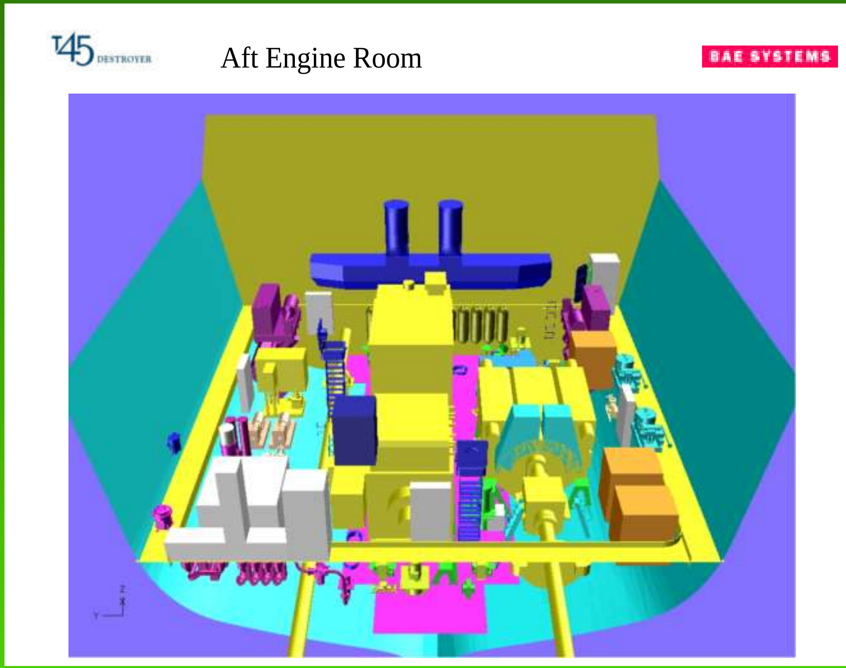
- Modifications of the combustion process
  - Retarded injection
  - Injection rate modelling
  - Miller supercharging
- Exhaust gas treatment in the combustion chamber
  - Fuel-water emulsion
  - Direct water injection
  - Humidification of intake air

Engine external (Secondary)

- Exhaust gas treatment outside the combustion chamber
  - Catalytic Subsequent Exhaust gas treatment SCR
  - Non-Thermal Plasma AEA Technology

Environmental Aim - UK MOD(N)

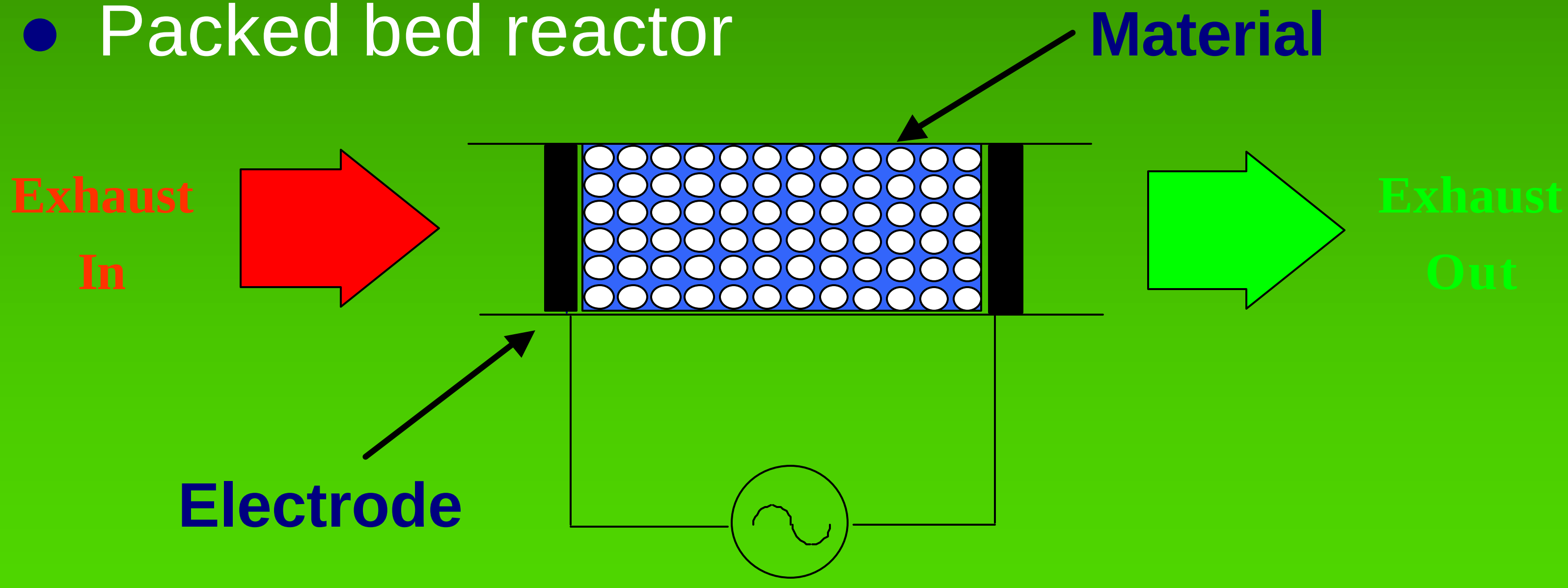
To maintain legislative compliance



- DEVELOPMENT
  - Aftertreatment as good as SCR
  - improved performance
    - low load
    - shock
    - nil reductant requirement
    - fullest range of engine sizes
    - all environments
    - (including submarines)
    - all MGO fuels

NTP - Principle of Operation

- Surface discharge
- Electrically augmented catalyst
- Alternating high voltage
- Packed bed reactor



1/10th scale system design

Combined NOx and particulate removal

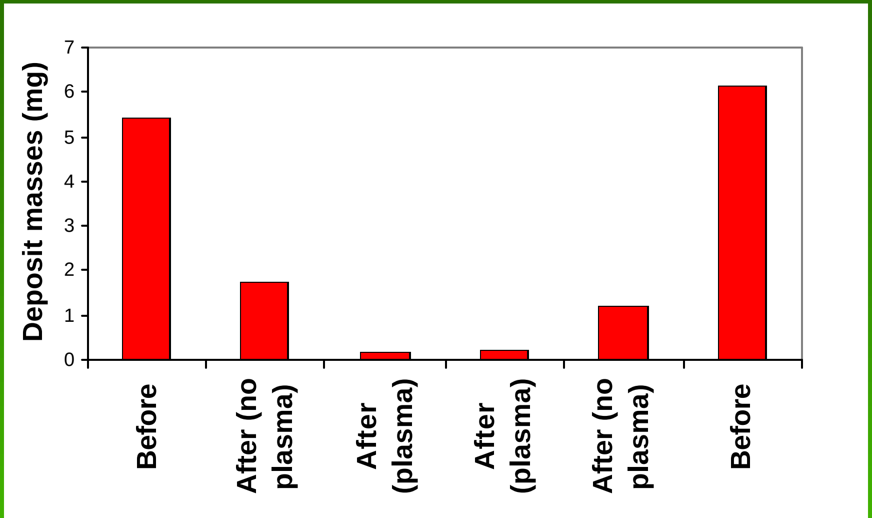
- Encapsulating full scale design features
- Ship Integration
  - Type 23 Frigate
  - HUNT, SRMH, LPH, ASTUTE, FASM, FSC, CV(F)
  - ILS / ARM
- Safety Case
  - DEFSTAN 00-56, JSP 430, JSP 375 & JSP 418
- To be tested on indicative engine
  - Paxman Valenta/ VP185

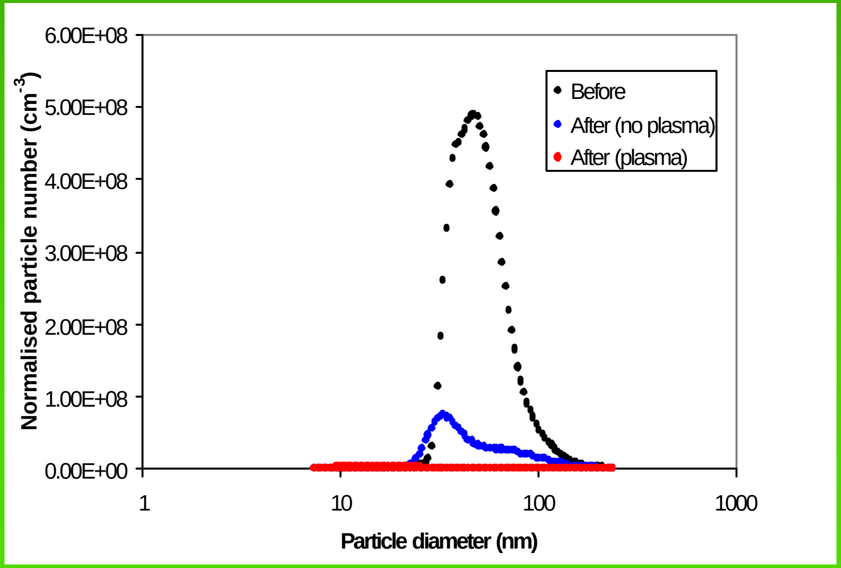
NTP Treatment of Particulates

Inlet

Outlet no plasma

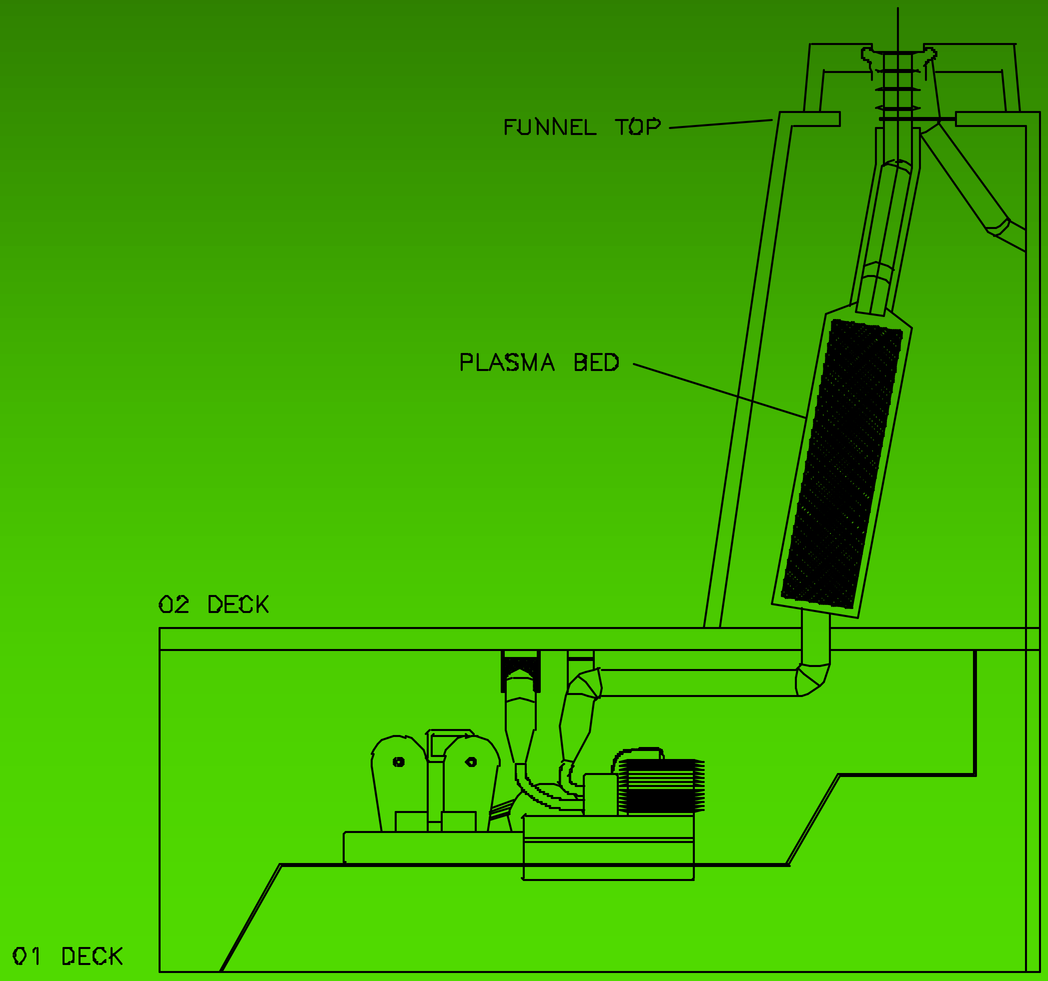
Outlet plasma





Full-Scale System Conceptual Design

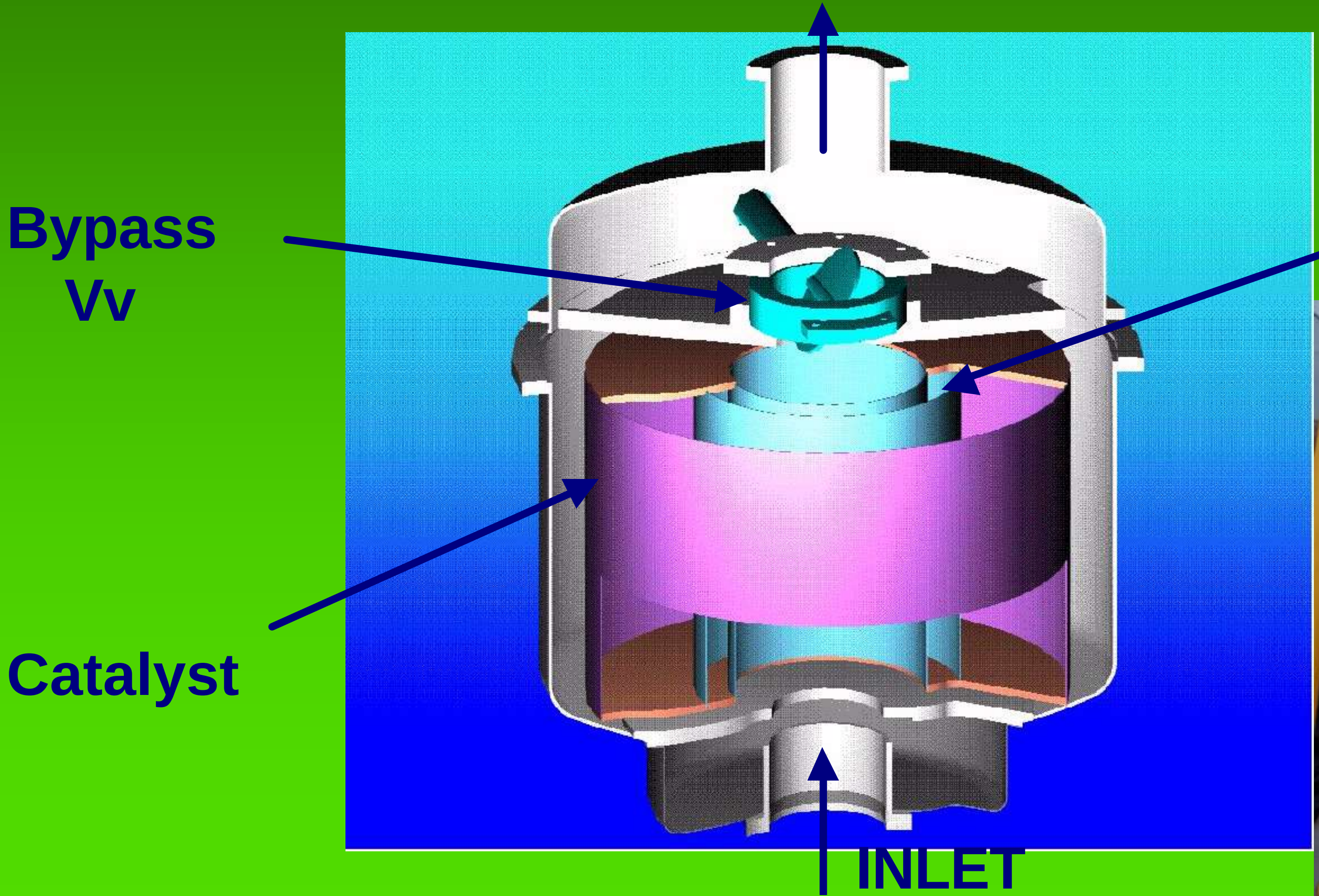
Replacement of silencer



Non Thermal Plasma Unit

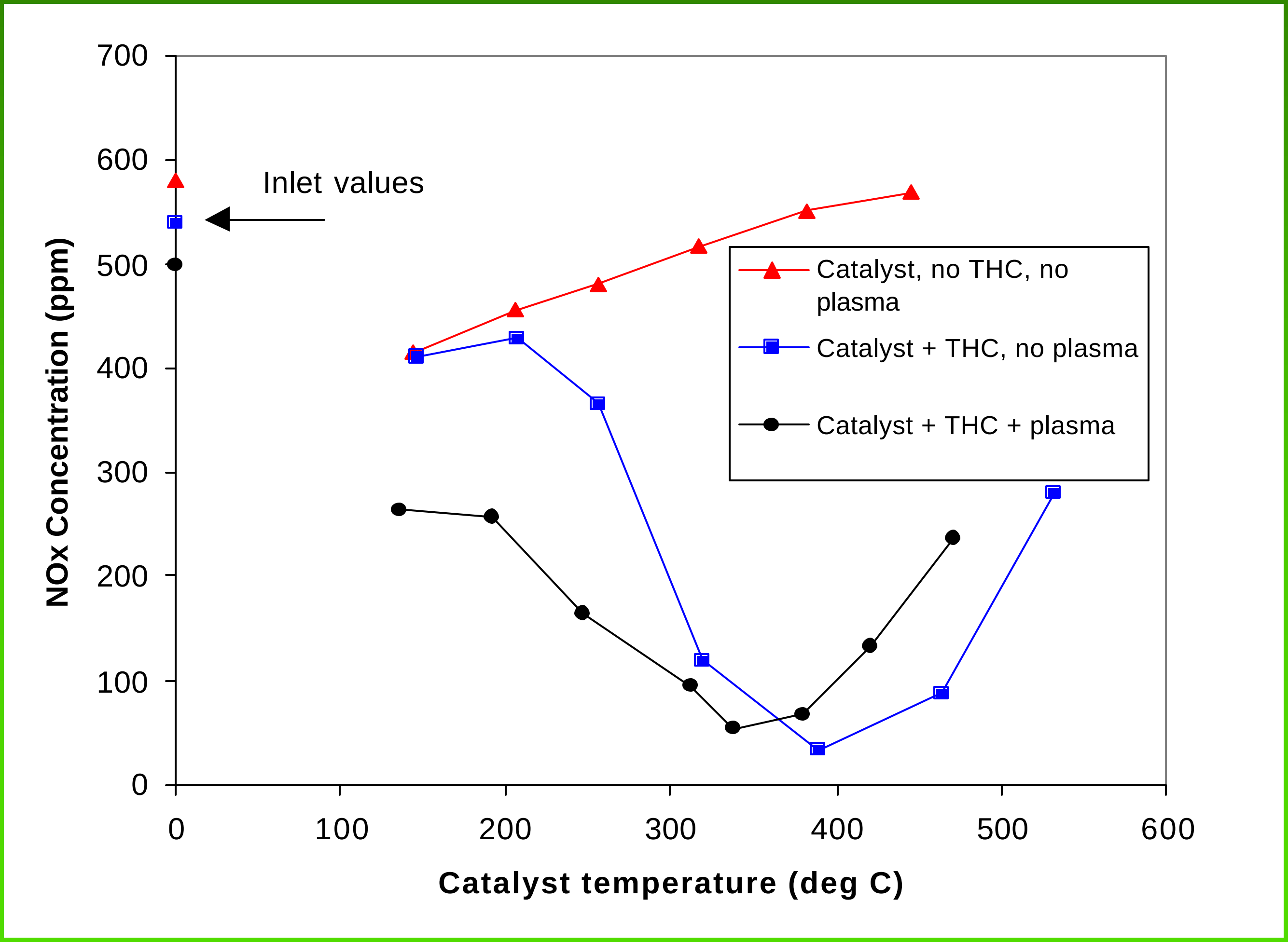
Small scale - 1/10th Size

- Procurement and Manufacture 1/10th Scale!!!!!



Laboratory performance

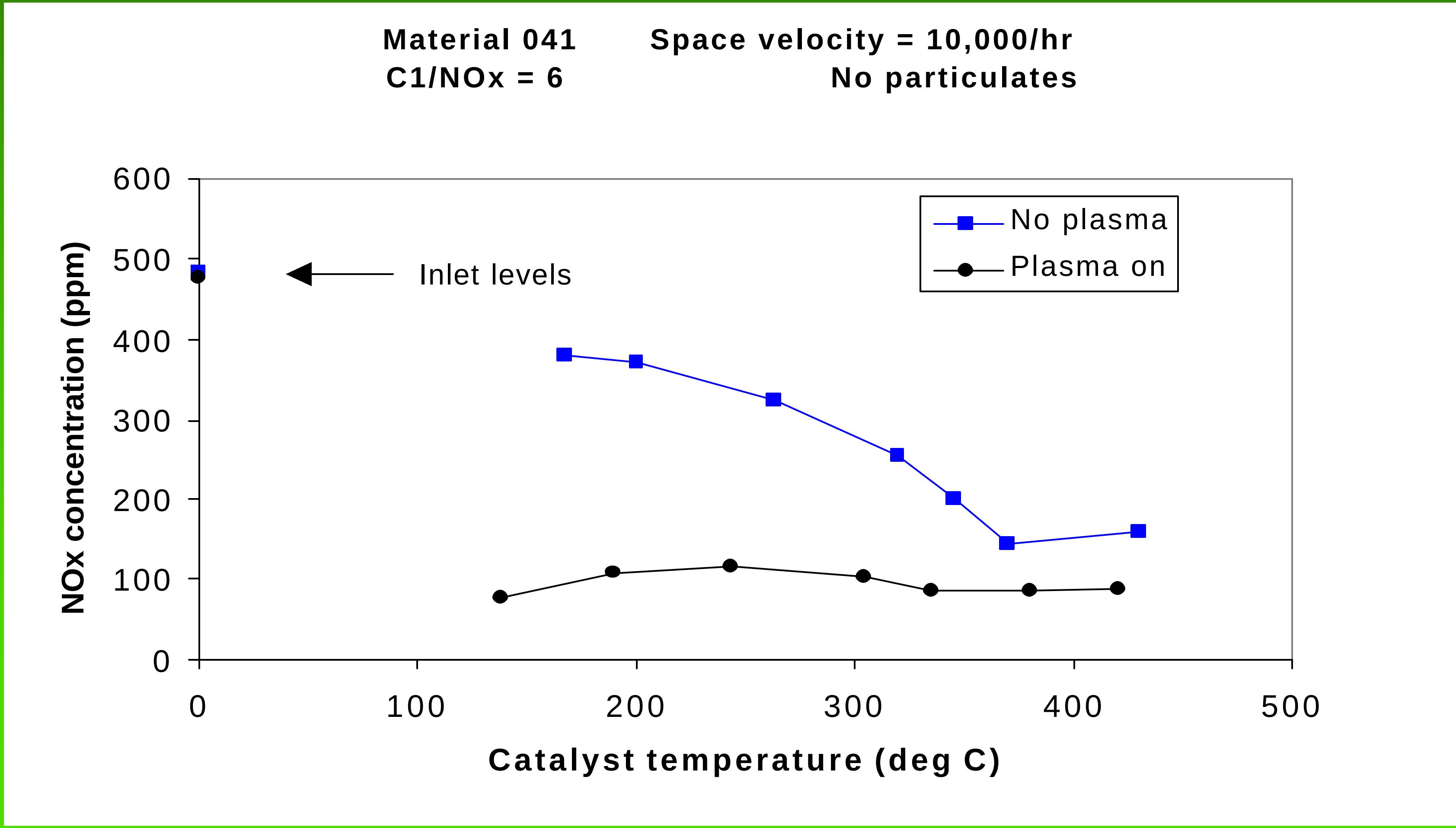
Synthetic exhaust



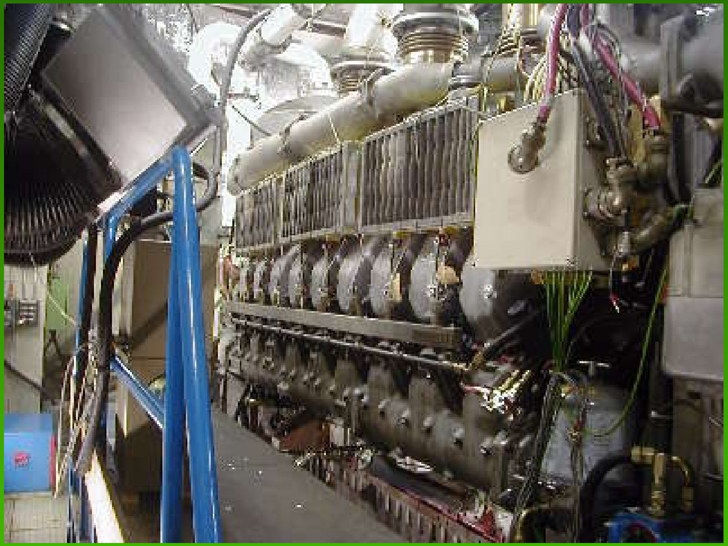
- 10% O_2
- Space velocity 10000/hr
- 60 J/L
- C1:NOx ~ 6 (propene)

Laboratory Performance

Genset Exhaust



Test cell at MAN B&W (Paxman's)



Test modes

D2 cycle - constant speed auxiliary engine (marine rating)

Test cycle type D2	Speed	100%	100%	100%	100%	100%
		1800 rpm	1800 rpm	1800 rpm	1800 rpm	1800 rpm
	Power	100%	75%	50%	25%	10%
		3250 kW	2438 kW	1625 kW	813 kW	325 kW
	Weighting factor	0.05	0.25	0.3	0.3	0.1

Sprint mode - hotter exhaust temperature

Speed - 1950 rpm

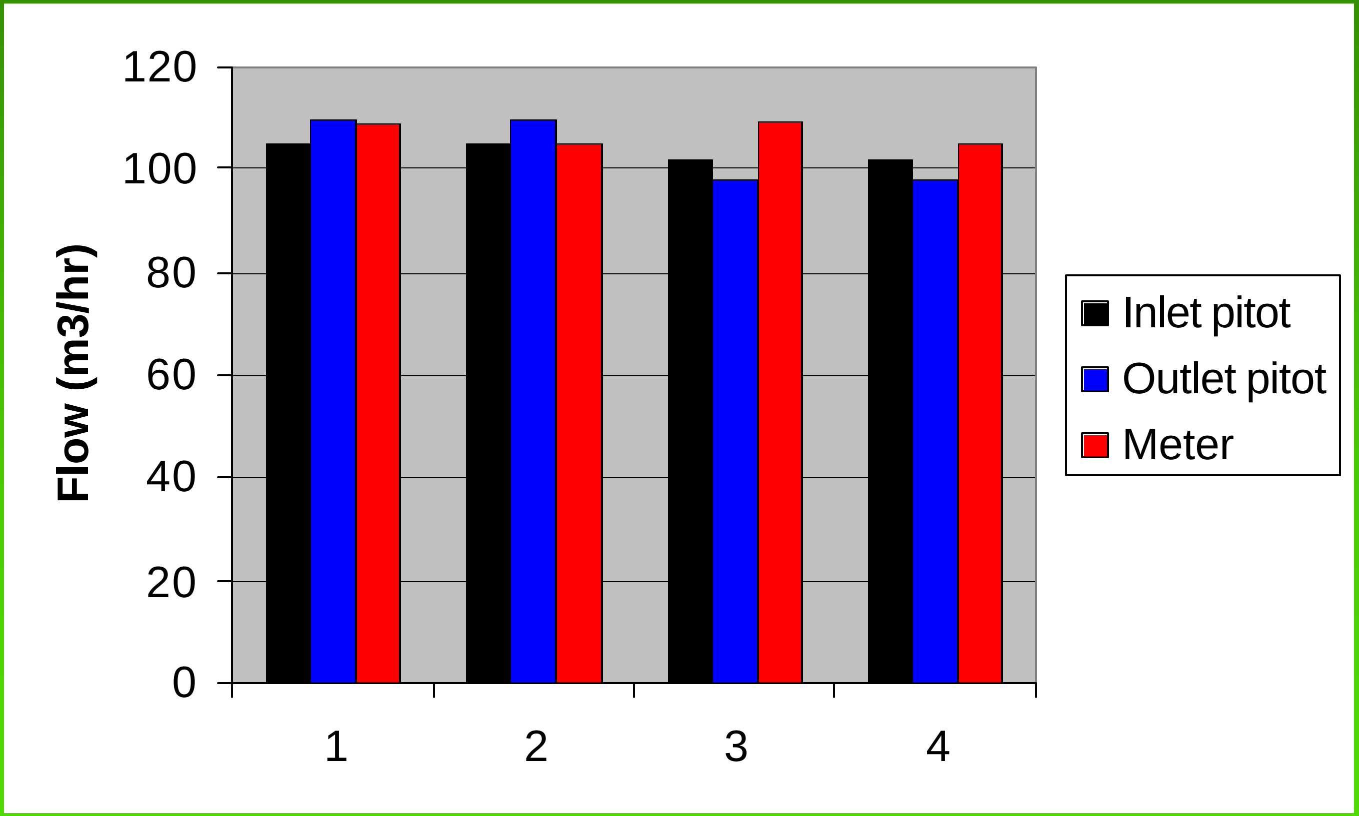
Power - 4000 kW

Emissions Measurements

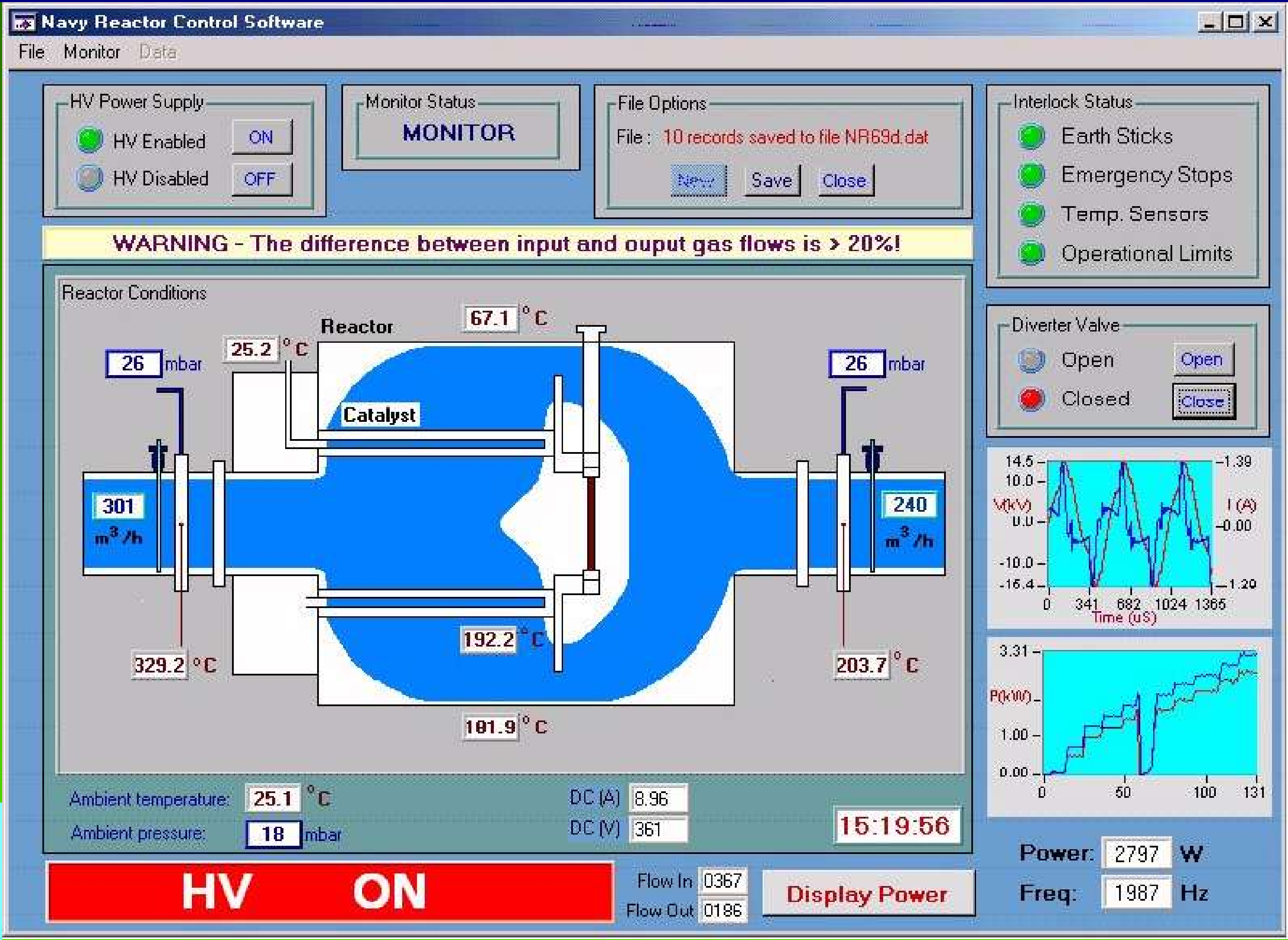
- Emissions bench
  - AVL CEB2 bench
    - NOx, NO, THCs, CO, O_2, CO_2
- Smoke measurement
  - Bosch Smoke Number
- Pre and post sampling

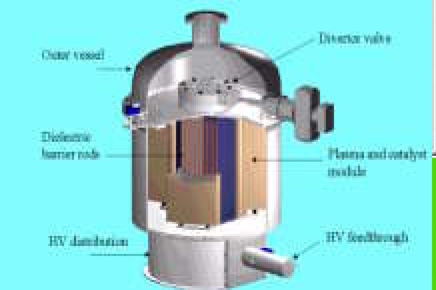
Flow Measurement Validation

Comparison with meter connected to pipework using a fan to push air through system.



Control System





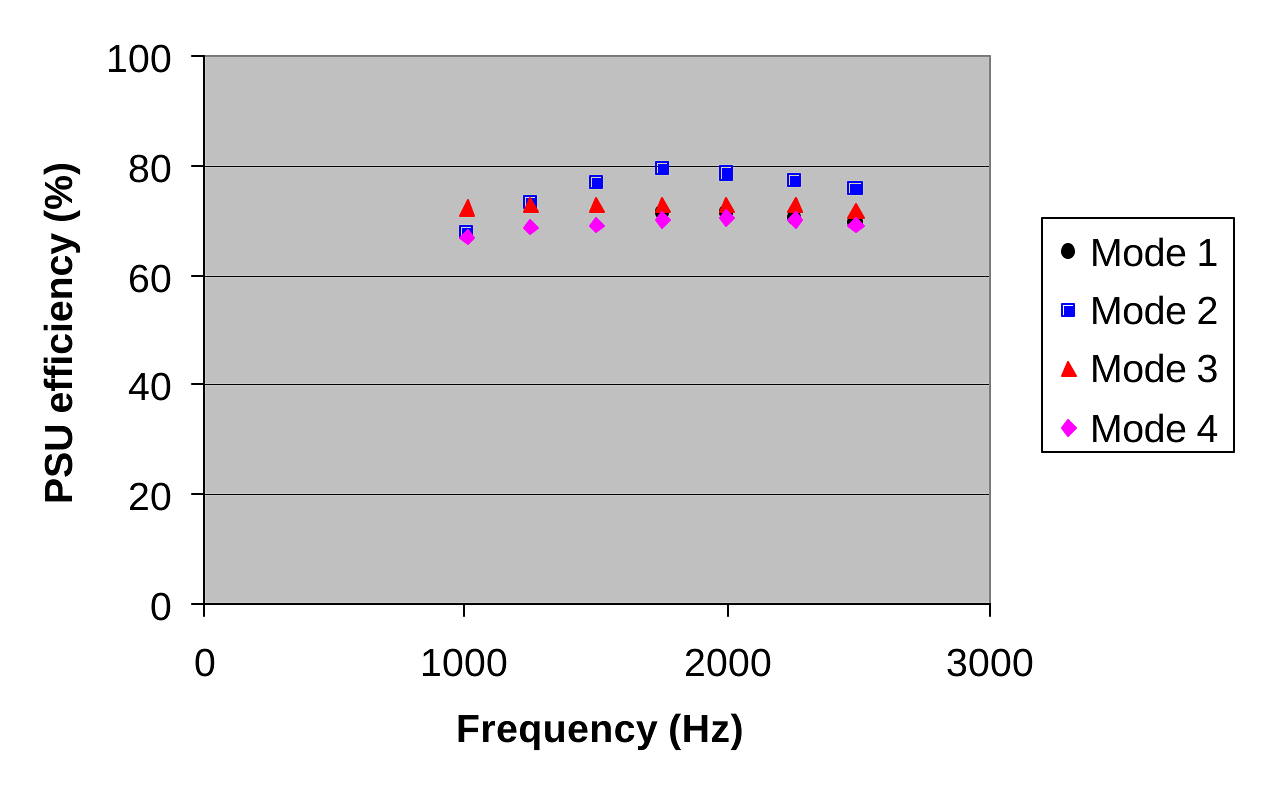
Fuel comparison

- Genset fuel had much lower sulphur level compared to trials fuel

	Genset fuel	Paxman 18VP185 Fuel
Type	RF-73-A-83	A2
Date of Analysis	21/08/01	22/02/02
Hydrogen content (%m/m)	13.61	12.7
Carbon content (%m/m)	86.39	86.2
Sulphur content (%m/m)	0.043	0.11

PSU Efficiency and Engine Load

- Efficiency dependence on frequency and load
  - single frequency, simpler design
  - choice of frequency determined by weight/size



Summary of MAN B&W Trials

- 80-90% NOx removal observed in lab trials
- Engine test cell trials showed 30% NOx, 40% NO removal
  - systematic checks carried out into measurement technique, operational parameters
  - main difference is fuel/ exhaust composition (sulphur)
- New and used catalyst being analysed
- Retest catalyst sample from trials
- Engine noise reduced by plasma system
- Electrical load is independent of frequency and engine mode

Non-Thermal Plasma Programme

Paxman Trials

1996 - 1999
Laboratory scale evaluation

1999 - 2002
1/10th scale demonstrator

Full scale system build

STAGE 1 → **STAGE 2** → **STAGE 3** →

Electrocat / plasma development

Summary: - MPS2132 -

- The Fleet
- UK MOD Trends
- Emissions
  - SCR/NTP for MOD

DIESEL DEVELOPMENT OFFICER

A Non-Thermal Plasma Application for the Royal Navy

Lt Cdr Derek Hughes

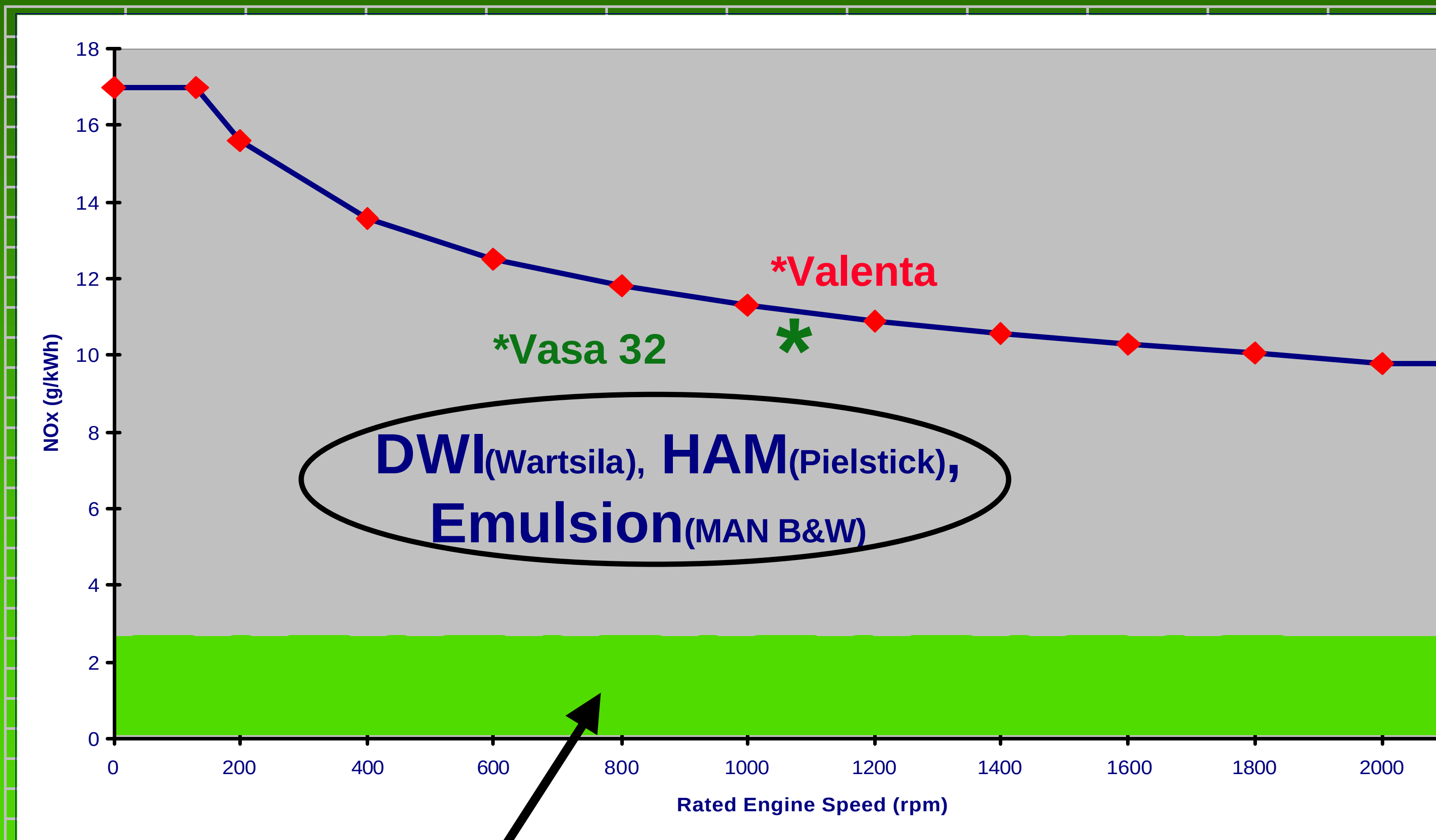
(WSA - MPS2132)

?? QUESTIONS ??

Flow measurement

- Need flow to calculate -
  - specific energy
  - space velocity
- Total flow can be calculated by methods described in IMO NOx technical code (ISO 8178-1)
- Use of a slipstream necessitates measurement

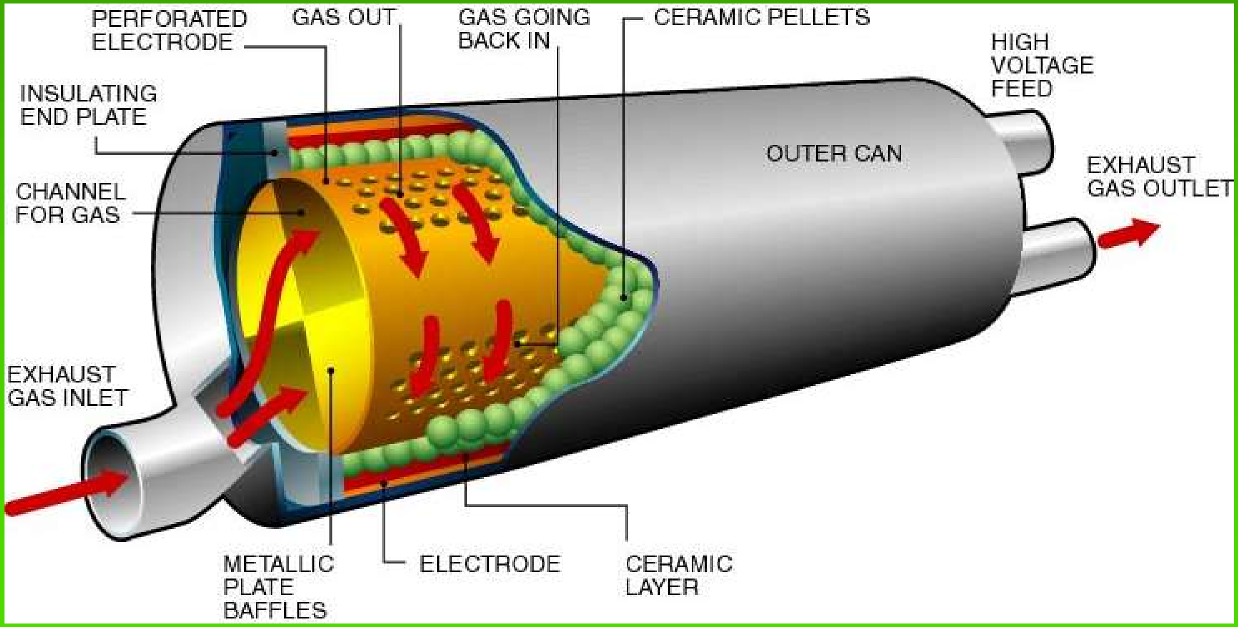
IMO NOx Emission Standards



SCR Reduction

Use of AEA Technology diesel particulate filter Technology

- AEA Technology Diesel particulate filter to be used for 1/10th scale system
  - separate particulate oxidation and NOx reduction
  - advantages for power supply technology



Environmental Aim

To maintain legislative compliance:

- SCR - Demonstrator at PDL (1995), Environmental Awareness Training Facility - HMS Sultan(UCL RN MSc Project)