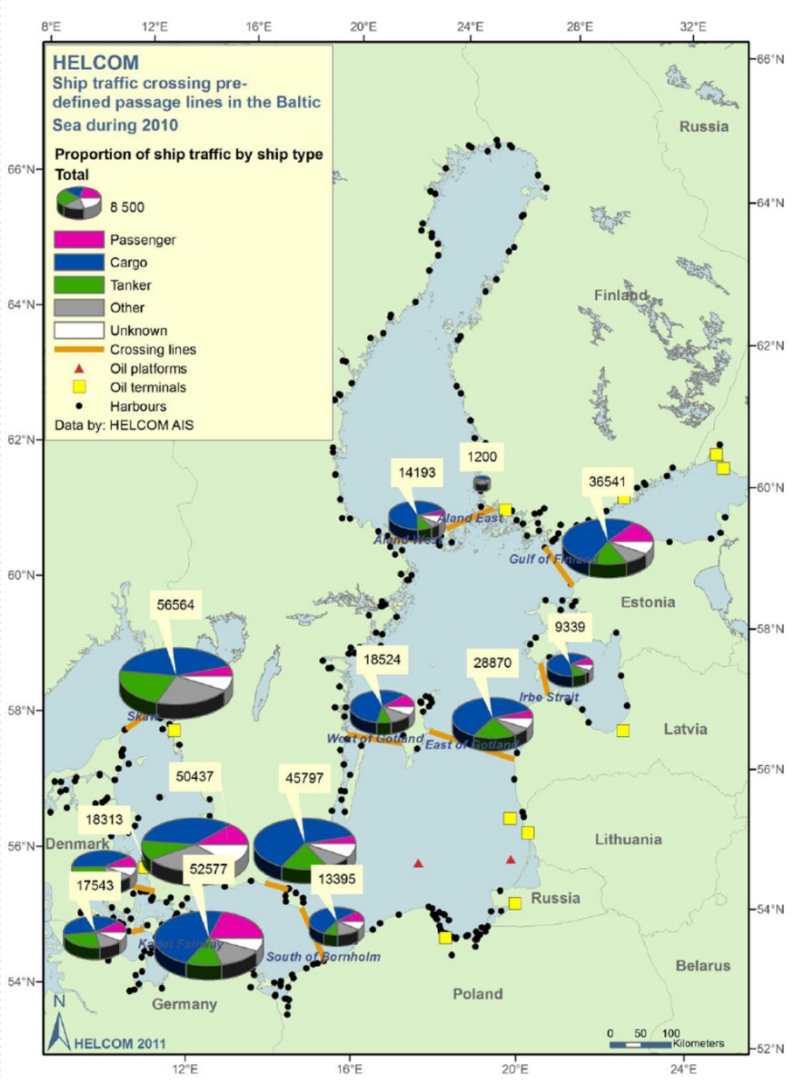
IMO Tier-III NECA. Unjustified costs, Technological and Operational risks

Engine Research & Development Center,
Saint-Petersburg, Russia,
Tel: +7(812)719-7330
e-mail: cnidi_ecoservice@rdiesel.ru
www.rdiesel.ru
L. Novikov

Arguments of Correspondence Group HELCOM for implementation on the Baltic Sea NECA from 01.01.2016



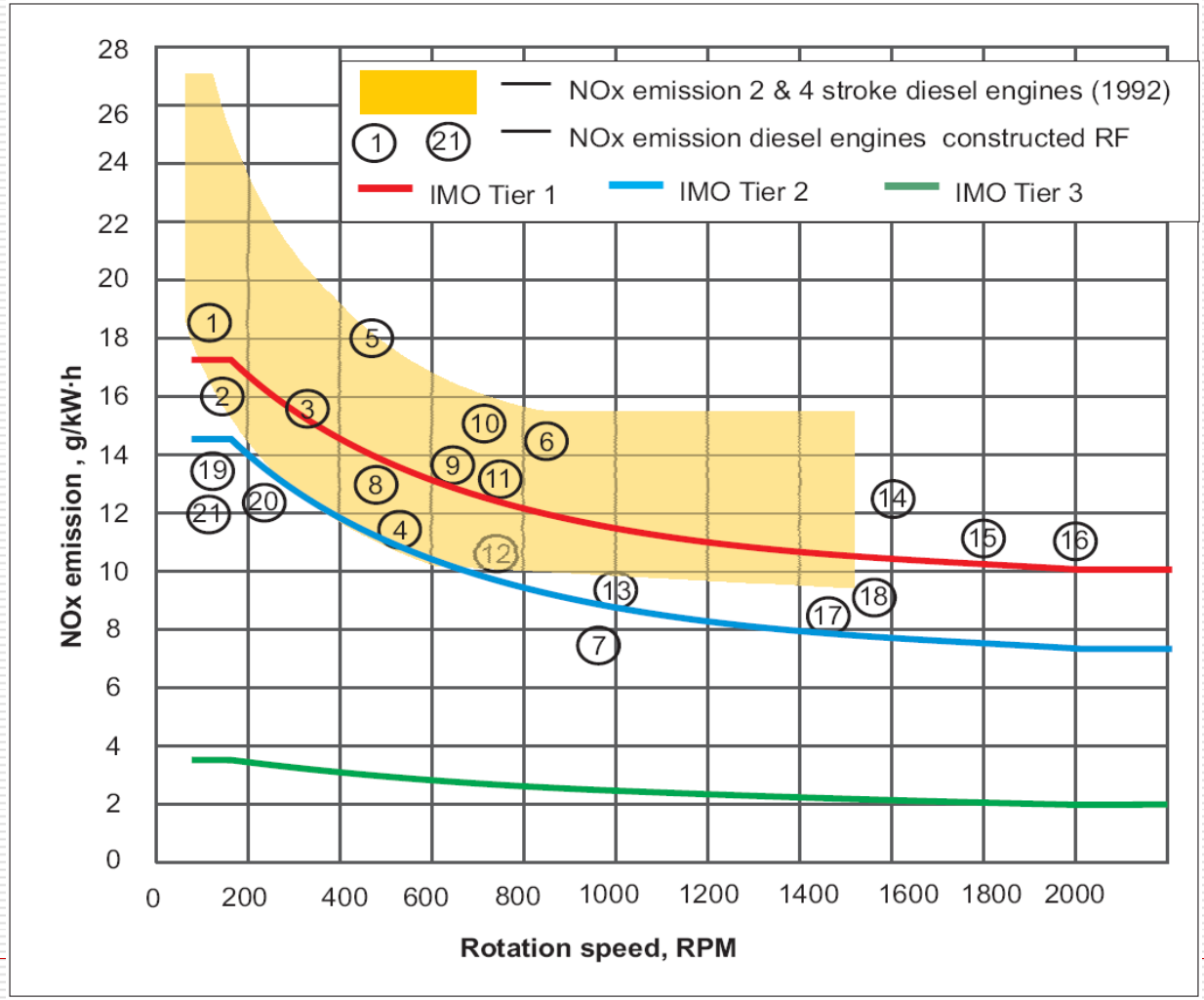
- Shipping on Baltic sea affect to:
  — air pollution
  (NO_x — more than 10 %)
  —water pollution
  (NO_2 — more than 20-30 %).
- SCR-NH_3 Technology — uncontested means for decrease of NOx emission to requirement of IMO TIER-3.
- Implementation of IMO TIER-3 for marine diesel engines will reduce of NO_x emissions from the ships traffic to 60 % by year 2040.

Dynamics of change for NOx emissions limits from marine diesel engines (Regulation 13 Annex VI to МАРПОЛ 73/78)

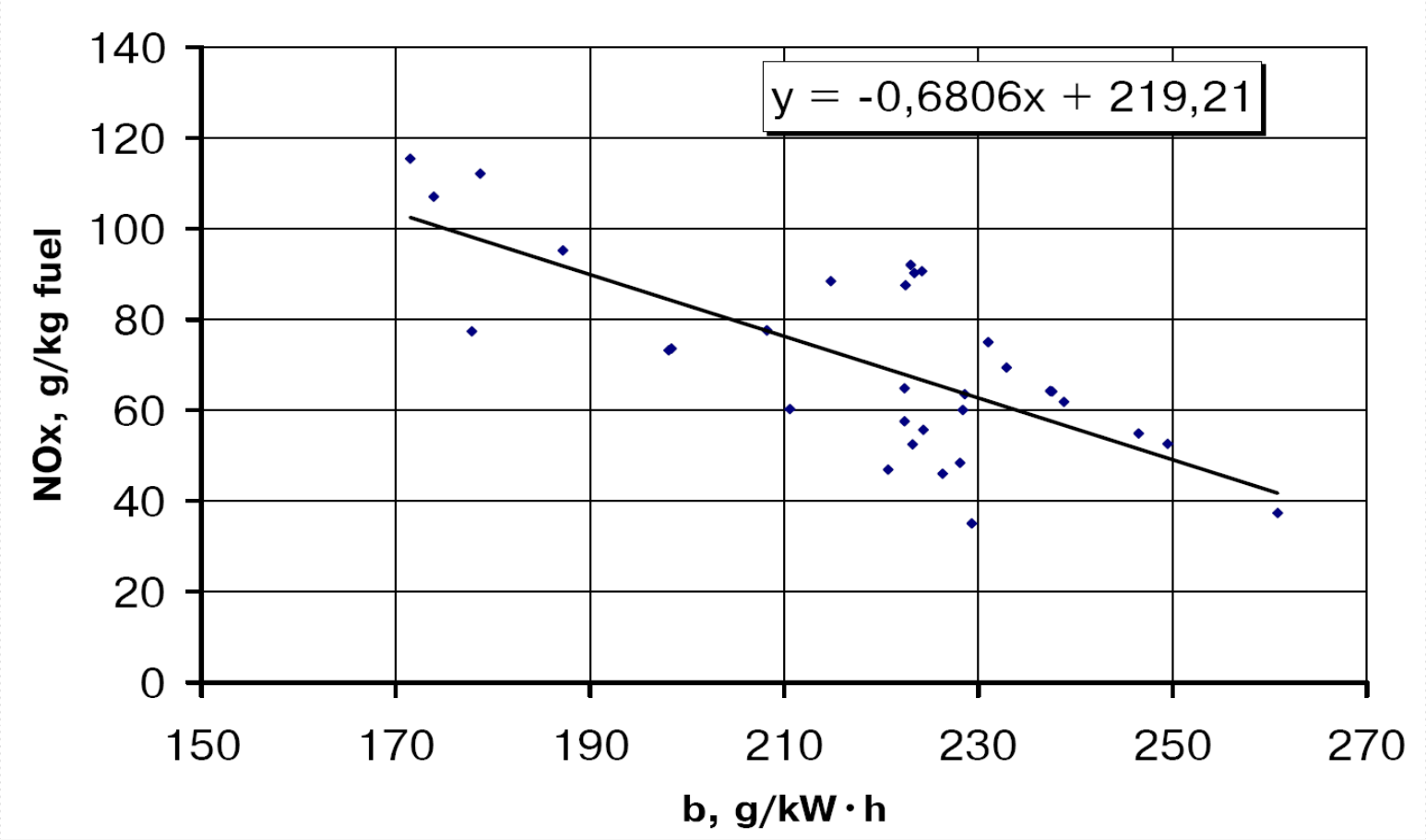
The action period	e_{NOx}, g/kW·h at speed rotation (n), RPM			Test procedure
	≤ 130	130–2000	≥ 2000	
01.01.2000–01.01.2011 (Tier 1)	17,0	$45 \cdot n^{-0,2}$	9,8	E2, E3 & D2 cycles (ISO 8178/4)
01.01.2011–01.01.2016 (Tier 2)	14,4	$44 \cdot n^{-0,23}$	7,7	
After 01.01.2016* (Tier 3)	3,4	$9 \cdot n^{-0,2}$	2,0	

* In NECA

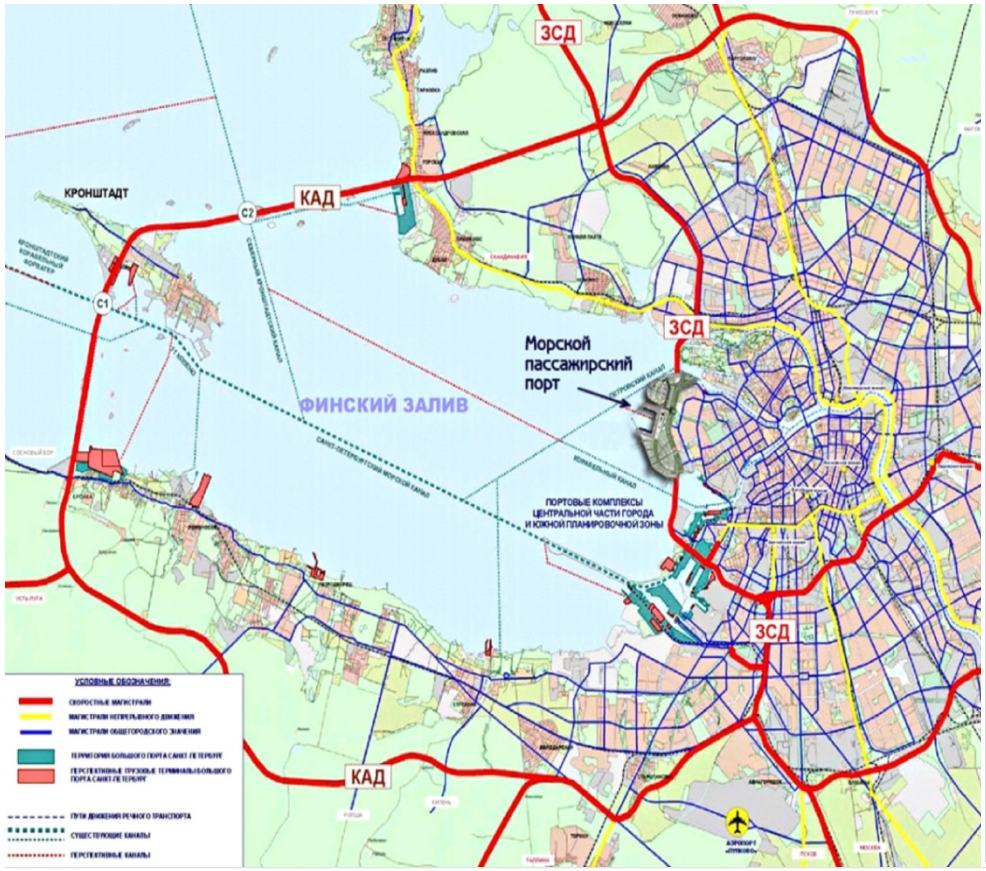
NOx Emissions of marine diesel engines constructed in the Russian Federation



The generalized data for calculation of NOx emissions from the ships traffic operation in the Gulf of Finland

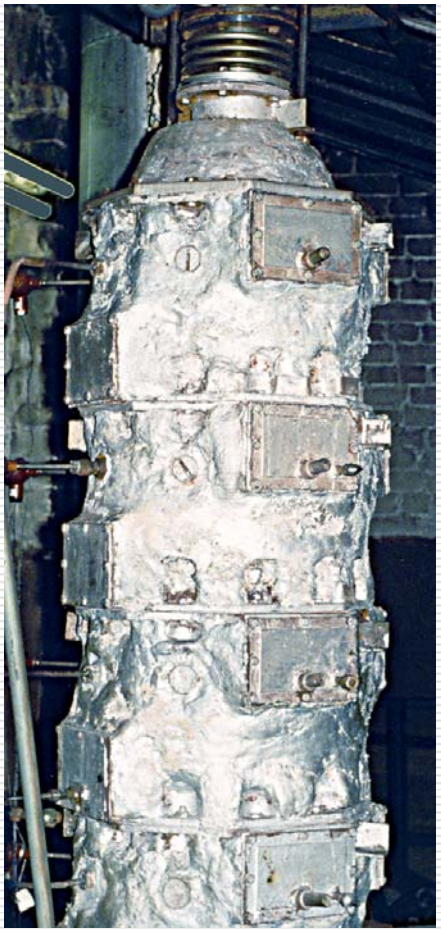


The ships traffic contribution to atmosphere pollution over water area of the Gulf of Finland (2010)

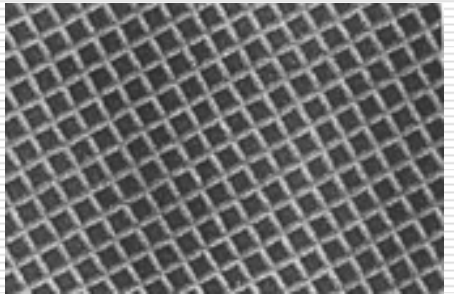


Pollution source	Emissions, thousand tons	Including		NOx %
		SO_2, thousand tons	NOx thousand tons	
Stationary sources	50,4	6,4	19,6	13,7
Automotive transport	573,9	5,7	113,5	78,9
Fleet	**11,3**	**1,5**	**8,0**	**5,5**
Railway transport	3,3	0,4	2,8	1,9
TOTAL	**638,9**	**14,0**	**143,9**	**100**

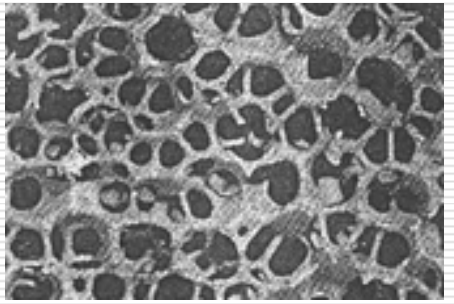
Experimental SCR (NH_3) reactor with various type of catalysts (1992)



TiO_2/V_2O_5

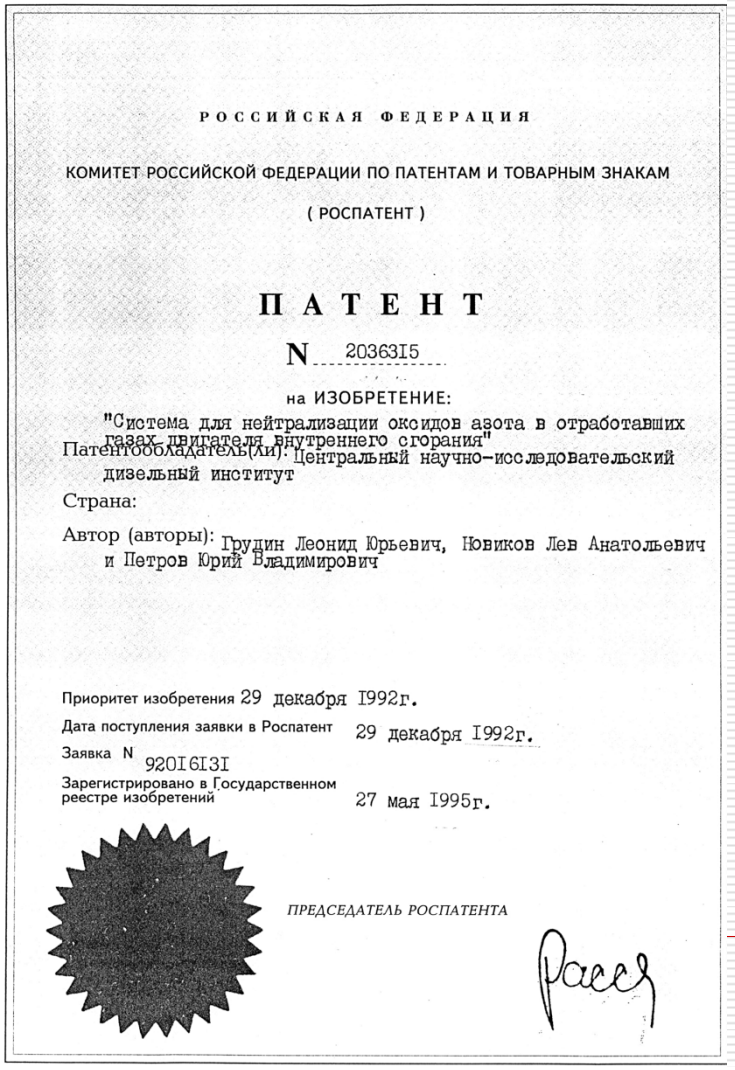


$Ni + Al_2O_3/Pt$



$Fe + \gamma\text{-}Al_2O_3/Cu$ ZSM

Patents of the Russian Federation on SCR (NH_3) technology and catalyst structure (TiO_2/V_2O_5)



РОССИЙСКАЯ ФЕДЕРАЦИЯ

КОМИТЕТ РОССИЙСКОЙ ФЕДЕРАЦИИ ПО ПАТЕНТАМ И ТОВАРНЫМ ЗНАКАМ

(РОСПАТЕНТ)

П А Т Е Н Т

N 2036315

на ИЗОБРЕТЕНИЕ:

"Система для нейтрализации оксидов азота в отработавших газах двигателя внутреннего сгорания"

Патентообладатель(ли): Центральный научно-исследовательский дизельный институт

Страна:

Автор (авторы): Грудин Леонид Юрьевич, Новиков Лев Анатольевич и Петров Юрий Владимирович

Приоритет изобретения 29 декабря 1992г.

Дата поступления заявки в Роспатент 29 декабря 1992г.

Заявка N 9201613I

Зарегистрировано в Государственном реестре изобретений 27 мая 1995г.

ПРЕДСЕДАТЕЛЬ РОСПАТЕНТА

РОССИЙСКАЯ ФЕДЕРАЦИЯ

КОМИТЕТ РОССИЙСКОЙ ФЕДЕРАЦИИ ПО ПАТЕНТАМ
И ТОВАРНЫМ ЗНАКАМ
(РОСПАТЕНТ)

П А Т Е Н Т

№ 2061543

на ИЗОБРЕТЕНИЕ

"Сотовый блочный катализатор восстановления оксидов азота аммиаком"

Патентообладатель (ли): Храмов Борис Леонидович, Юрченко Эдуард Николаевич и Новиков Лев Анатольевич

Автор (авторы): они же

Приоритет изобретения 1 августа 1994г.

Дата поступления заявки в Роспатент 1 августа 1994г.

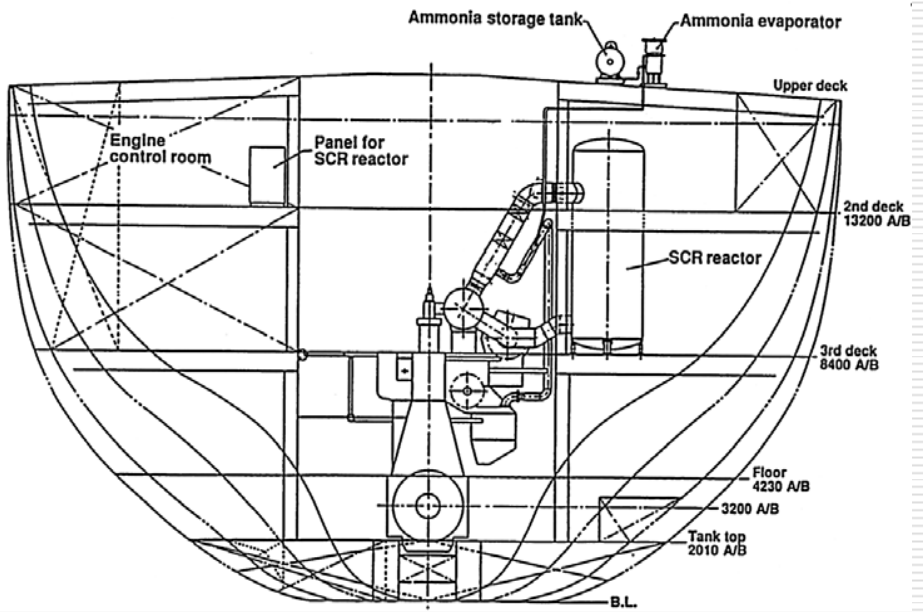
Заявка № 94029271

Зарегистрирован в Государственном реестре изобретений 10 июня 1996г.

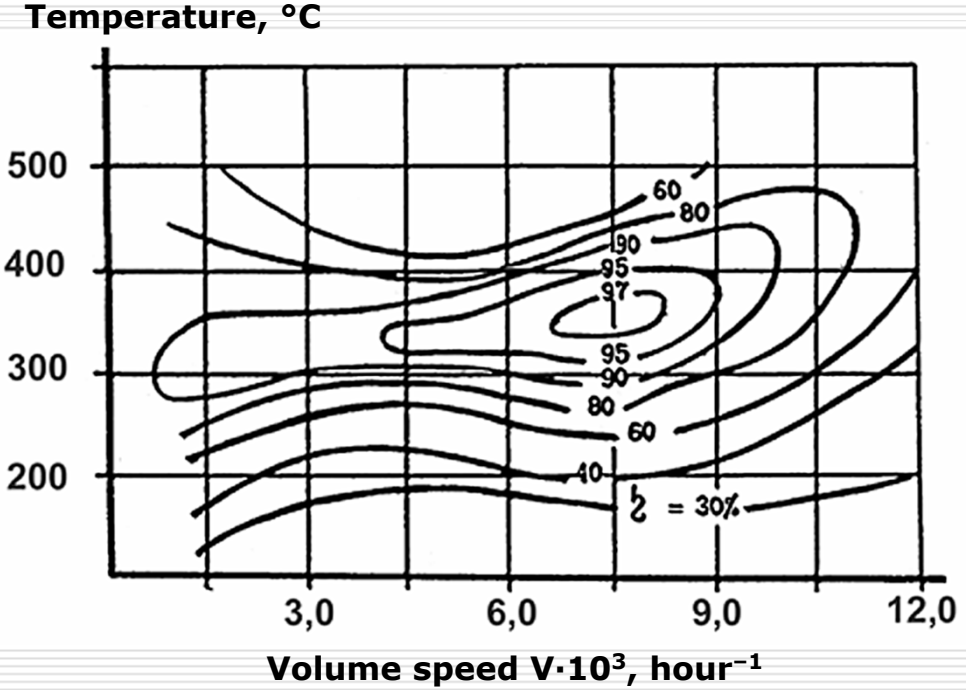
ПРЕДСЕДАТЕЛЬ РОСПАТЕНТА

Efficiency of exhaust clearing from NOx in SCR (NH_3) reactor

- **SCR (NH3) reactor on ship**



- **Efficiency of SCR (NH_3) process**

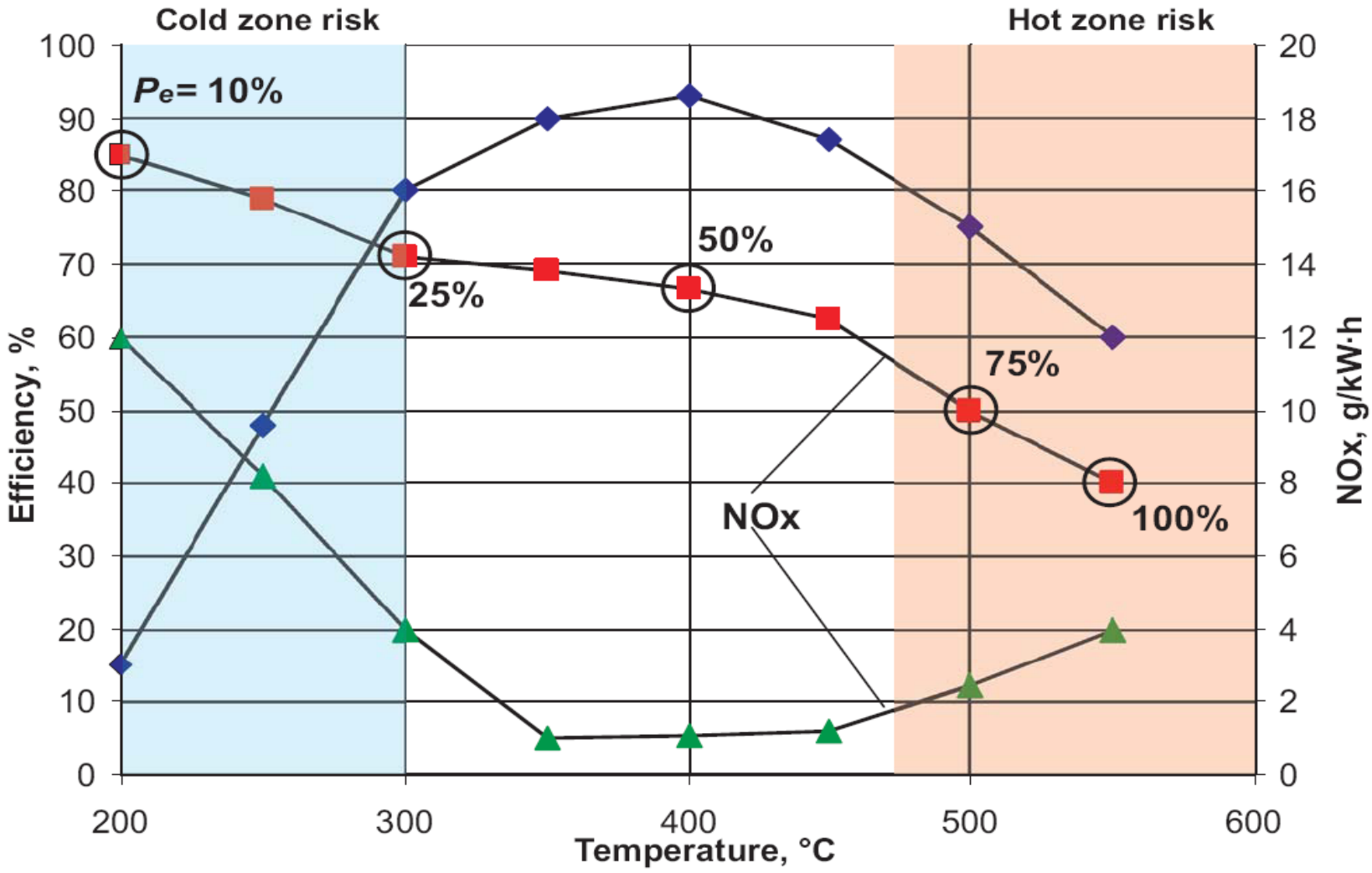


$$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$$

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

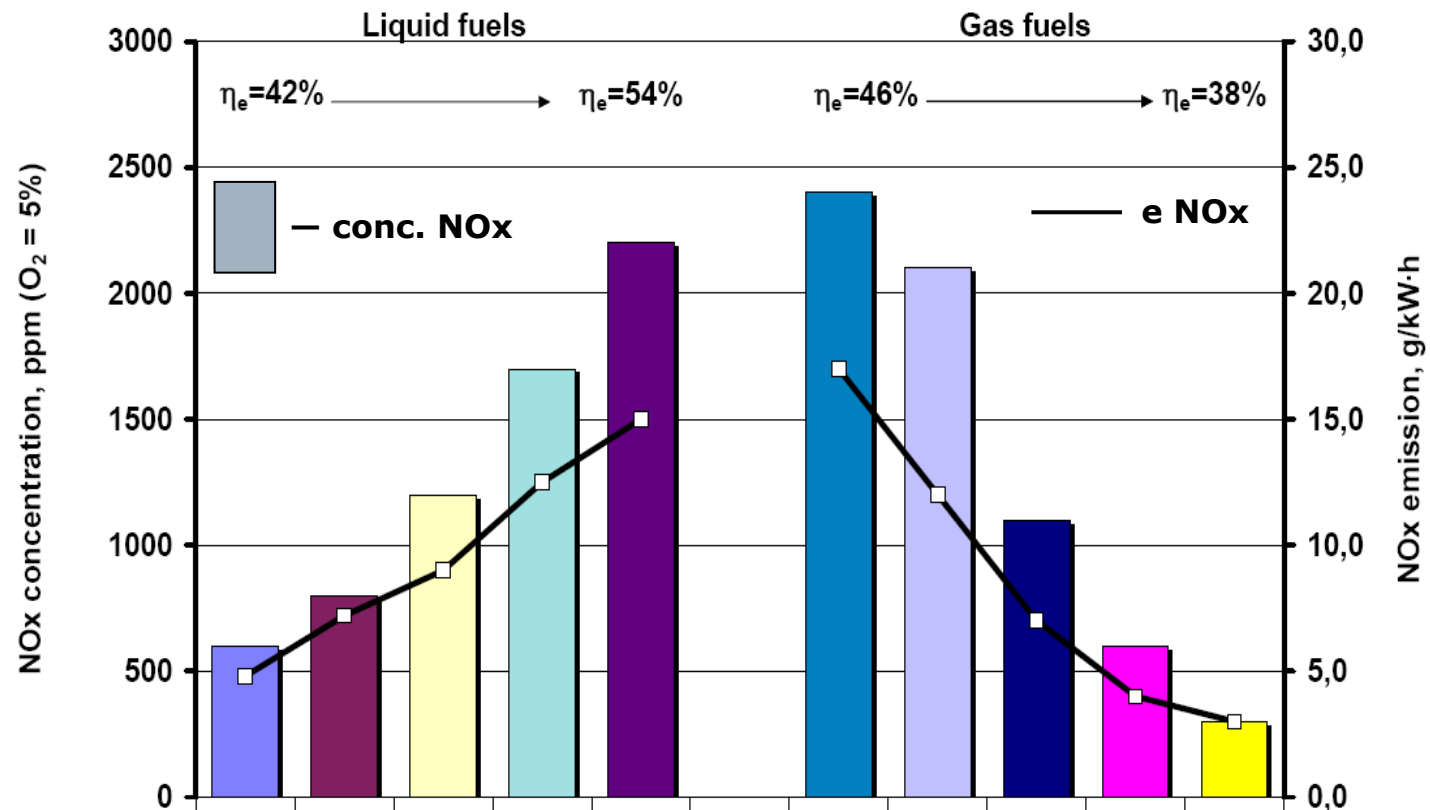
Operational efficiency of SCR (NH_3) technology (four stroke engines)



Technological and operational risks of application SCR (NH_3) technology on a vessel

Name	Cold zone T_{exh} < 300°C	Operational zone 450 < T_{exh} < 300°C	Hot zone 450 <T_{exh} <550°C
Technological risks	Supernormal NH_3 $4NH_3+5O_2 \rightarrow 4NO+6H_2O$	—	Catalytic oxidation NH_3 $4NH_3+4O_2 \rightarrow 2NO+N_2+6H_2O$
Operational risks			
«Poisoning» of Catalyst by SO_x (SO_2 + SO_3) (irreversibly)	Decrease of the catalyst operation life in 3–4 times	Decrease of process efficiency on 50–60 %	Replacement of Catalyst
Contamination of the catalyst by products of burning bad quality fuel (partially reversible)	Decrease of the catalyst operation life in 1,5–2 times	Decrease of process efficiency on 20–30%	Replacement of Catalyst
Contamination of the catalyst by soot and oil as a result of breakdown in diesel engine systems (irreversibly)	Decrease of the catalyst operation life in 2–3 times	Decrease of process efficiency on 30–40 %	Replacement of Catalyst

NOx emission and Efficiency of Diesel and RIC-engines at consumption of liquid, dual and gas fuels



	1	2	3	4	5		6	7	8	9	10
NOx, ppm	600	800	1200	1700	2200		2400	2100	1100	600	300
eNOx, g/kWh	4,8	7,2	9,0	12,5	15,0		17,0	12,0	7,0	4,0	3,0

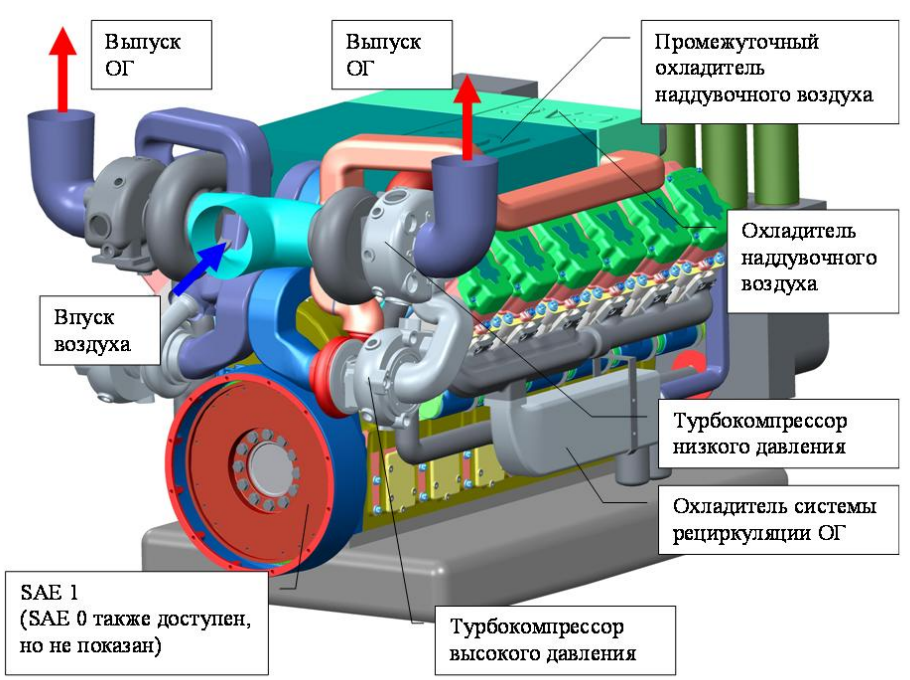
1. Dimethyl ether
2. Ethanol
3. Biodiesel
4. Diesel fuel, middle speed diesel engines
5. Heavy fuel, low speed diesel engines
6. Dual fuel engine (15 % pilot oil)
7. Dual fuel engine (5 % pilot oil)
8. Gas engine with spark ignition
9. Gas engine with pre-combustion chamber ignition
10. Gas engine with supercharging of a thin mixture

Perspective marine diesel engine (without exhaust clearing)

JSC «Zvezda»(RF) IMO TIER-3

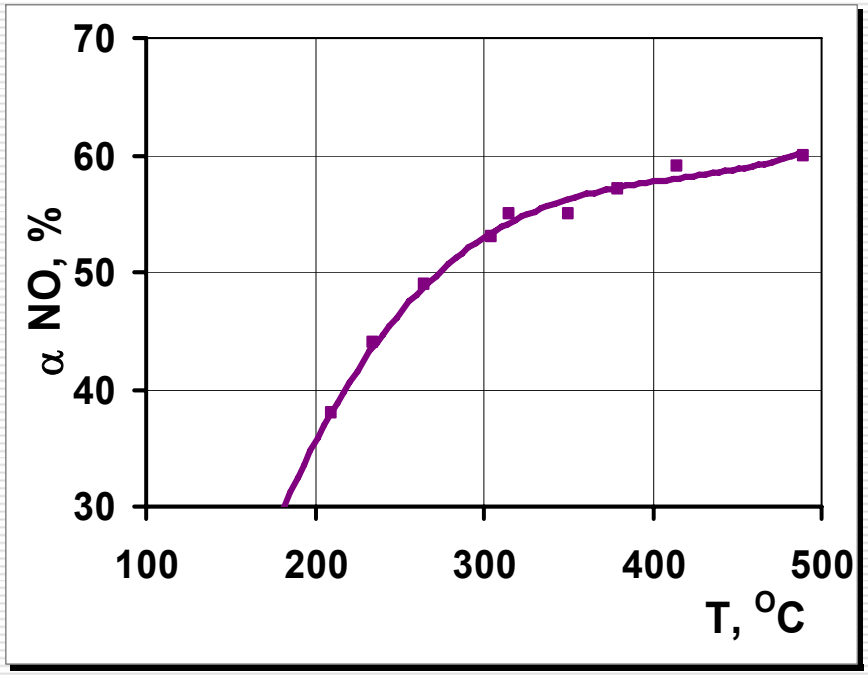
Technologies:

- **Miller's cycle (Pz=230 bar)**
- **EGR with cooling (30 %)**
- **Fuel injection «Common rail» (P=2600 bar)**
- **Controlled process of fuel injection**
- **Two-stage register mode Turbo charging system (Pint =600 kPa)**
- **Intermediate cooling of charge air**
- **Controlled bypass in charge air system (α = const)**

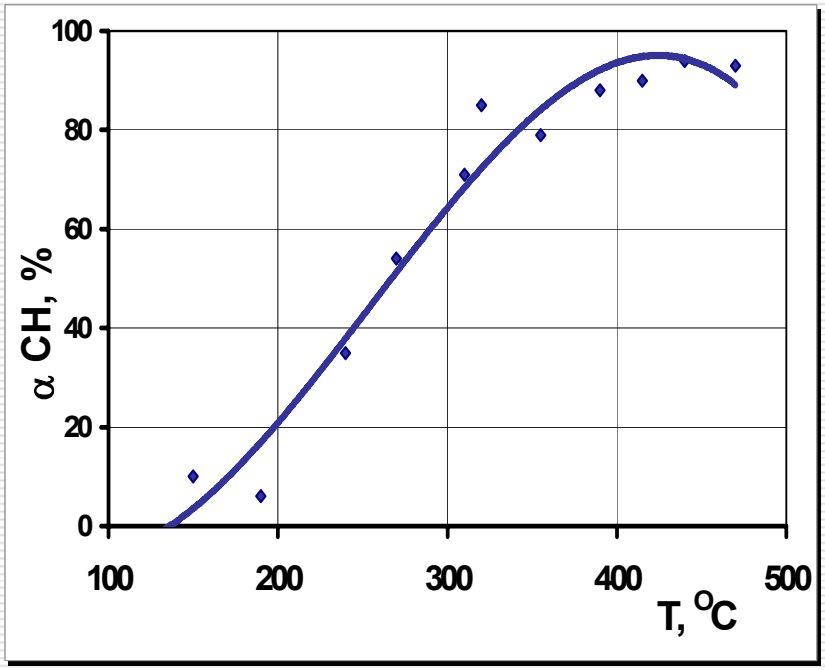


Efficiency of NOx reduction by the propane (C_3H_8) in SCR (CH) reactor

- Conversion NOx, %

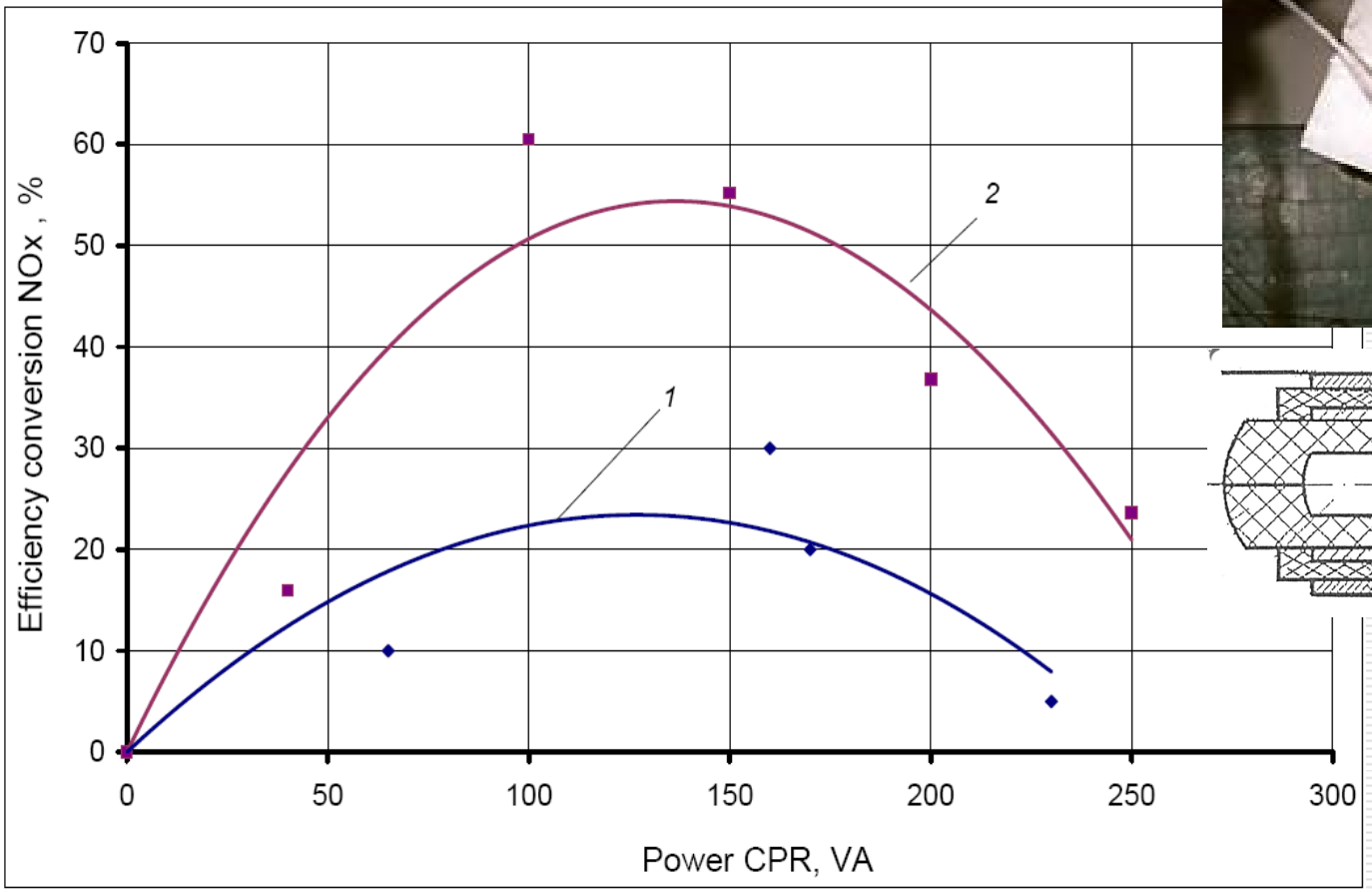


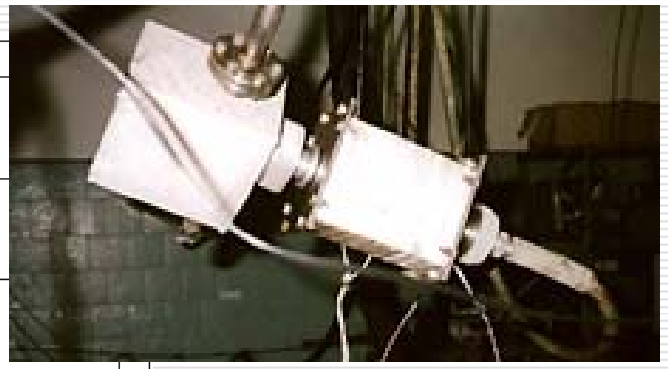
- Conversion C_3H_8, %

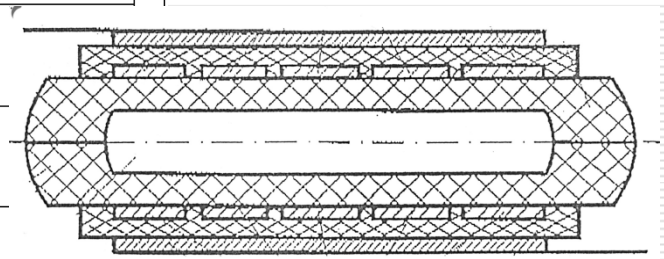


NO = 700–1100 ppm; C_3H_8 = 0,77 %; V_{exh} = 4,8·10^4 h^{-1}

Efficiency of NO_x Conversion in reactor of cold plasma







1 **— diesel power 2,9 kW, NOx inlet = 100 ppm;**
2 **— diesel power 5,0 kW, NOx inlet = 380 ppm**

Conclusion

- Ships traffic brings the insignificant contribution (no more 5 %) to air pollution and waters on Baltic Sea Area. The prediction of the ecological conditions improvement, based on erroneous (or not correct) data also unreasonable.

- Implementation of IMO Tier-3 from 01.01 2016 on forthcoming material cost for ship-owners (increase by 40-50 %) is not comparable with insignificant ecological effect

- SCR-NH3 technology possesses substantial defects and will not provide expected operational efficiency on ships

- Technologies EGR and LNG (Gas fuel) are perspective, however the stage of their industrial development does not provide achievement of level IMO Tier-3

- Implementation NECA on Baltic is expedient to delay before industrial development of safe alternative technologies

Thank you for attention!