UNOLS Green Boats and Ports Workshop – Portland, OR

Barrett Carpenter

Technical Marine Sales Engineer

Peterson Power Systems

PETERSON CAT®

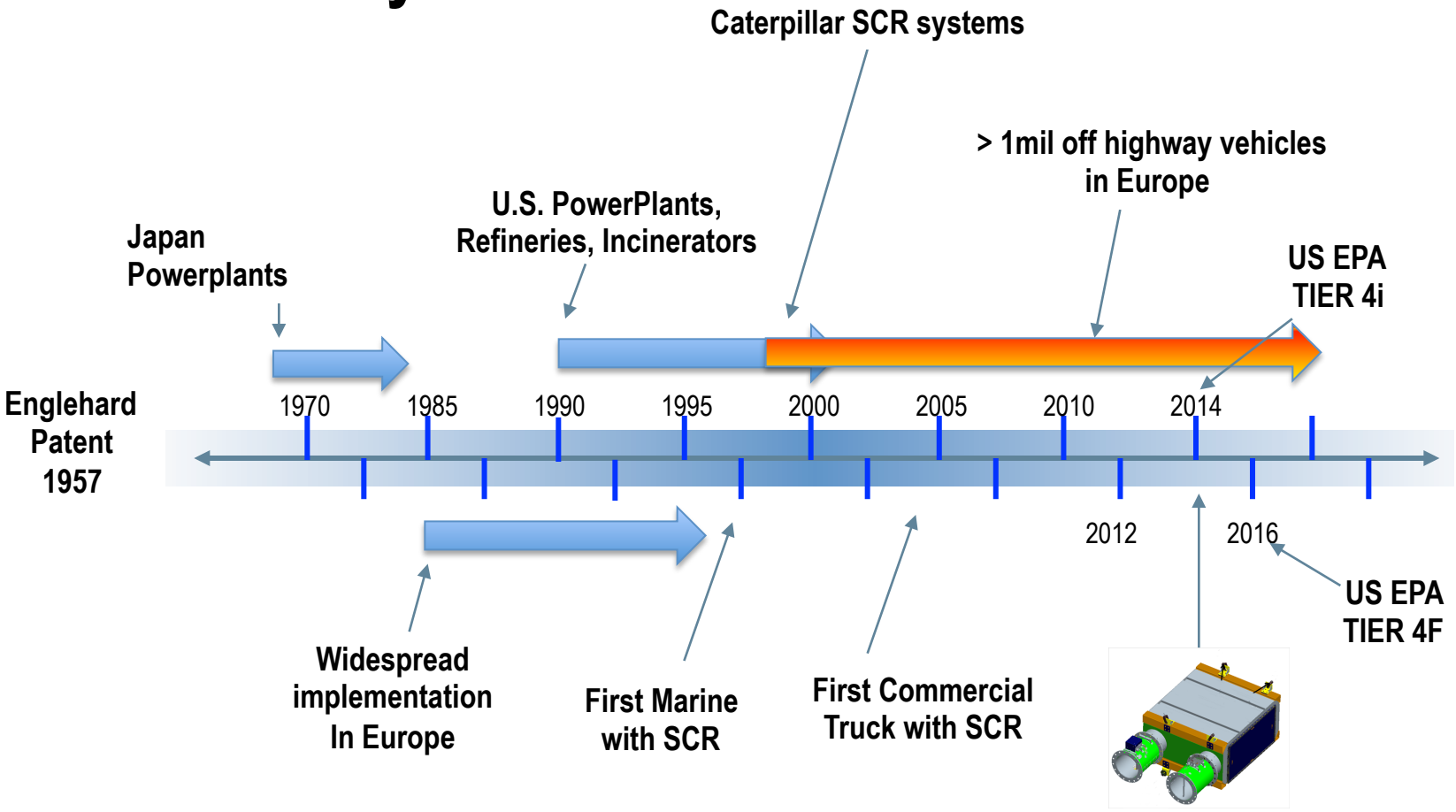
CAT®

CAT EPA Tier-4/IMO III
Green Emissions Solutions for Research Vessels

EPA MARINE TIER-4 EMISSIONS STANDARDS

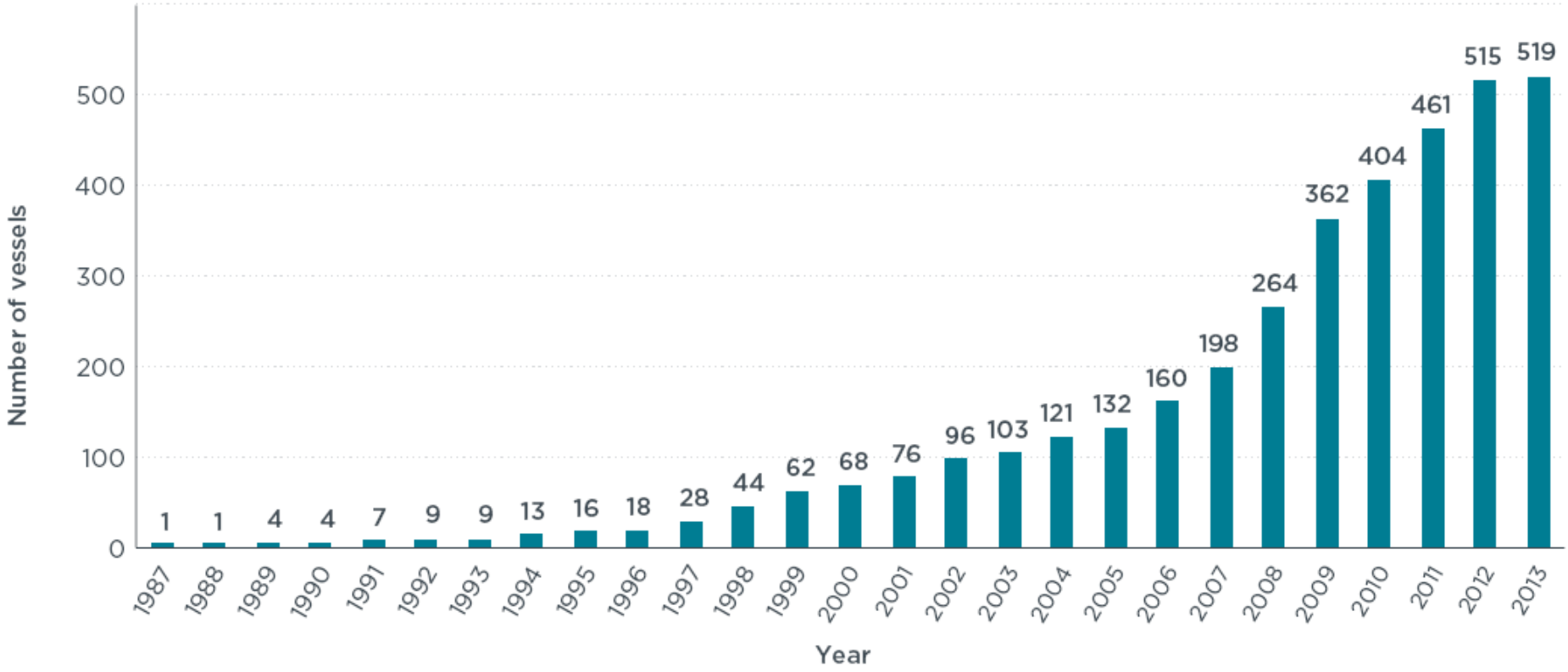
Table 8. Tier 4 Standards for Marine Diesel Category 1/2 Engines	
Power (P)	Date
kW	
P ≥ 3700 (4962hp)	2014[c]
	2016[b,c]
2000 (2682hp) ≤ P < 3700 (4962hp)	2014[c,d]
1400 (1887hp) ≤ P < 2000 (2682hp)	2016[c]
600 (804hp) ≤ P < 1400 (1887hp)	2017[d]
a - 0.25 g/kWh for engines with 15-30 dm^3/cylinder displacement. **b - Optional compliance start dates can be used within these model years.** **c - Option for Cat. 2: Tier 3 PM/NOx+HC at 0.14/7.8 g/kWh in 2012, and Tier 4 in 2015.** **d - The Tier 3 PM standards continue to apply for these engines in model years 2014 and 2015 only.**	

SCR History



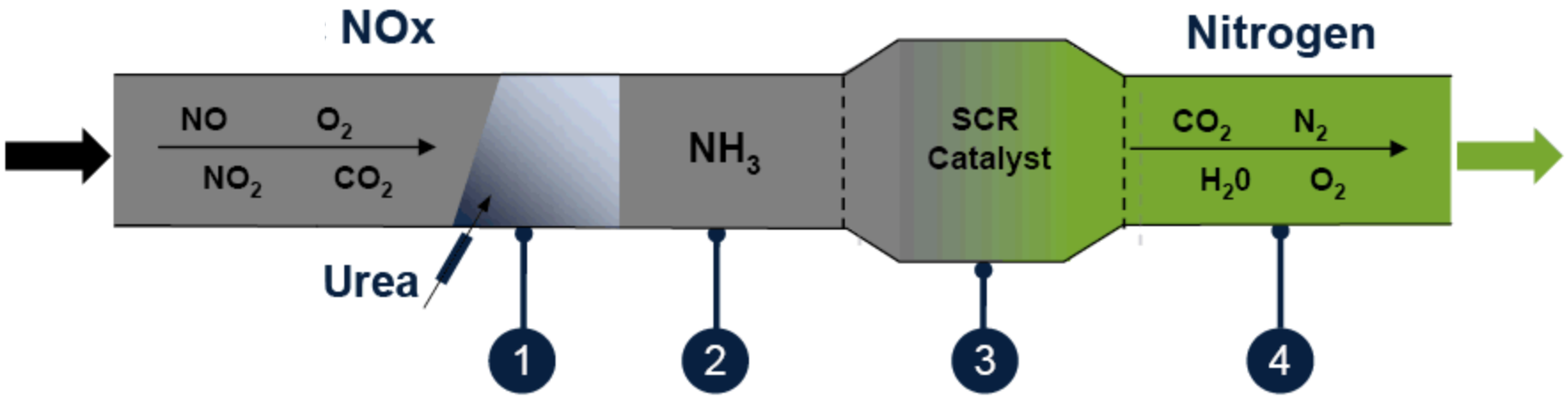
- Proven history, reliable and durable technology
- Over 500 Marine SCR installations operating globally

Marine SCR Installations by Year



http://www.theicct.org/sites/default/files/publications/ICCT_MarineSCR_Mar2014.pdf
IMO report MEPC66/6/6

Chemical Reaction

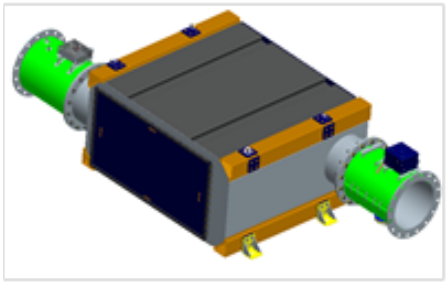


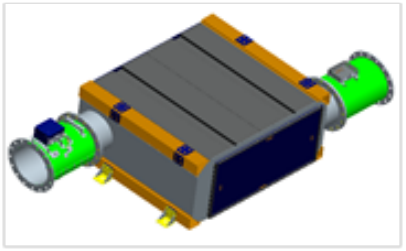
1. Injection of Urea into Exhaust Stream
2. Evaporation of Water – Conversion of Urea to NH_3
3. NOx reduction when ammonia contacts SCR catalyst
4. Output of Nitrogen, N_2

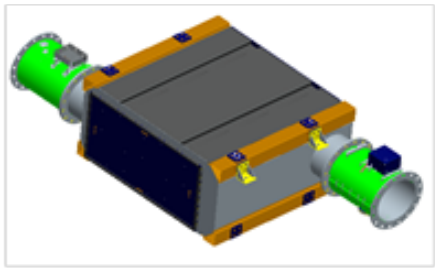
Components of SCR

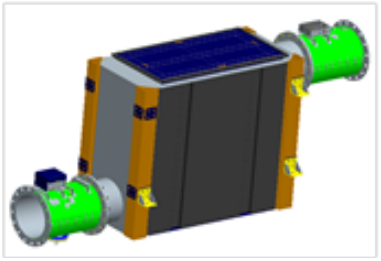
- Diesel Exhaust Fluid (DEF)
- Pump Electronics Tank Unit (PETU)
- DEF Injector
- Mixing Tube
- SCR Catalyst

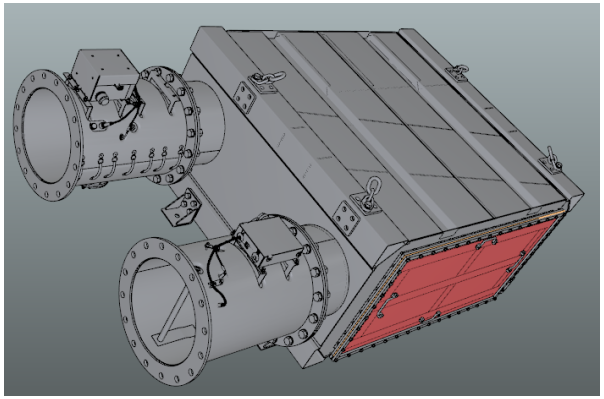
U-flow & Z-flow Flexible Installation

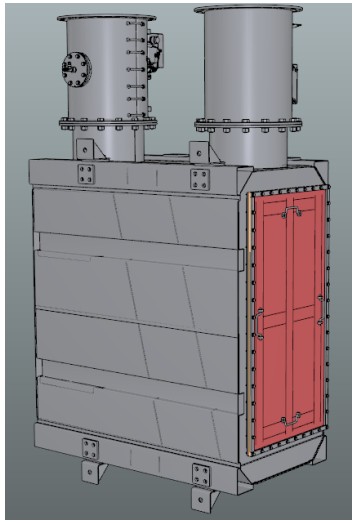






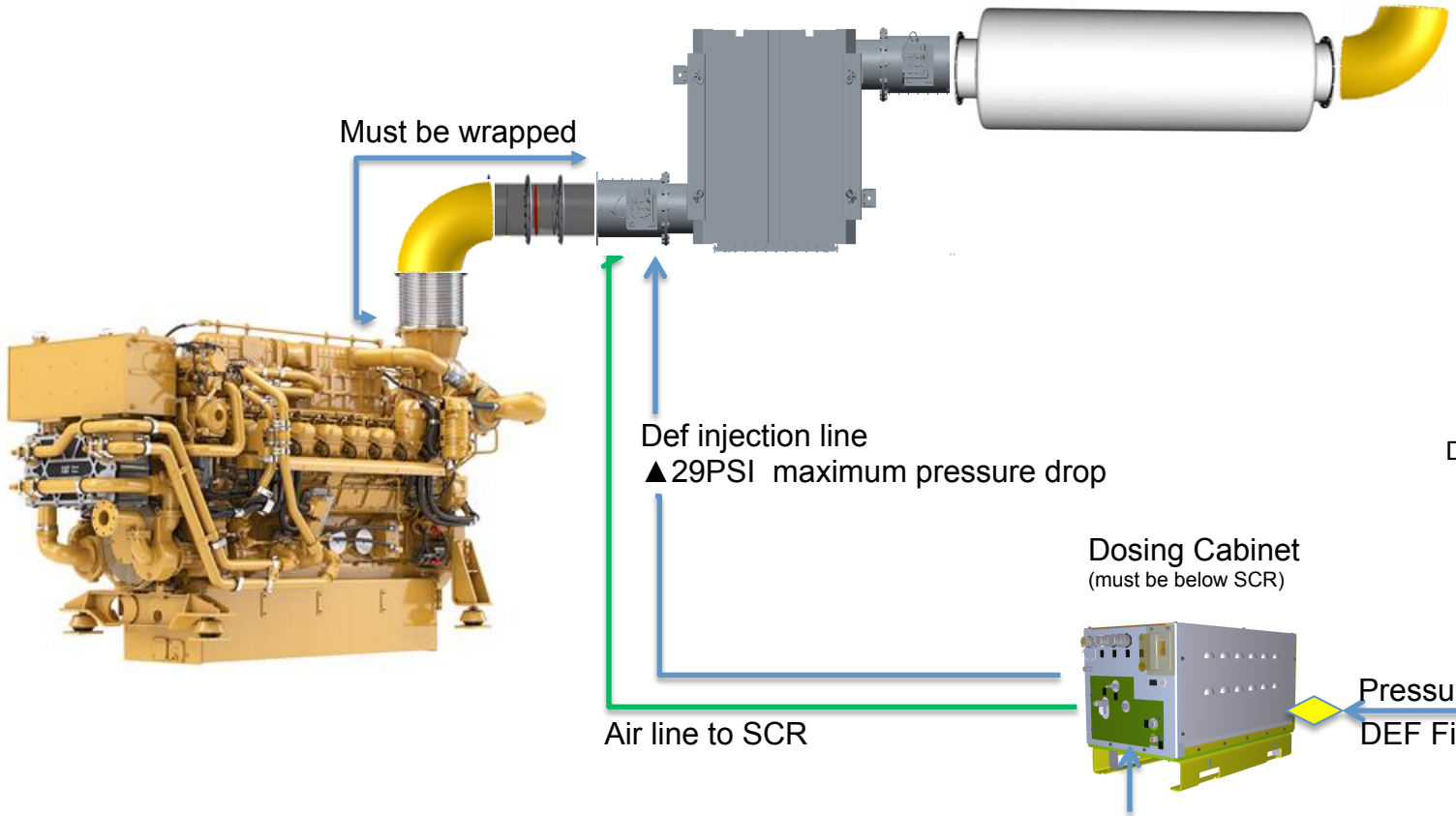






C32/ 3500E Mechanical Systems Overview

Total Backpressure = 75” H2O (18.7 kPa)
Customer piping = 27” H2O (6.7 kPa)



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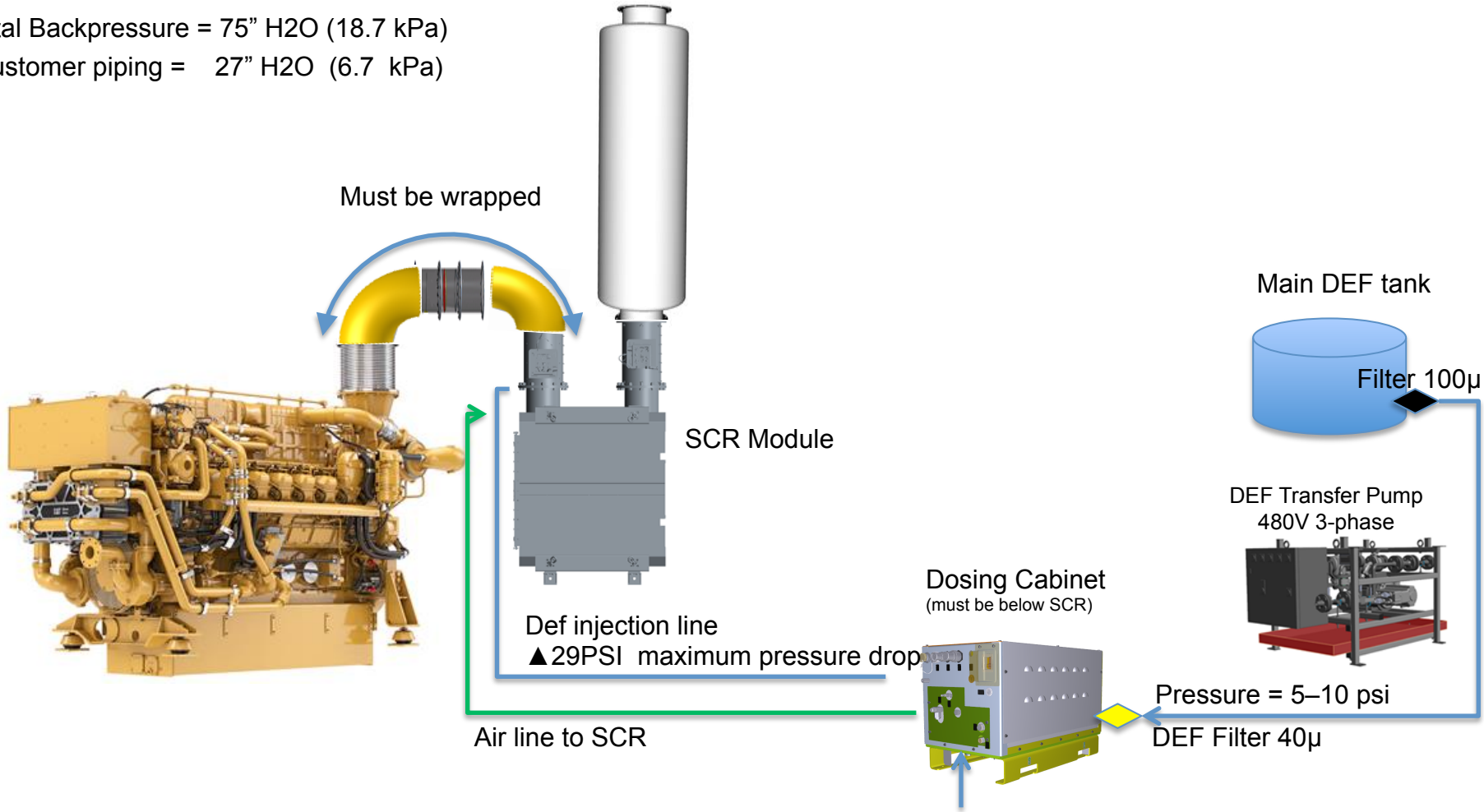


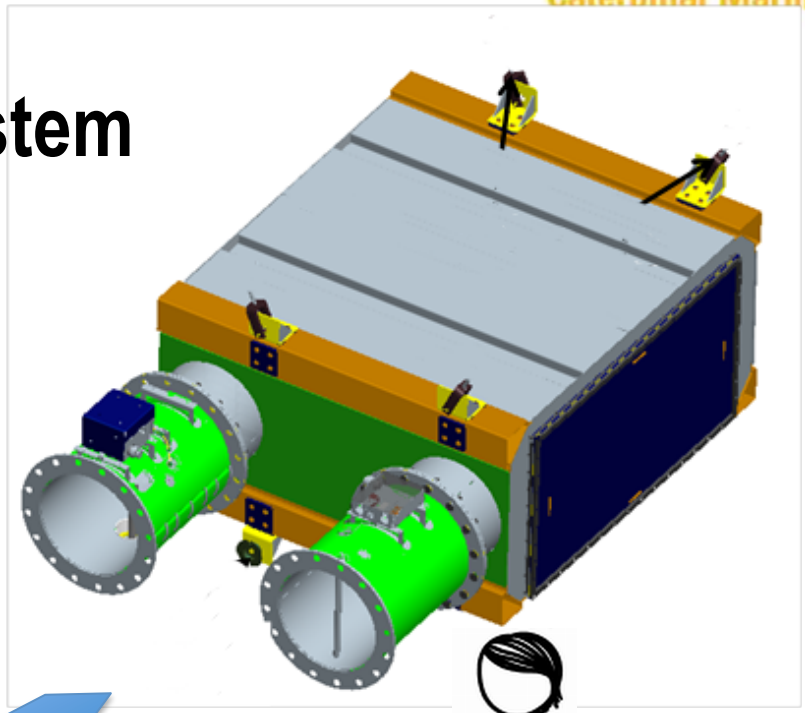
Open vs Closed Loop Systems

- *Open Loop System*
  - No feedback from engine
  - Dosing based on tables

- Closed Loop Complete System
  - Continuous condition-based Urea Injection
  - Engine will control dosing based on load factor and exhaust temperature inlet to SCR Module

Complete Closed Loop System

"dude"



"over here"

"hello?"

MAK

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3500 Marine SCR – Lowest Emissions / Highest Benefits

Caterpillar Marine

Closed Loop Control

- **Lowest Consumption**
- **Extended Useful Life**
- **Ensures Compliance**
- Flexible to Urea Quality

Sound Reduction

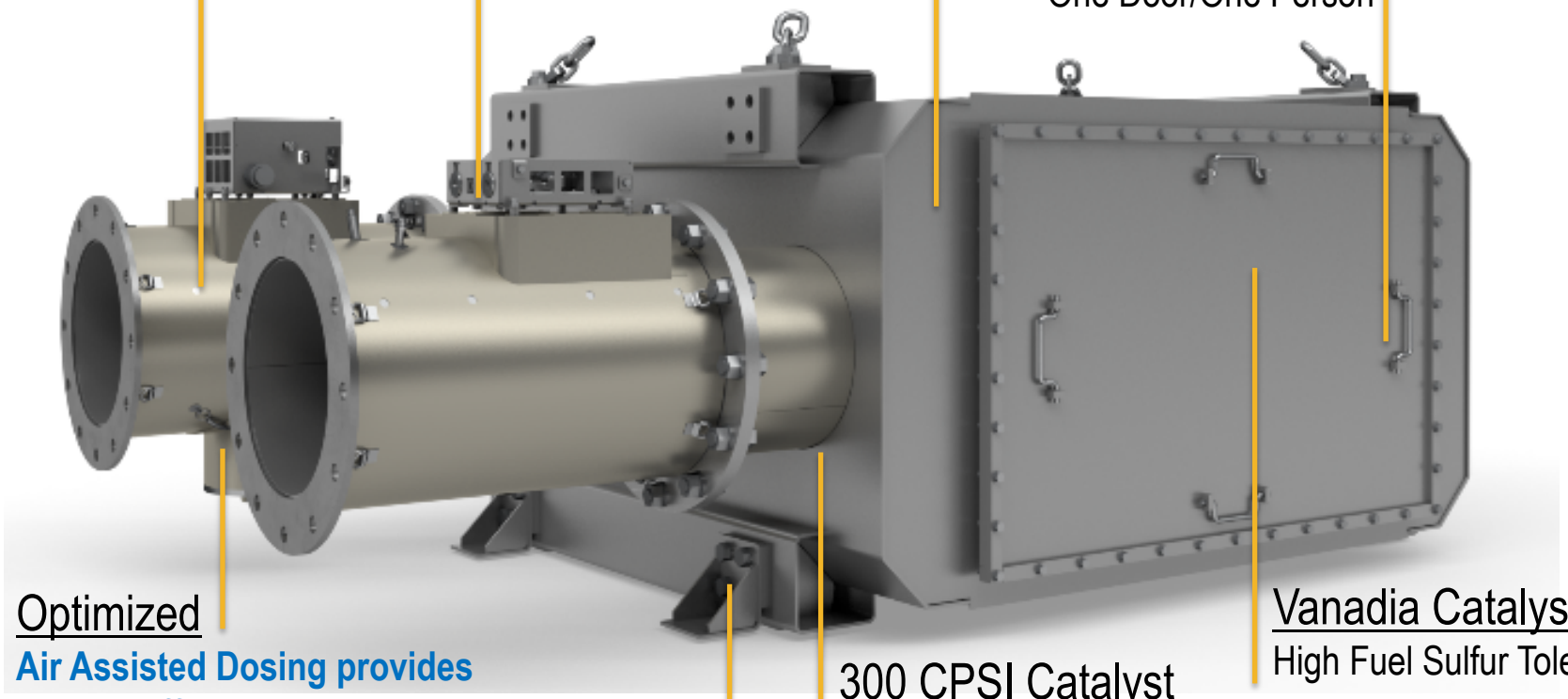
Up to 25dbA

Integrated

DEF Mixing

Ease Of Service

One Door/One Person



Optimized

Air Assisted Dosing provides highest efficiency mixing to lower operating costs

Flexible

Mount in all directions

300 CPSI Catalyst

High Nox Conversion Efficiency

- Compact
- **Ensures Compliance w/ extended Useful Life**

Vanadia Catalyst

High Fuel Sulfur Tolerance

MaK

CAT

Catalyst Lifetime

EPA requirement for lifecycle of the Catalyst is 10,000 hours

SCR Replacement Intervals Based on Average Load Factor and Hours					
Average Application Load Factor (%)	10	25	50	75	100
SCR Replacement Interval (hrs)	20,000	16,000	13,000	11,000	10,000

DEF Tank Sizing - *No One Size Fits All…*

Straight Forward Inputs

- Operating Load Profile (% time, % power)
- Operating Hours per Year
- DEF Type (32.5% vs. 40% urea conc.)

✓ **Use EVA™ to calculate DEF consumption**

Less Straight Forward Inputs

- Number of DEF tanks per vessel?
- Multi-Compartment tank(s)?
- Location of tank(s)?/ space constraints
- Typical bunkering frequencies?
- % Volume fill of DEF tank(s)?
- Tank cooling/heating capability?

EVA™

Cat® | EPA [illegible] 516E | 3386 bhp at 1800rpm

Year 1 Diesel Fuel Consumption & Cost

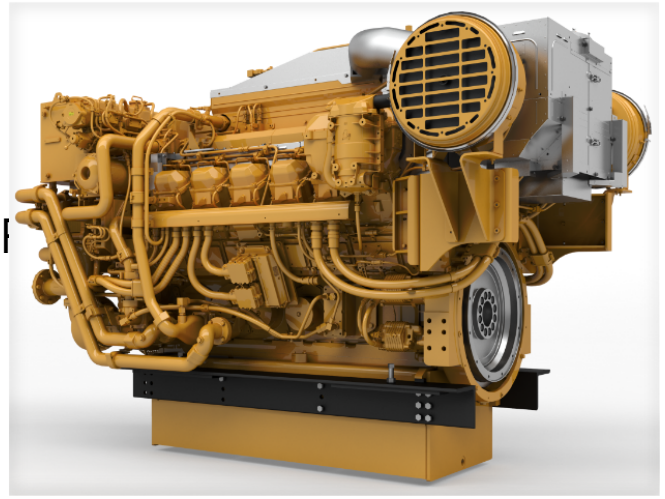
	per engine	per vessel
Gallons / hour	31.8	63.5
Gallons / day	305	609
Gallons / week	2,133	4,265
Gallons / month	9,267	18,534
Gallons / year	111,202	222,404
Cost / year	**$278,005**	**$556,011**

Year 1 DEF Consumption & Cost - (32.5% conc.)

	per engine	per vessel
Gallons / hour	2.3	4.7
Gallons / day	22.5	45.0
Gallons / week	158	315
Gallons / month	685	1,370
Gallons / year	8,221	16,443
Cost / year	**$9,866**	**$19,731**

YEAR 1 TFC COSTS / VESSEL	$575,742

3500E – Flexible IMO II / III Switchable



3500E Base Engine:

- Multiple fueling Calibration Capability
- Base Calibration – IMO II engine out Nox
- Backpressure and Exhaust temperature Optimized for Cat SCR
- Can be sold as Engine Only with IMO II certification

3500E IMO III:

- 3500E Base Engine with integrated Caterpillar SCR

Operational Modes

- Mode 0 - IMO II engine out Nox fuelling map
- Mode 1 – IMO III: BSFC optimized Nox calibration with Caterpillar SCR
- Mode 2 – IMO II: BSFC optimized Nox calibration with Caterpillar SCR only dosing to IMO II levels

Contact ASC for Tactical Availability

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PETERSON'S TIER-4 MARINE PROJECTS

(Photo copyright Oregon State University)

Oregon State University "UNOLS RCRV"

3 x CAT Tier-4 C32/Siemens VDEP Gensets

Provided and Commissioned by Peterson Power Systems

Harley Marine Tug "Earl Redd"
First Tier-4 Final Tug
Operational in United States

2 x CAT 3516E Engines
Provided and commissioned by Peterson Power Systems

(Photo by Kurt Redd
Diversified Marine Inc.)

(Photo by Kurt Redd - Diversified Marine Inc.)

(Photo by CatsMan2 - Flickr)

Foss Maritime Tug "Caden Foss"
Second Tier-4 Final Tug
Operational on the West Coast

2 x CAT 3516E Engines
Provided and commissioned by Peterson Power Systems

PETERSON CAT®

CONTACT US TODAY!
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