CSSC 中国船舶 青岛双瑞 SUNRUI

SUNRUI
Ammonia Fuel Supply System

http://www.sunrui.com.cn

Contents

01 Industrial Background

02 R&D Progress

Industrial Background – Fuel Solutions

Solution	Details	Pros	Cons
MDO/MGO/ LSFO	Current Standard Fuel in the Marine Industry	Easy to adopt, fuel efficiency improving due to (i) general fleet renewal and (ii) new technologies, slow steaming can reduce carbon	High GHG, PM, NOx, low sulphur fuels more expensive
LNG	Requires LNG capable engine with different fuel handing system and increased fuel storage space, long history of operation	Adoption growing, proven technology, bunkering network evolving (well developed in Europe and E. Asia), very low NOx, SOx, PM, >20% less CO_2. Methane slip on engines being reduced and supply chain improving. Potential to switch to synthetic LNG or bio-LNG later on to reduce WTW emissions. LNG carriers can use waste boil-off gas.	Methane slip potential, still a fossil fuel, regional variation in bunkering availability, current pricing high and future pricing uncertain, high CAPEX (especially retrofit), potential loss of cargo capacity.
LPG	Requires LPG capable engine with different fuel handling system	Low NOx, SOx, PM, c.10-20% lower CO_2. LPG carriers can use cargo as fuel, extensive terminal infrastructure	Limited uptake as marine fuel to date outside of LPG carriers, still fossil fuel, economic incentive depends on pricing.
Methanol	Primarily produced from natural gas, can be used in dual-fuel oil/methanol engines	Fuel handling and risk management simpler than LNG, zero CO_2 emissions for 'green methanol' reduced NOx, SOx, existing terminal infrastructure	Retrofit complex, low energy density, likely to be costly in short-term, toxic and flammable. Lack of bunkering. Global production limited.
Biofuels	While many engines are compatible, some ships require modification to fuel system and engine.	Some types of biodiesel already widely available from existing waste products. Requires limited changes to engines and fuel handling	Typically no reduction in TTW CO_2 emissions. emissions vary according to supply chain, sustainability issues (e.g. land use for palm oil production).
Hydrogen	Development focussed on zero-emissions fuel cells, can also be used in specialist combustion engines	Potentially both clean and abundant, attracting significant investment in technology, fuel cells more efficient than combustion engines	Fuel production is still energy-intensive, large-scale production expensive, undeveloped bunkering infrastructure, difficult and expensive to store at -253°C
Ammonia	Can be produced from a range of sources and used in combustion engines or fuel cells (as a 'hydrogen carrier').	Already produced and traded at scale, zero TTW emissions, 'green ammonia' produced using renewable electricity could be fully GHG emissions free	Current production process (Haber-Bosch) is highly energy intensive, low energy density, toxic and corrosive, significant NOx emissions.
Batteries	Batteries can store electrical energy for propulsion by charging ship using High Voltage Shore Connection (HVSC)	Ship itself does not generate emissions, could be net-zero CO_2 if power source also emissions free, already in use on manyferries, expanding network of HVSC facilities at ports.	Still impractical for larger vessels or those on long voyages due to size of batteries needed, upstream emissions still possible, potential loss of cargo space, unsuitable for many locations.
Nuclear	Vessel powered by small nuclear power plant	Extremely high power, mature technology, minimal emissions from ship	Emissions still produced by fuel production, creation of nuclear waste, significant risks, adoption faces political and regulatory issues

from Clarkson

Industrial Background – Fuel Solutions

	Supporting Facilities	Technical Issues	Energy Density	Construction Cost	Fuel Cost	Storage	Carbon Emission	Security	Main Problem
MDO/MGO/LS									Highest carbon emissions
LNG									Methane escape; Can't solve carbon emissions
LPG									Applicable to LPG carriers only
Methanol Fuel									Green methanol with high price;
Ammonia Fuel									Toxicity, Corrosion
Hydrogen Fuel									Cryogenic Storage
Nuclear									Security; Nuclear pollution;

Bad → Good

Industrial Background

Purpose

For having a greener future and providing better and up-to-date products and services to SUNRUI Clients.

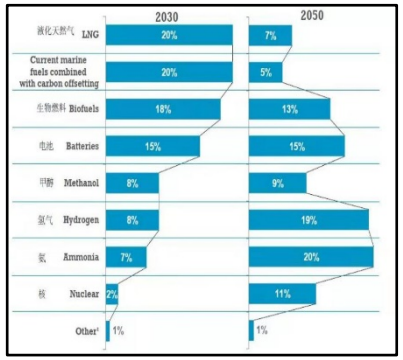
UN
Conventions & Agreement

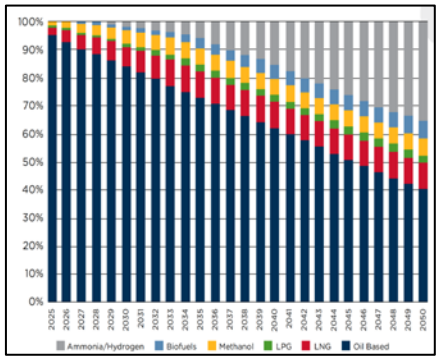
- 1997 Kyoto Protocol
- 2015 Paris Agreement
- 2021 Glasgow Convention

IMO
Reduction Strategy

- 2018 MEPC Session72
- 2021 MEPC Session 77

Classifications
Trend Predictions





Prediction of Marine Fuel Consumption from LR & ABS

Marine Ammonia Fuel
Development

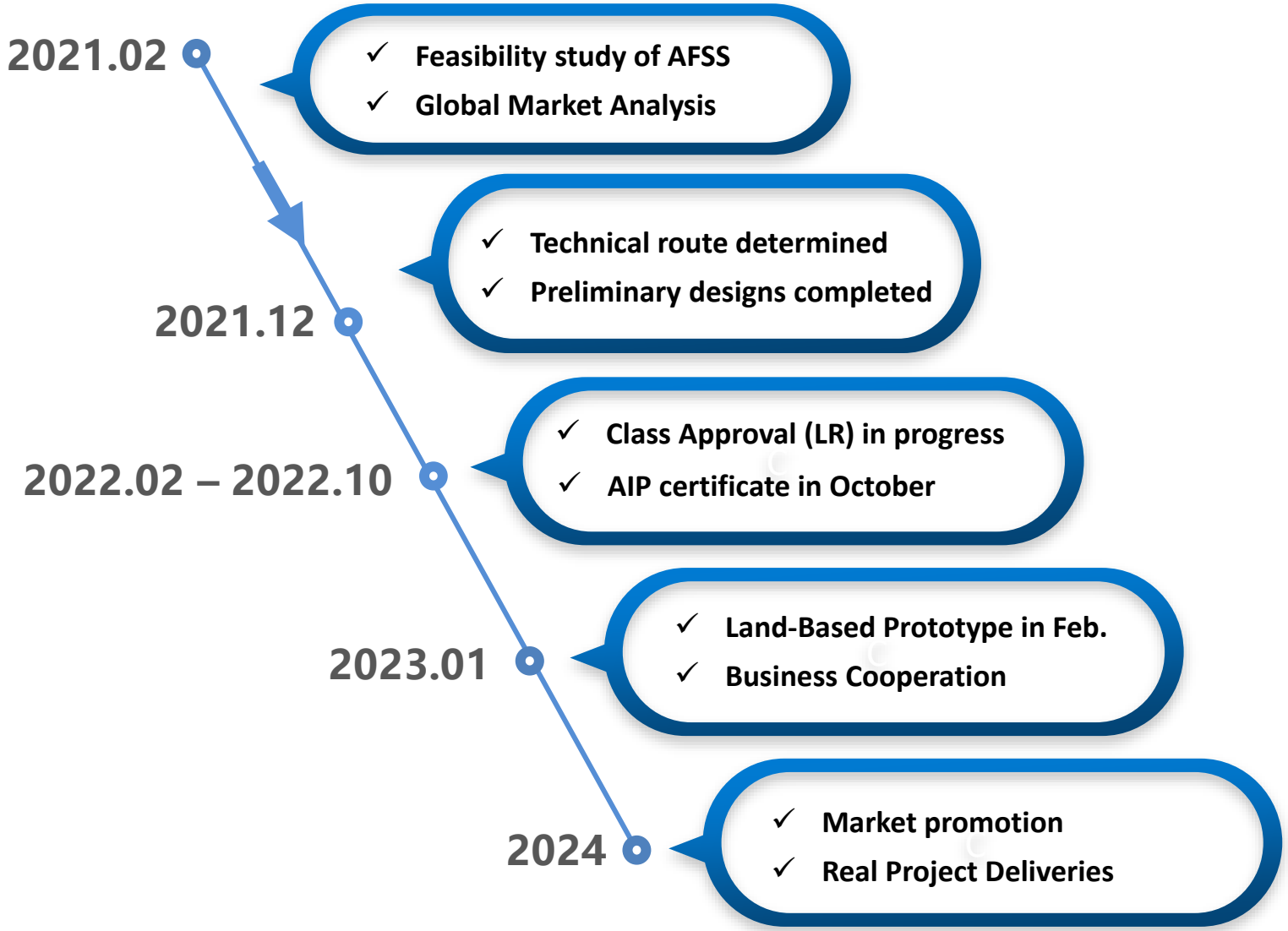
- **ME R&D:**
- MAN-ES and Wärtsilä in 2024
- **Ship Type R&D:** New Designs has been announced
- **Facilities:** Mature application on land

Contents

01 Industrial Background

02 R&D Progress

R&D History and Future Scenarios

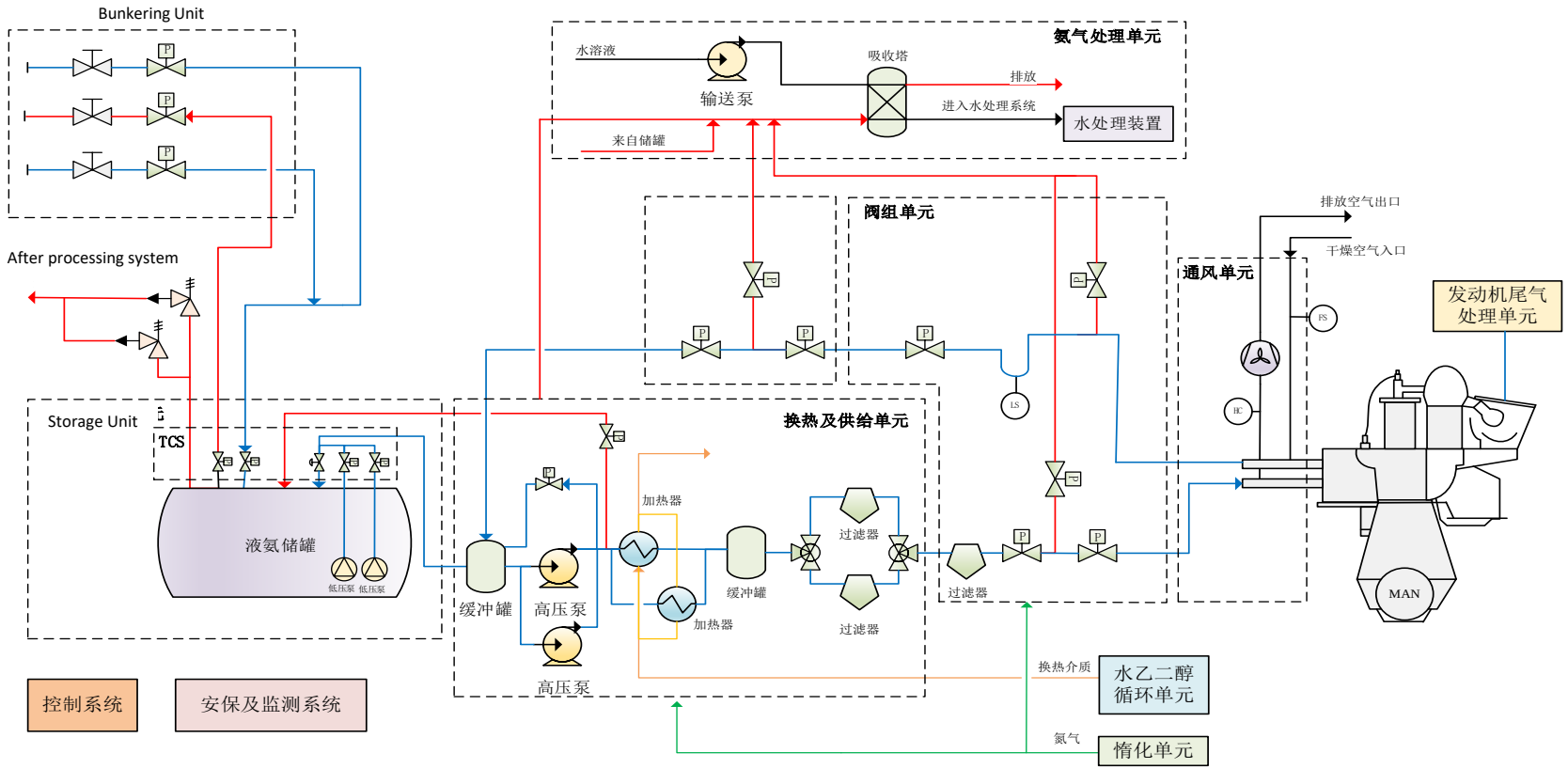


青岛双瑞
SUNRUI
Ammonia

Technical Route – Ammonia Fuel Supply System

◆ **Based on MAN engines – Focusing on Ammonia Supply & Exhaust Treatment**

Technical Parameters	
ME Power	6G70ME-LGIA
ME Model	21840 kW
ME NO.	1 Set
Composition	Liquid Ammonia
Flow Rate	13.7 m3/h
Pressure	83±2 barg
Temperature	25~45 ℃



Key Technologies & Solutions

Key Challenges

- Liquid Ammonia Storage
- Ammonia Gas Treatment
- Pressurization & Heat Exchange
- Automatic Control System
- Exhaust Treatment

Other Challenges

- Liquid Ammonia Bunkering
- Safety Protection
- Ammonia Purging
- Ammonia Leakage Analysis

Key Technologies – Liquid Ammonia Storage

	01	02	03
Challenges	Low Energy Density & Corrosive	Liquid Ammonia Storage	Stress/Fatigue/Temp Analysis
Solutions	Material Comparison Carbon Steel Carbon Manganese Steel Stainless Steel Aluminum Alloy	Storage Method Comparison Normal T High P Low T Low P Low T Normal P	ANSYS Simulation Analysis Pressure Fatigue Temp Field
Goal	Material Features Manufacturing process Optimized tank material for different vessel types	Design Pressure Cost Effective Optimized ammonia storage schemes for different vessel types	Accuracy of the Simulation Result Reliable design and analysis result from the simulation

Key Technologies – Liquid Ammonia Storage

Tank Material Comparison						
	Material	Allowable Temperature	Yield Strength	Tensile Strength	Allowable Stress (MPa)	PWHT
Carbon Steel	Q245R	> -20℃	245MPa	400MPa	148	N
	Q345R	> -20℃	345MPa	510MPa	185	Y
Carbon M Steel	16 MnDR	> -40℃	315MPa	490MPa	174	Y
	15 MnNiDR	> -45℃	325MPa	490MPa	178	Y
Stainless Steel	S30408	> -196℃	205MPa	515MPa	137	N
Aluminum Alloy	5083	> -196℃	110MPa	270MPa	67	N

Allowable Temp of Q245R > -20℃

Difficult for large tanks to have post weld heat treatment

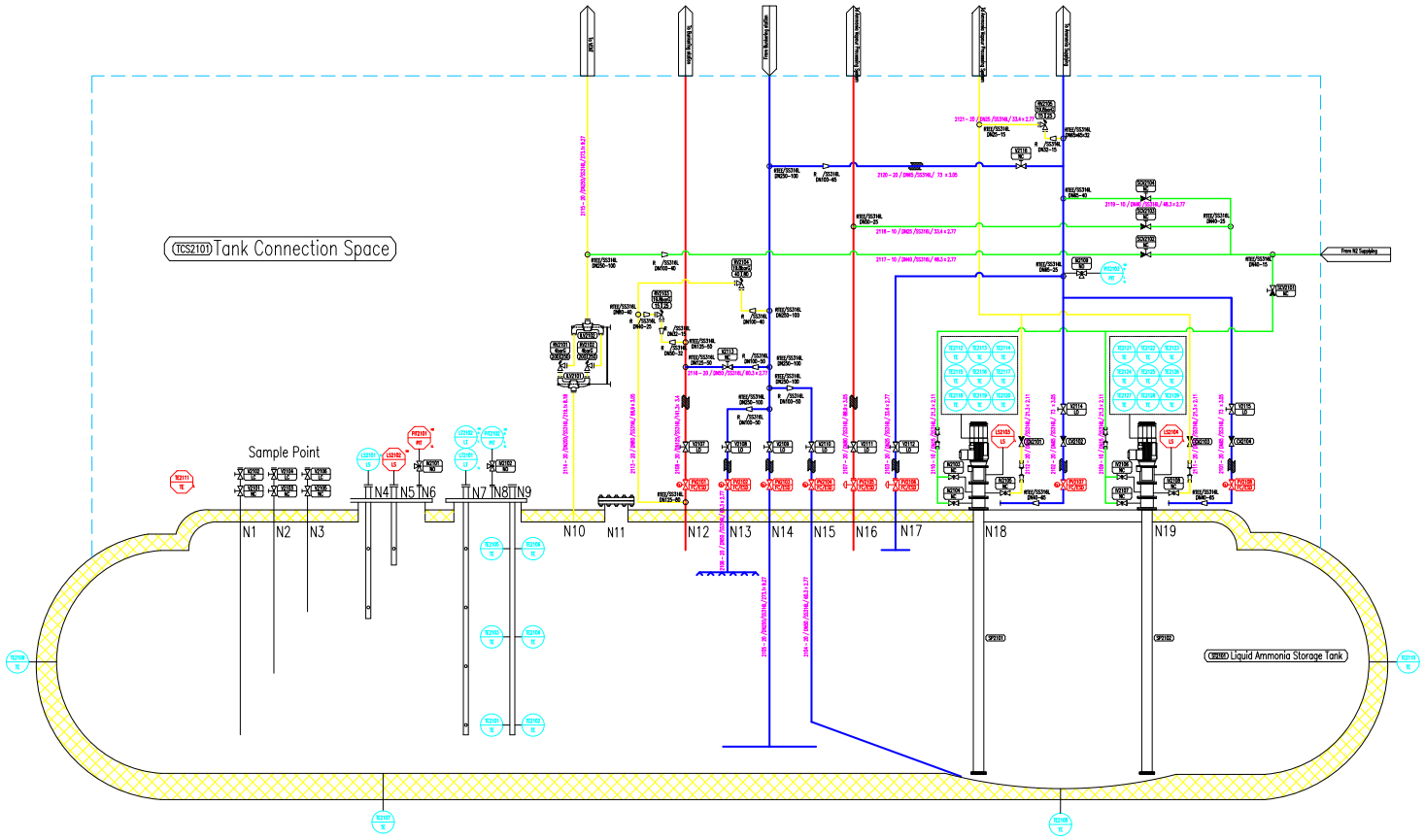
High welding technic required for Aluminum Alloy

⇩

Preferred Tank Material - S30408

Key Technologies – Liquid Ammonia Storage

Main Parameters			
Type	Type C	Tank Material	S30408
Designed Capacity	3000 m³	Insulation Material	PUF
Actual Capacity	3054 m³	Insulation Thickness	150 mm
Medium	Liquid Ammonia	MAX. Capacity	90.9%
Operating Pressure	4 barg	BOR	0.059%
Operating Temperature	-33 ℃	Bunkering Flow Rate	600 m³/h
Designed Temperature	-40 ℃	Supply Rate	13.7m³/h



P&ID of Type C Ammonia Fuel Tank

Key Technologies – Pressurization & Heat Exchange

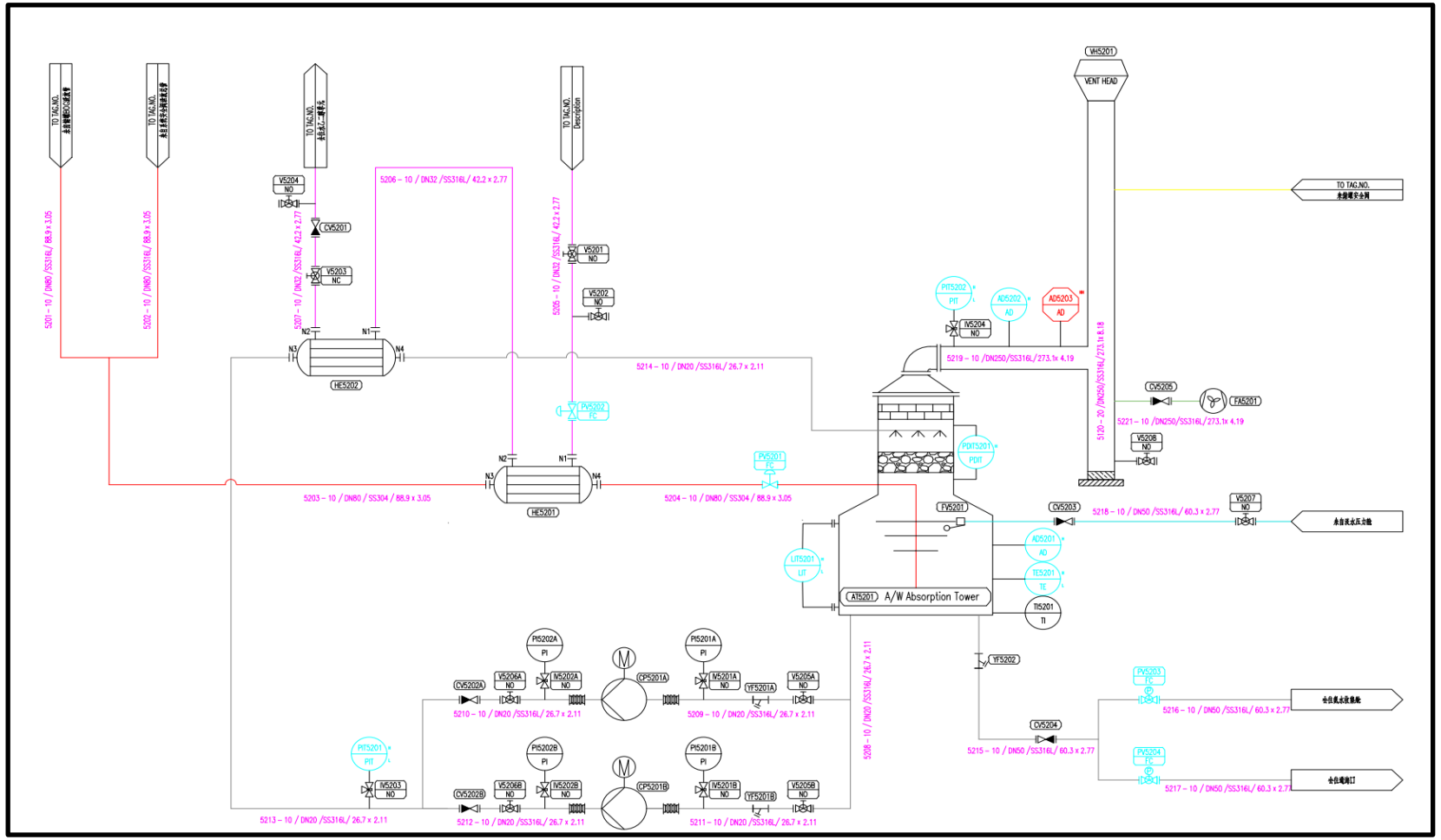
	01	02	03
Challenges	Compatibility between Supply and Consumption	Technical Route	Technical Proposal of High-Pressure Pump
Solutions	Hierarchical Pressurization Low-Pressure Pump High-Pressure Pump Pressure Stabilization Buffer Tank Before HP Gas-Liquid Separation Buffer Tank After HP Heat Exchange Key Parameters Medium Heat Exchanger	Technology Comparison Reliability & Cost Effective	Comparison of Different High-Pressure Pump Models Stability & Cost Effective
Goal	Applying Optimization for Different Control Schemes	Diversified Technological Fundamental	Applying Customized Schemes for Different Facilities

Key Technologies – Ammonia Gas Treatment

	01	02	03
Challenges	Direct discharge of ammonia gas to the atmosphere is prohibited	Design of Ammonia Treatment Unit	Design and Testing of Ammonia Absorb Tower
Solutions	Ammonia Treatment Comparison → absorb by water; absorb by acid; combustion; catalytic oxidation; Air Dilution	Technical Route Comparison	Design Verification
	Cost Effective & Technical Challenges	Installation Space & Maintenance	Accuracy of Simulation Result
Goal	Optimized Ammonia Treatment Solution	Diversified solutions for different ship types	compare the results from experiment and simulation

Key Technologies – Ammonia Gas Treatment

Independent design of the Absorption Tower & Vent Mast



Advantages:

- The filling element will increase the contact surface between ammonia gas and liquid, which is suitable for large gas flow conditions
- The heat exchanger can prevent frozen issues and the absorb efficiency reduction during ammonia dissolution caused by low-temp
- Analysis and simulation of Ammonia Absorption via CFD to verify the accuracy of the result

Key Technologies – Exhaust Gas Treatment

Challenges

Treatment of N_2O、NO、NO_2 and Ammonia in exhaust gas

Solutions

Method

- determine the catalyst
- SCR Optimization
- Utilization of Ammonia

⇩

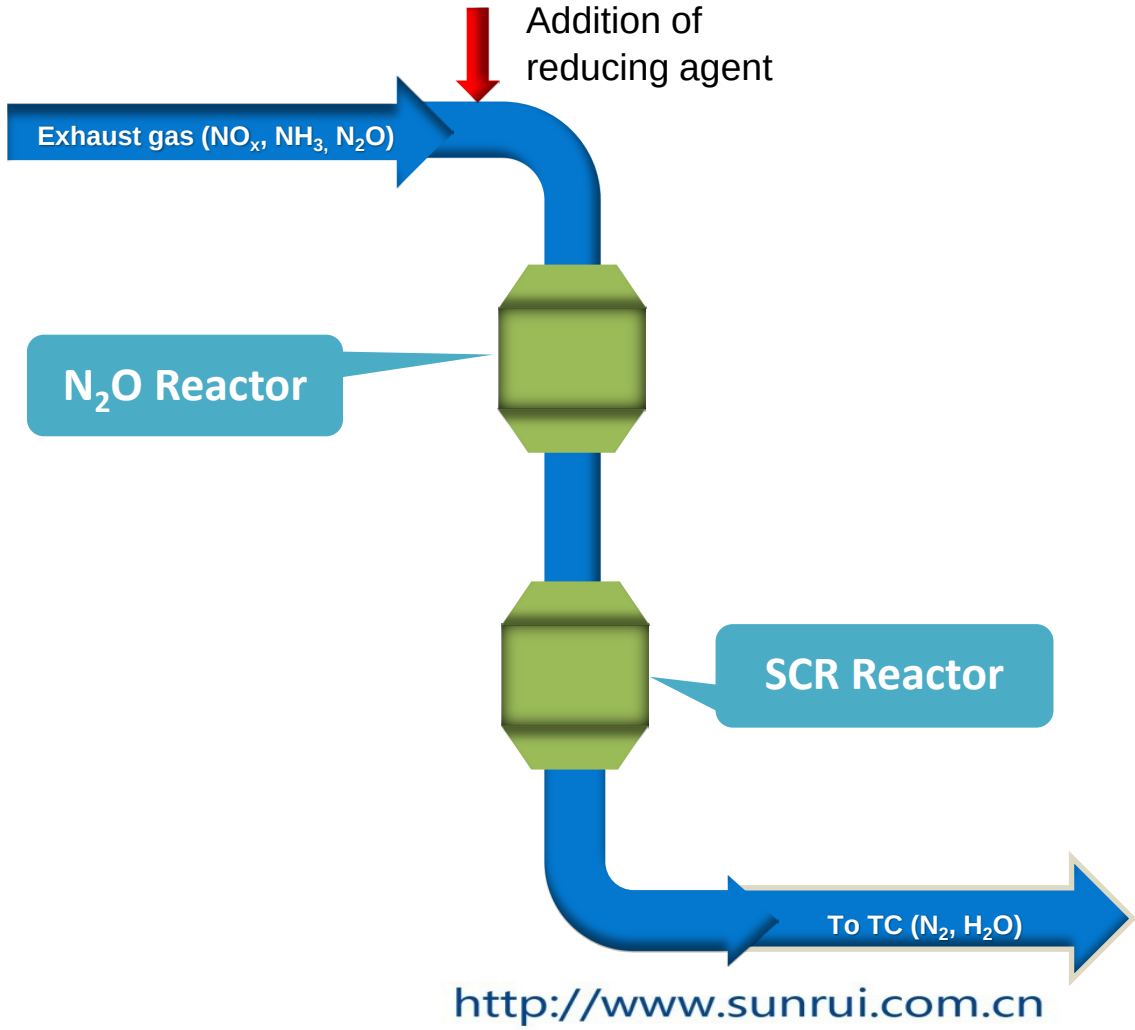
Technical Issues & Cost Effective

⇩

Goal

Develop new treatment solution based on current SCR design

⇨



合作创造未来
cooperation for a better future
双赢发展　瑞泽五洲