2018 AIChE Annual Meeting,
at Pittsburgh, PA

Confidential

Test Results of the Ammonia Mixed Combustion at Mizushima Power Station Unit No.2 and Related Patent Applications

October 31, 2018

The Chugoku Electric Power Co., Inc.

Energia Research Institute

Energia

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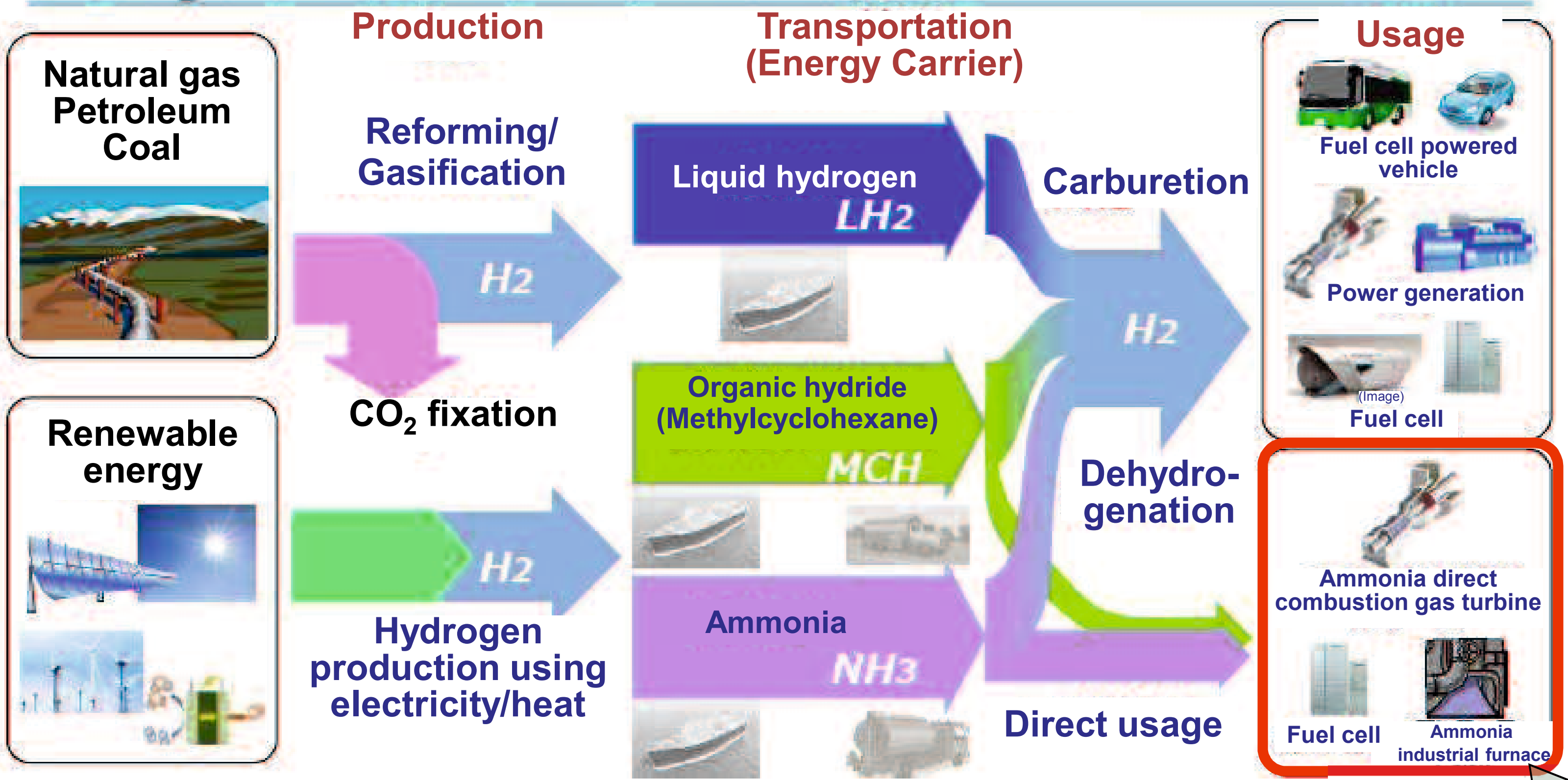
1. Outline of Research

1-1. Energy Carrier (Direct Combustion of Ammonia)

Overview: Efforts regarding the energy carrier issue

Establishment of a CO_2-free hydrogen value chain



- Hydrogen can be produced from a variety of energy sources such as fuel or electricity. (It is possible to achieve a significant reduction in CO_2 emissions.)
- Hydrogen is a gas with a low calorific value and is difficult to transport and store. It is important to develop technologies (energy carriers) that can transport large volumes of hydrogen as well as related technologies that use hydrogen as an energy source.

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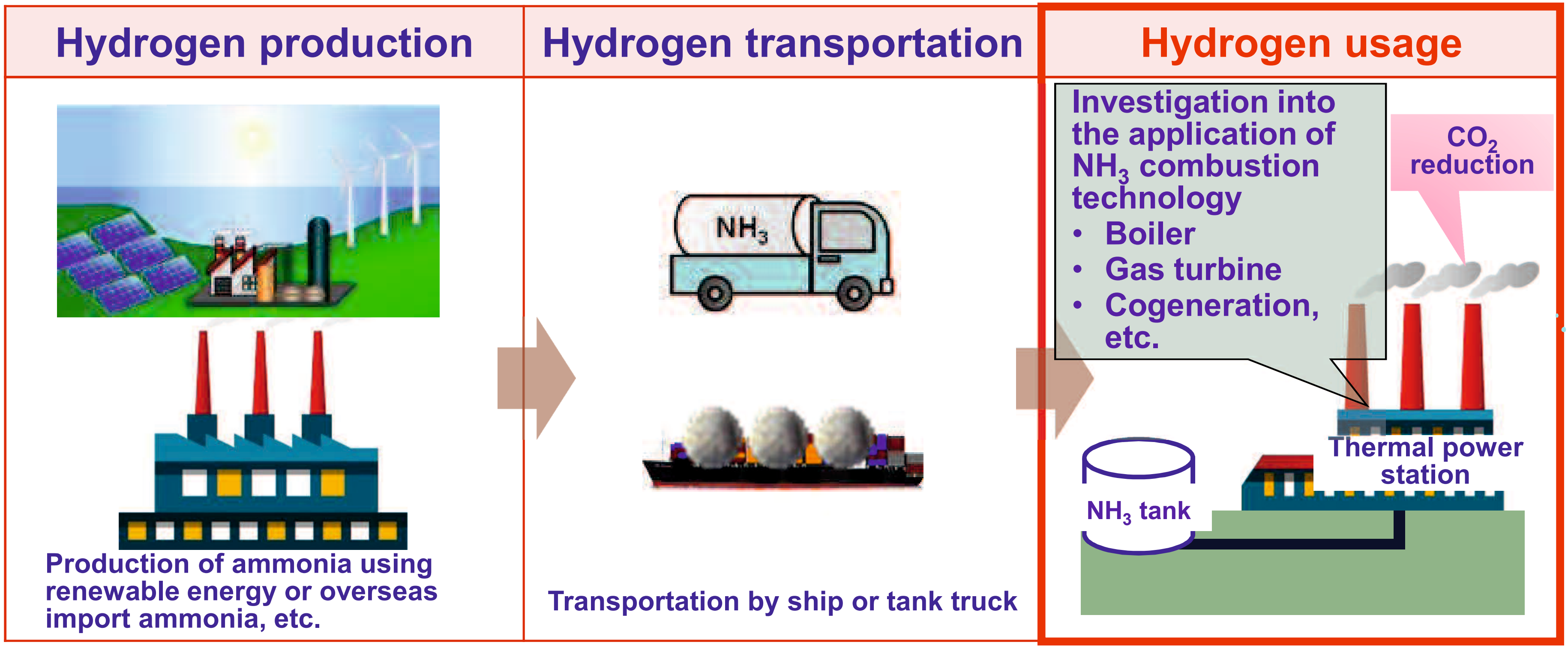
1-2. Outline and Aims of Research

[Outline]
Currently, we are undertaking commissioned projects through our Energy Carrier/Ammonia Direct Combustion Team as part of the Cabinet Office's Strategic Innovation Promotion Program (SIP). Part of these initiatives involves ammonia mixed fuel combustion tests at the Mizushima No. 2 boiler.

[Aims]
We aim to maximize the utilization of existing facilities and identify problematic issues through the implementation of mixed fuel combustion tests at a minimum cost in order to facilitate future research.



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1-3. Overall Research Plan

Research schedule and budget (details)	FY2015	FY2016	FY2017	FY2018
Team meeting	Participate ▼ ▼	▼ ▼	▼ ▼	
(1) Theoretical feasibility assessment	① Study regarding the use of ammonia at thermal power stations ② Study regarding pulverized coal fired boilers ③ Study regarding cogeneration	① Study regarding the use of ammonia at thermal power stations ② Study regarding pulverized coal fired boilers ③ Study regarding cogeneration	Ammonia mixed fuel combustion tests (Plan modification) Implement ammonia mixed fuel combustion tests to improve accuracy and enhance feasibility assessment content.	
(2) Feasibility assessment based on model verifications			Feasibility assessment based on model verifications	
(3) Feasibility assessment based on system verifications				Feasibility assessment based on system verifications

1-4. Feasibility Assessment Contents (Example)

FS Contents (Partial Excerpt)

Part I. Outline of Research

Part II. Equipment-Related
1. Investigation of equipment to be received
2. Investigation of tank related issues
3. Investigation of equipment to be dispensed
4. Investigation of boiler modifications, outline of the boiler remodeling plan, investigation of combustion equipment modifications, investigation of boiler system modifications
5. Investigation of control devices, basic control plan, control device modification content

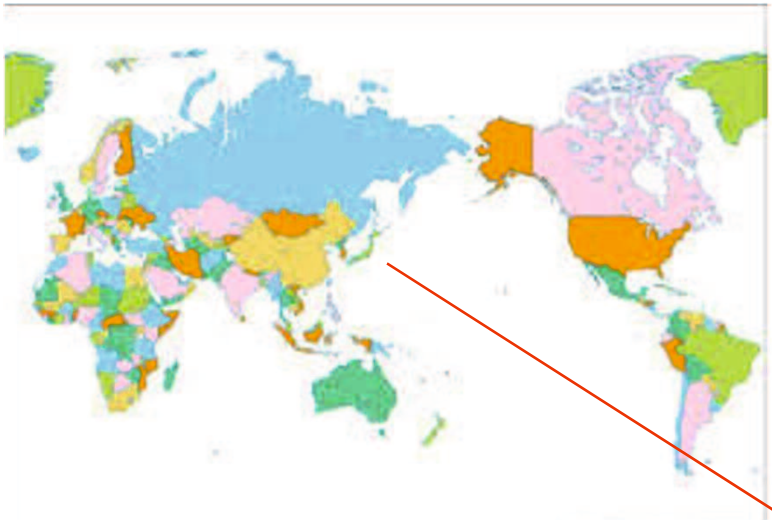
Part III. Plant-Related
1. Investigation of the layout
2. Investigation of electrical equipment
3. Investigation of operational characteristics, startup characteristics and load fluctuation characteristics, minimum load
4. Investigation of heat balance
5. Investigation of unit performance and environmental values, unit performance, boiler performance, environmental values, permits and licenses
6. Investigation of construction plans, construction schedule

Part IV. Expansion Feasibility Study
1. Planning conditions and aims
2. Investigation of ammonia supply system
3. Investigation of economic feasibility
   (1) Conditions for investigation
   (2) Trial calculation results
4. Investigation of CO_2 characteristics
   (1) Conditions for investigation
   (2) Trial calculation results

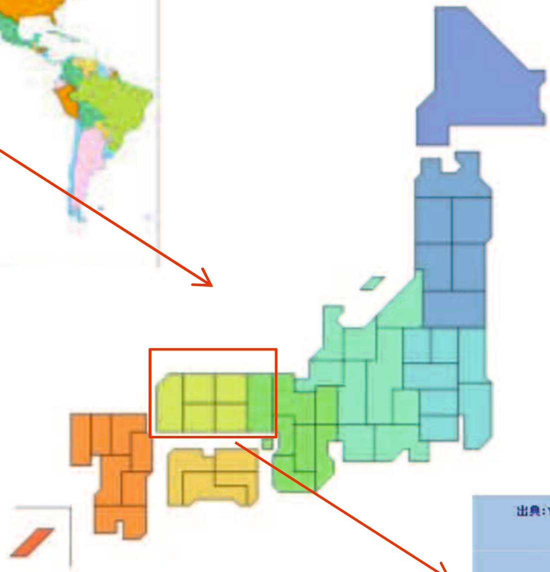
Part V. Summary
1. Main achievements
2. State of achievement of initial target

2. Mizushima Power Station

2-1. Location (1/2)



Japan



Chugoku Region

2-1. Location (2/2)

Chugoku Region

Mizushima Power Station

2-2. Outline of Power Station

	Unit 1	Unit 2	Unit 3
Output	285 MW	156 MW	340 MW
Commencement of operation	November 1961	August 1963	February 1973
Fuel	Natural gas	Coal	Natural gas

■ **Power Station Introduction**

Upon the establishment of the Mizushima Industrial Complex, the Mizushima Power Station started operation in 1961 before the construction of other plants in order to cover the electricity consumption of the entire complex.

Since the start of operation, we have repeatedly switched to the most suitable type of fuel at each particular time due to occasional energy situations and recent increased global environmental issues.

In April 2009, Unit 1 was converted to natural gas combined-cycle power generating facilities and we are now supplying highly efficient and clean electricity.

Mizushima Power Station is cooperating with comprehensive environment protection measures to conserve the local environment of Mizushima which contains both the historical town of Kurashiki along with a modern industrial complex.

The power plant site has an area of approximately 267,000 square meters, which is around six times that of Tokyo Dome. Around 25% of the area is green space.

Source: Chugoku Electric Power website.

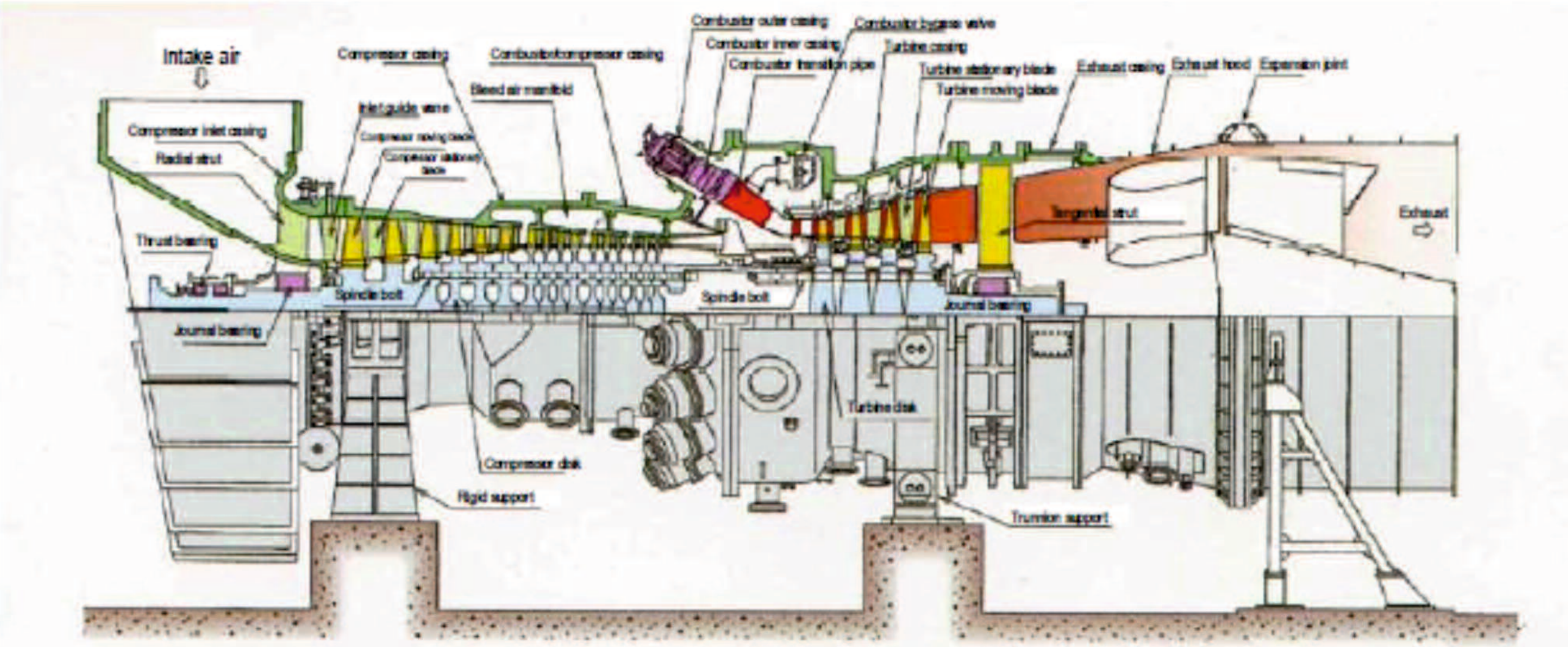
2-3. History

History of Mizushima Power Station

Item	Unit 1	Unit 2	Unit 3
Output	285 MW	156 MW	340 MW
Fuel	Coal → Crude oil →Coal→LNG	Crude → Coal	Crude → LNG
Start of commercial operation	November 1961	August 1963	February 1973
Start of commercial operation after conversion to oil	February 1970	—	—
Start of commercial operation after conversion to coal	July 1984	May 1984	—
Start of commercial operation after facility modernization	June 1993	June 1993	June 1994
Start of steam supply	—	May 2005	—
Start of multi-fuel fired power generation with natural gas	—	March 2006	—
Start of commercial operation after conversion to natural gas	—	—	April 2006
Start of commercial combined cycle power generation	April 2009		

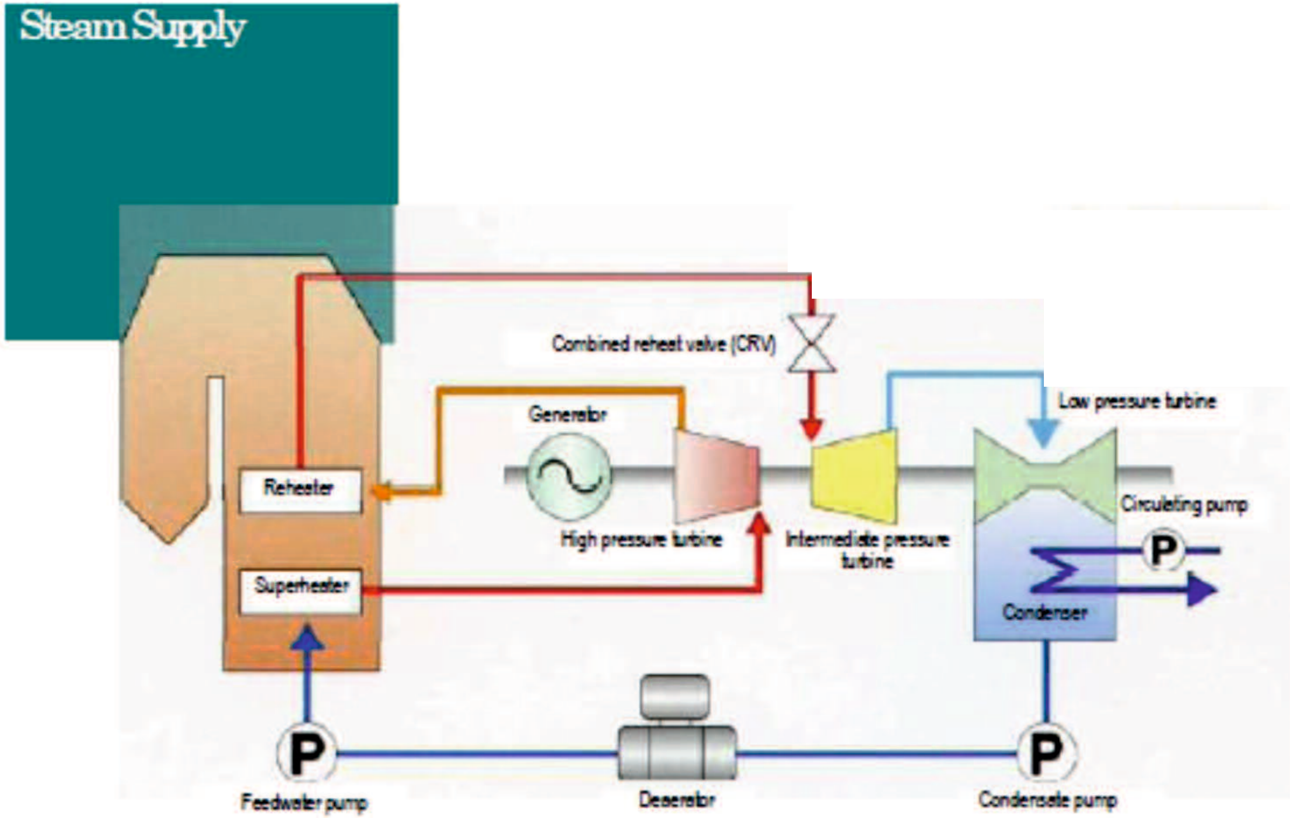
2-4. Unit 1 (Rated output: 285 MW)

Unit 1 has adopted a 1300°C gas turbine, M501F3, which enables high efficiency and high availability operation and is easily compatible with the existing steam turbine.



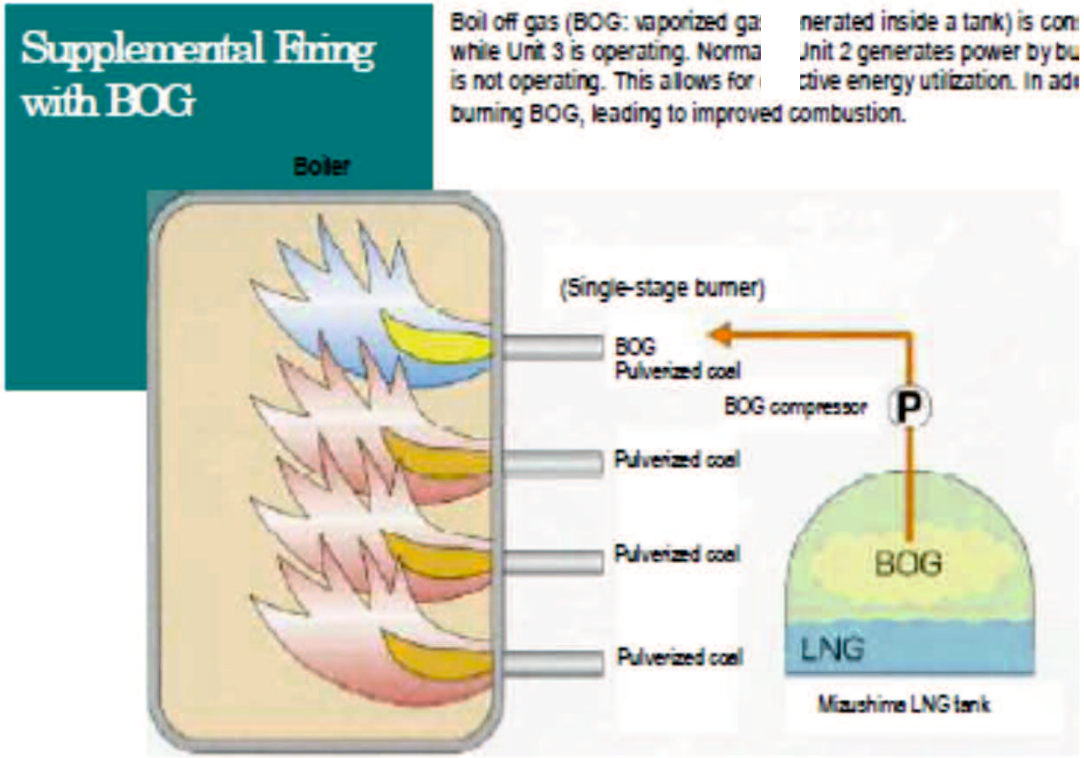
2-5. Unit 2 (Rated output: 156 MW)

Unit 2 has started operation using heavy oil as fuel in 1963 which was designed to be able to be converted to coal combustion in the future. It has been converted to coal combustion in 1984 and has been operating until now. It is a rare unit in Japan which keeps high availability even now although it has passed for over 50 years since the start of operation.



2-6. Boil off gas combustion equipment

Boil off gas (BOG: vaporized gas generated inside a tank) is constantly generated inside the LNG tank, and it is burned with LNG by the Unit 3 boiler while Unit 3 is operating. Normally, Unit 2 generates power by burning pulverized coal, but is able to burn BOG with the single-stage burner while Unit 3 is not operating.
This allows for effective energy utilization. In addition, the amount of unburned combustibles contained in ash can be reduced by burning BOG, leading to improved combustion.



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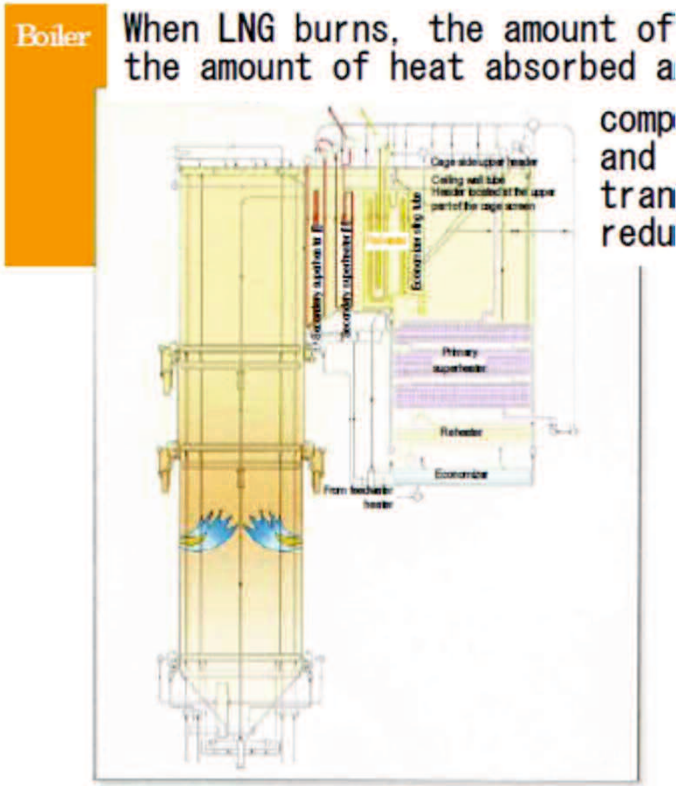
2-7. Unit 3 (Rated output: 340 MW)

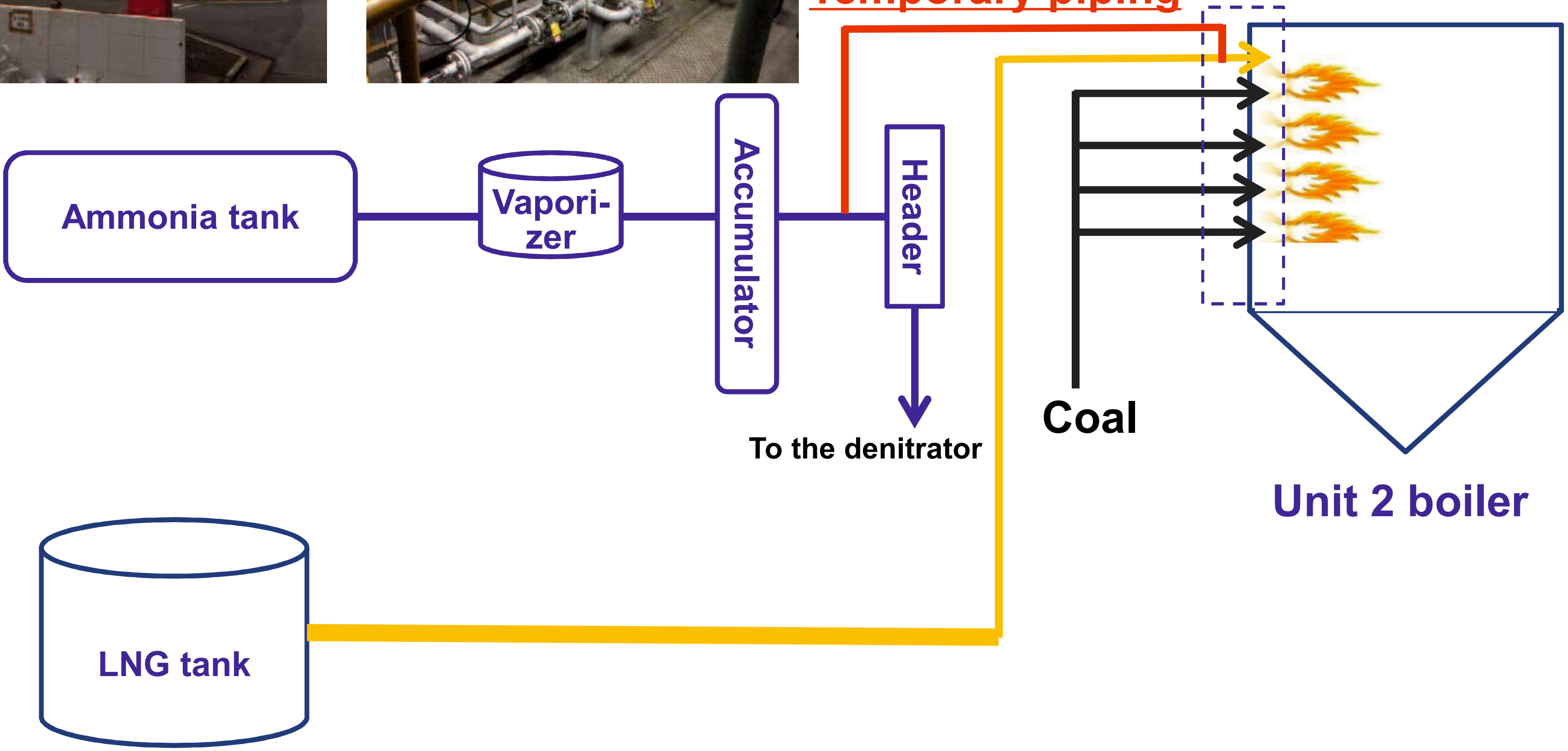
Unit 3 converted from heavy crude oil to LNG in April 2006 and is operating with only LNG supplied from the Mizushima LNG base. Because Unit 3 is operating with only LNG, it no longer causes SOx and dust and eliminates the need for desulfurization equipment and electrostatic dust collectors. This has resulted in a reduced environmental burden and plant energy consumption.



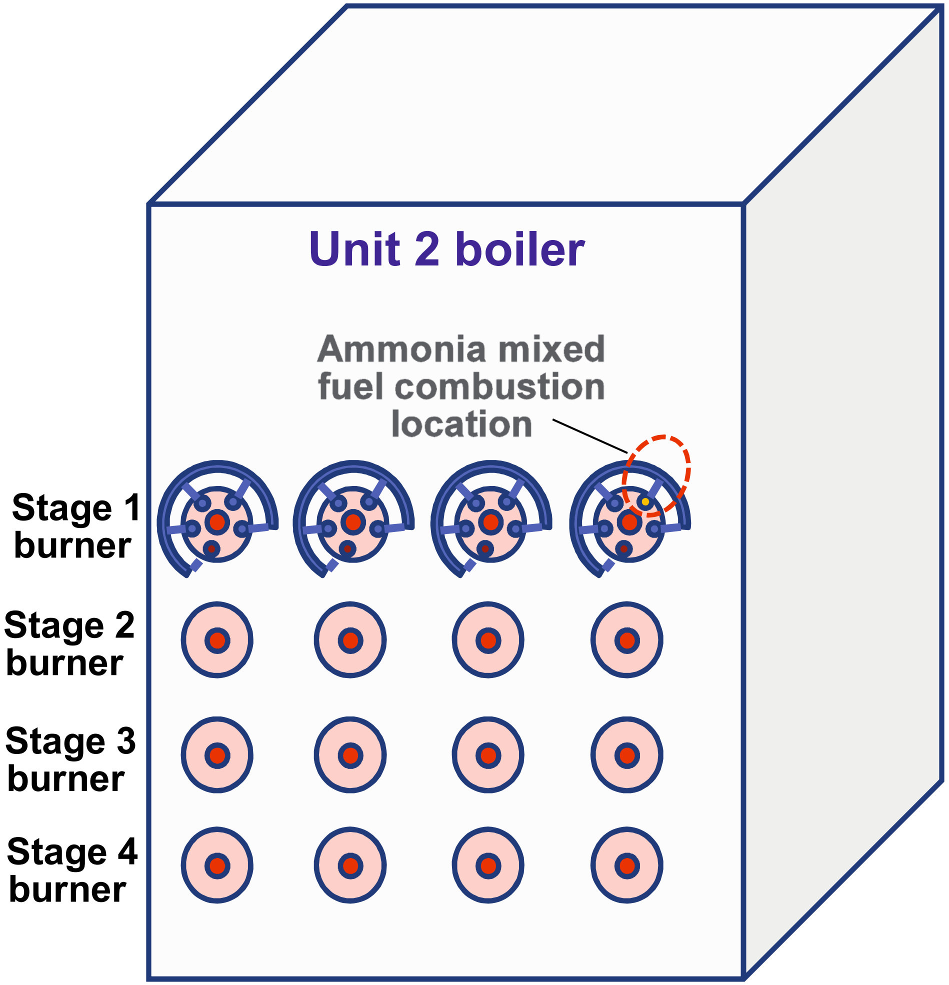
3. Test Facilities

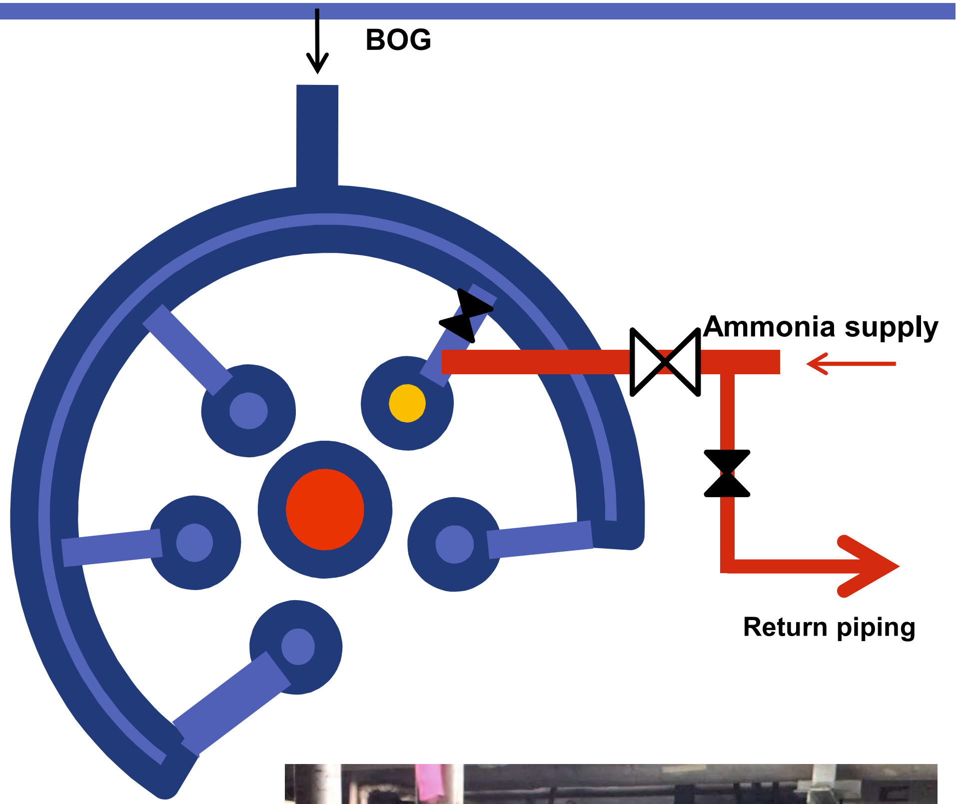
3-1. Temporary System

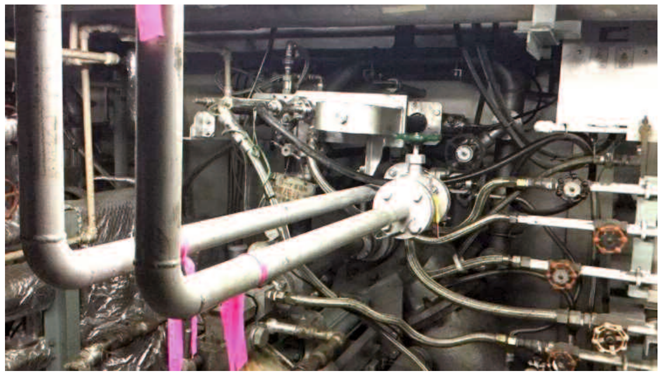
Piping was laid from the existing ammonia facilities to the Unit 2 boiler BOG burner and ammonia mixed fuel combustion was carried out using the amount of ammonia able to be supplied to the coal combustion boiler.



3-2. Temporary Burner







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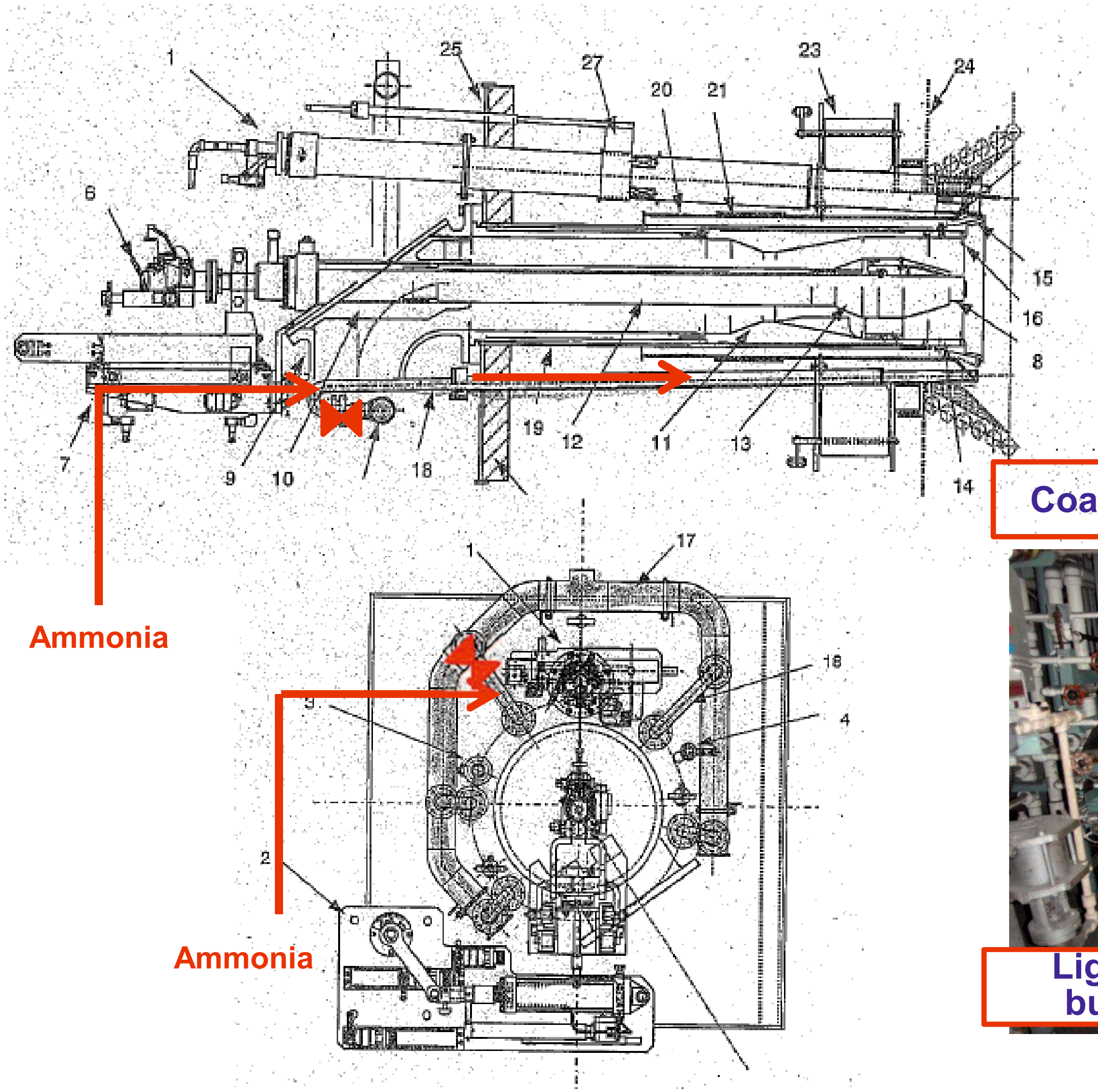
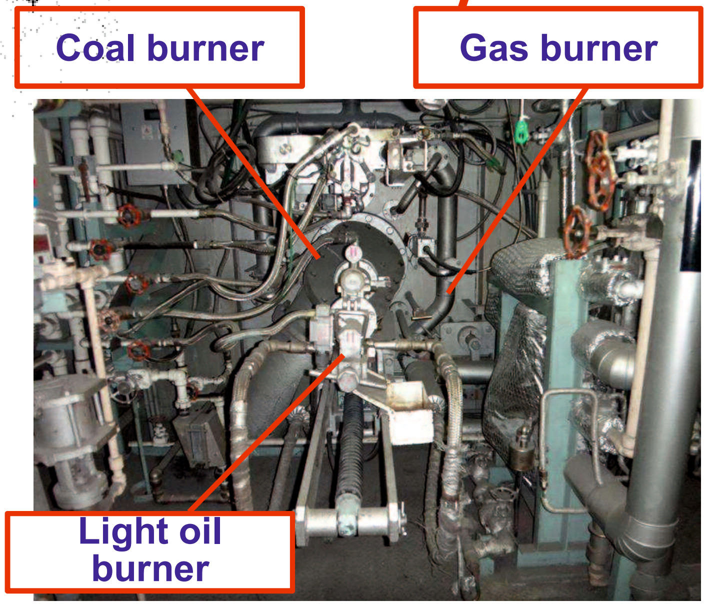
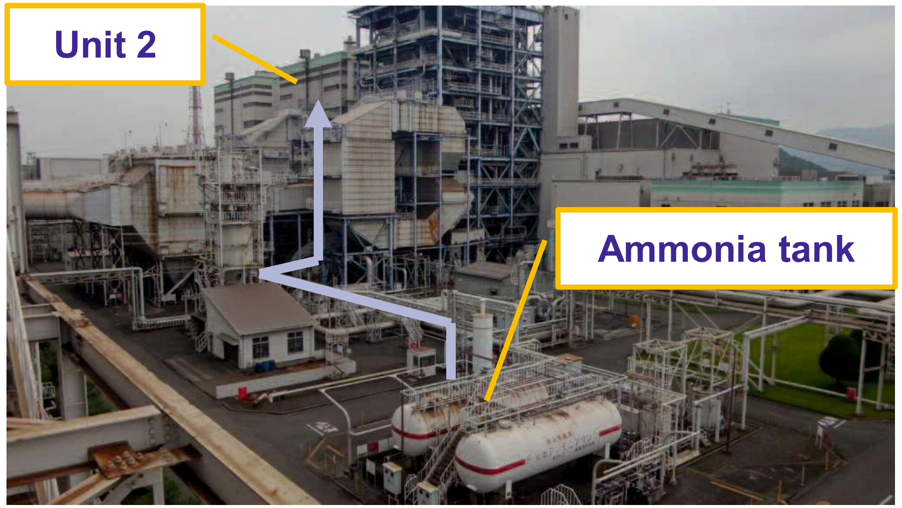
3-3. Area Around the Burner



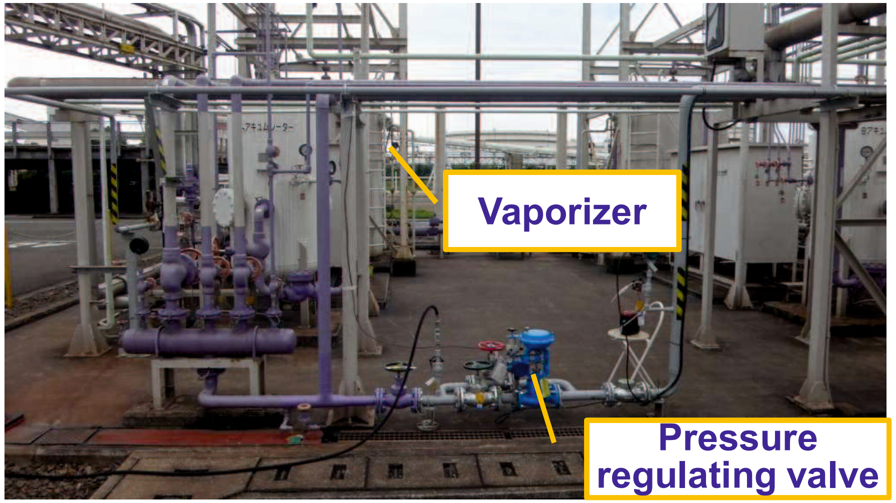
View of the burner from inside the furnace



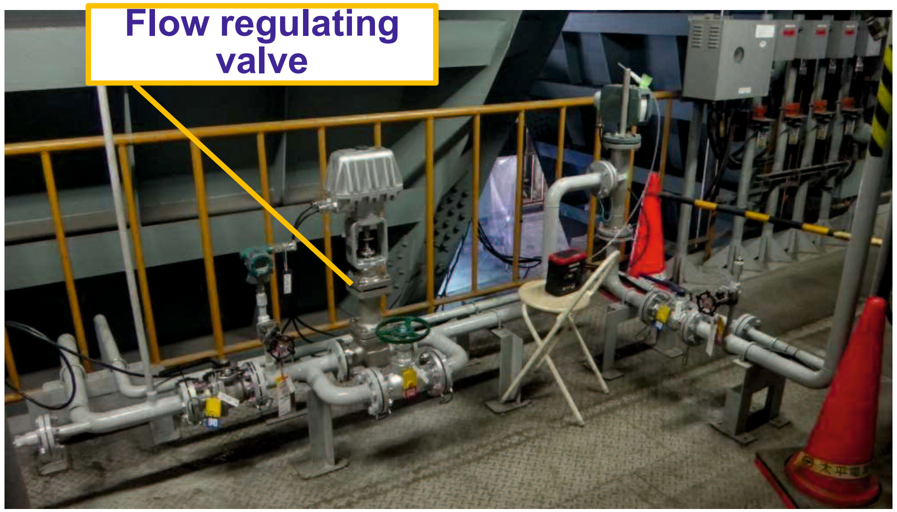
3-4. External Appearance



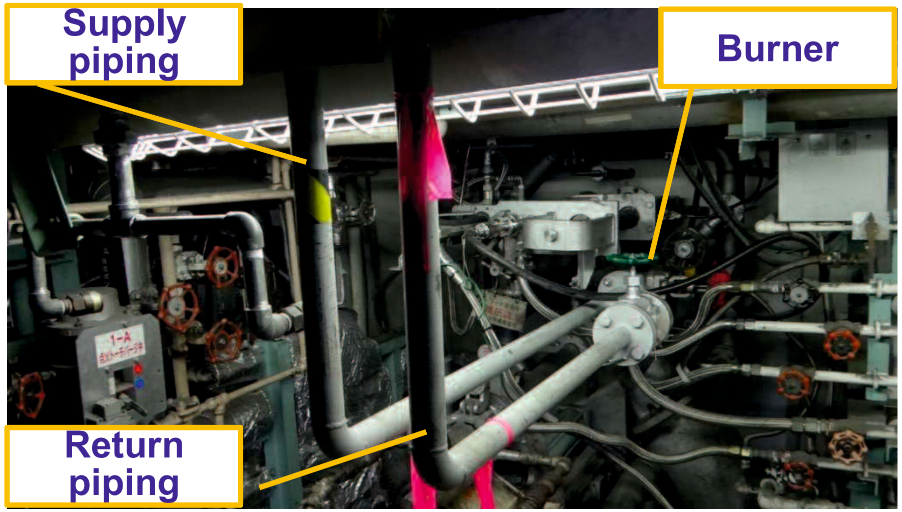
Overall view



Around the ammonia yard



Around the flow regulating valve



Around the burner

4. Testing Plan

4-1. Outline

- **Testing period:**
  Monday, July 3 to Sunday, July 9, 2017.
  Only during the daytime (8 am to 6 pm)

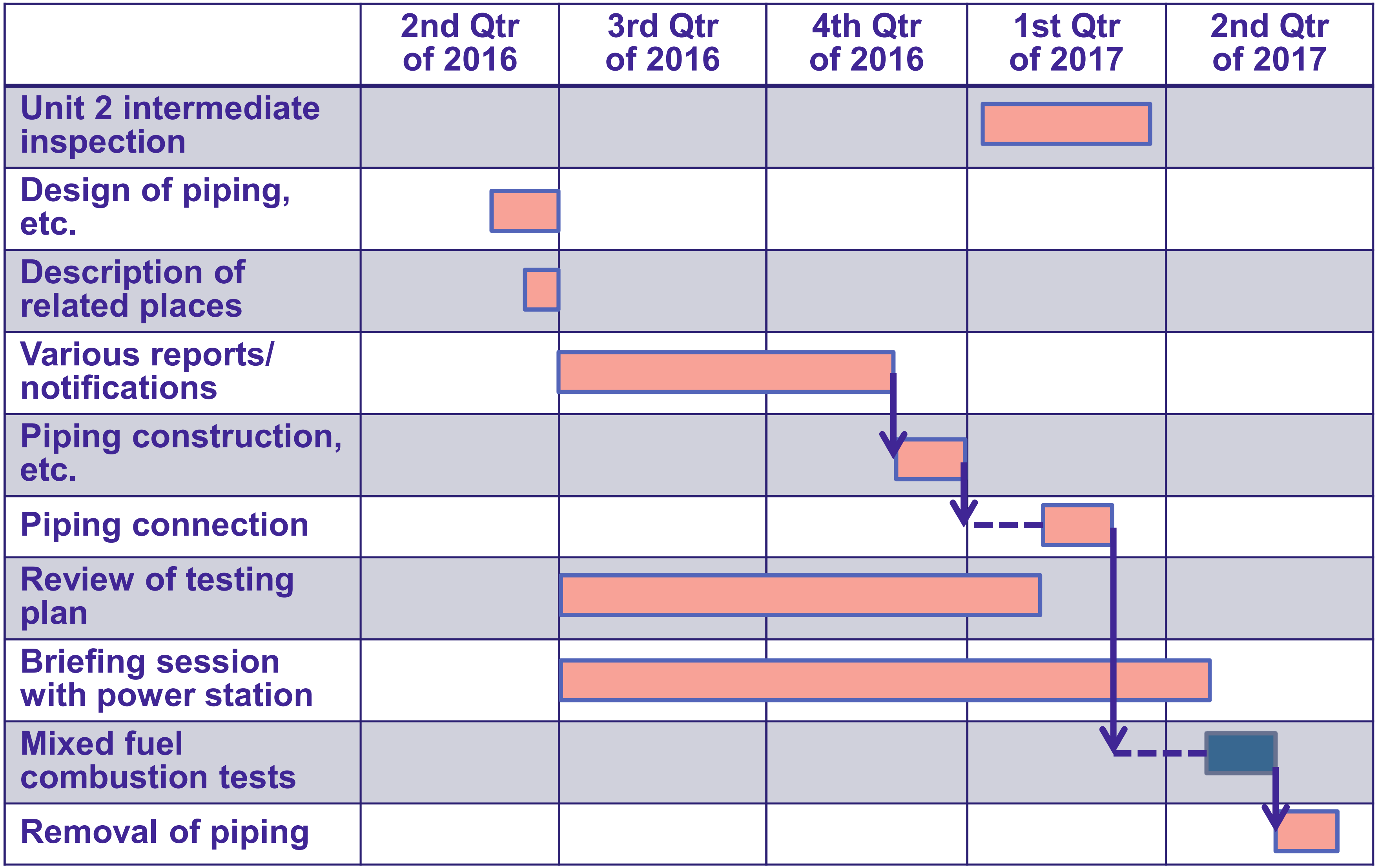
- **Ammonia consumption:**
  Up to 450 kg/h (maximum Vaporizer flow rate, equivalent to 400 kg of coal)

- **Mixed fuel burning ratio:**
  Approximately 0.6% (equivalent to 1 MW)
  However, on July 7 the test was conducted using a value of approximately 0.8% (≈1%) as Unit 2 was operated with a load of 120 MW.

- **Coal burner load during mixed fuel combustion**
  Ammonia combustion within the range where there is no excess exhaust gas emission (-1 MW).

- **Test content:**
  Pressure boosting test on the system after the vaporizer
  Ammonia burner combustion test, etc.

4-2. Overall Process



4-3-1. Preliminary Investigation Issues

Summary Sheet

a	Ammonia Combustion (1. Confirmation of explosion range, 2. Coaxial combustion, 3. Combustion confirmation method)
b	Effect on the Unit (1. Corrosion, 2. Ash clogging)
c	Submission of Notifications and Reports (Electricity Business Act, High Pressure Gas Safety Act, Fire Service Act)
d	Safety Measures (High Pressure Gas Safety Act)
e	Confirmation of Environmental Regulation Values (Amount of Exhaust Gas, NOx)
f	Investigation of Test Content
g	Investigation of Materials Compatible with Ammonia
h	Investigation of the Analysis of Unburnt Ammonia

a-1. Ammonia Combustion (Confirmation of Explosion Range)

○ **Allowable ammonia concentration values**

- **Explosive limit in the air: 15% to 28% (150,000 ppm to 280,000 ppm)**
  If no combustion occurred in this test, a level of around 2,000 ppm is acceptable.
- **Measuring instrument accuracy: 500 ppm (range) x 2% (accuracy) = 10 ppm**

Therefore, the allowable value is 10 ppm.

Flammable gas	Chemical formula	Molecular weight	Ignition temperature (℃)	Explosive limit (in air) (Volume %)		Explosive limit (ppm)	
				Lower limit	Upper limit	Lower limit	Upper limit
Ammonia	NH_3	17	651	15	28	150,000	280,000

4-3-3. Preliminary Investigation Issues

a-2. Ammonia Combustion (Coaxial Combustion)

○ **During ammonia combustion, the heat input of gas is adjusted to 1% or less. In this case, the burner heat input examination condition has a slight increase to 101% (coal 100% + gas 1%). This has no particular influence on factors such as the metal temperature.**

4-3-4. Preliminary Investigation Issues

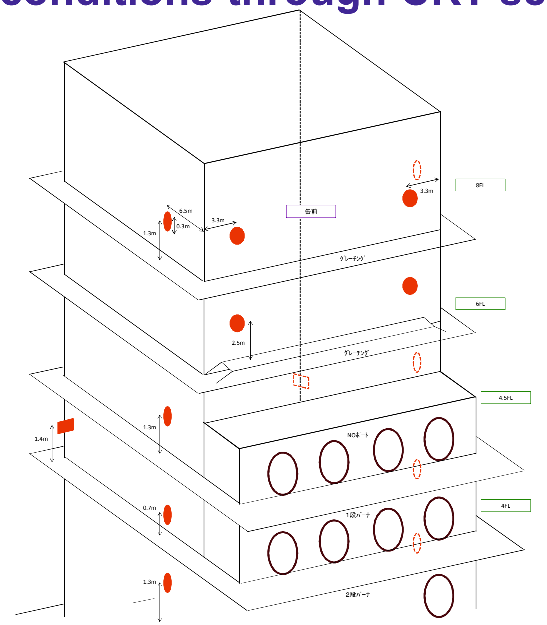
a-3. Ammonia Combustion (Combustion Confirmation Method (1/2))

① **As described below, the temperature of the burner measured using a radiation pyrometer is usually 1,350°C or higher. In addition, the minimum ignition temperature of ammonia is known to be 651°C. Therefore, if the ammonia combustion temperature measured using a radiation pyrometer is 800°C or higher, it can be assumed that combustion is occurring.**

② **The general state of combustion can be managed by looking through the observation holes.**

③ **The unburnt ammonia concentration is measured at the boiler outlet.**

④ **Monitor the entire plant conditions through CRT screens and data tables.**



Unit 2 boiler observation hole locations

a-3. Ammonia Combustion (Combustion Confirmation Method (2/2))

Unit 2 boiler in-furnace gas temperature reduction test data

* Types of coal used: Bontang (10%), Mount Owen (60%), Rio Tinto (30%)
* The burner temperature is measured with a radiation pyrometer through an observation hole (average value for 10 seconds)
* The atomized steam spray volume is an assumed value calculated from the volume of make-up water.

Implemented item			Before the test	Stage 1 & 2 atomization spray						
Point number	Unit	Item	June 2	June 2	June 3			June 4		June 5
			14:27	16:24	13:11	16:45	21:54	10:46	21:15	9:19
-	MPa	Atomization pressure (Stage 1 burner)	0.0	0.3	0.6	0.6	0.6	0.6	0.6	0.6
-	MPa	Atomization pressure (Stage 2 burner)	0.0	0.1	0.1	0.6	0.6	0.6	0.6	0.6
-	T/H	[Assumed] Atomization spray volume	0.0	2.0	Unknown	4.8	4.8	4.8	4.8	4.8
-	MW	Boiler master	153.2	153.2	152.1	152.1	152.1	152.1	152.1	152.1
-	°C	Burner temperature (Stage 1) Right	1,361	1,387				1,396		1,351
-	°C	Burner temperature (Stage 1) Left	1,396	1,370				1,364		1,369

4-3-6. Preliminary Investigation Issues

b-1. Effect on the Unit (Corrosion)

◎ **For coal combustion, N content generally only affects the NOx value and the generation of ammonium sulfate.**

◎ **It is assumed that the moisture content of the exhaust gas increases by around 0.4% which does not pose any particular problem.**

The material of the ammonia facilities is selected based on the "Ammonia Facility Regulations". In addition, it has been determined that there is no problem in regard to the boiler/smoke duct system as ammonia dissociates at the combustion temperature.

[Materials]

(1) Metals and nonferrous metals * "Ammonia Facility Regulations" (JEAC 3712-2013)

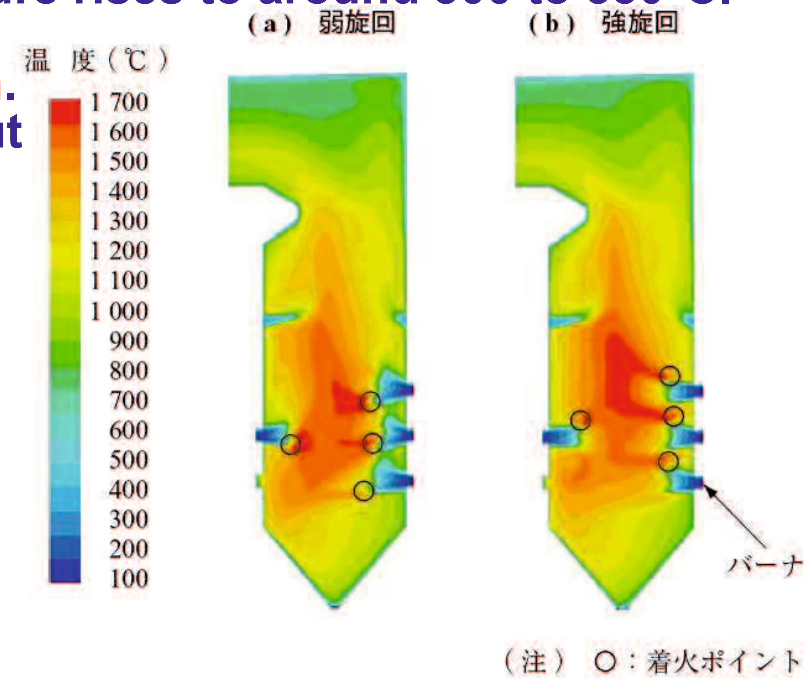
- **○Materials that must not be used**
  - **Copper and copper alloys, general structural rolled steel (SS, pressure resistant structures), carbon steel tubes for piping (SGP, piping that can leak ammonia)**
- **○Materials that are recommended not to be used**
  - **Steel plates for pressure vessels (SPV450 and SPV490), aluminum and aluminum alloys**

(2) Gasket and seal types * Reference: Packing Land website

- **○Must not be used**
  - **Fluororubber (FKM), fluorosilicone rubber (FVMQ)**
- **○Materials that are recommended not to be used**
  - **Nitrile rubber (NBR), tetrafluoroethylene propylene rubber (FEPM)**

b-2. Effect on the Unit (Ash Clogging)

- **At 500°C, ammonia is known to decompose 99.7%.**
  ⇒ Coal combustion temperature of 1,300°C or higher
- **N content is generally not a cause of problems such as the adhesion of ash.**
- **When sulfur trioxide (SO_3) is contained within the exhaust gas, acidic ammonium sulfate (NH_4HSO_4) is generated. Acidic ammonium sulfate decomposes when the gas temperature rises to around 300 to 350°C.**
  ⇒Exhaust gas temperature of 350°C or higher results in decomposition.
- **Analysis of the ash can be carried out when necessary.**



第 10 図 炉内ガス温度分布

出典：IHI技報Vol. 51 No.1 (2011)

4-3-8. Preliminary Investigation Issues

c. Submission of Notifications and Reports

Electricity Business Act, High Pressure Gas Safety Act, Fire Service Act, etc.

d. Safety Measures (High Pressure Gas Safety Act)

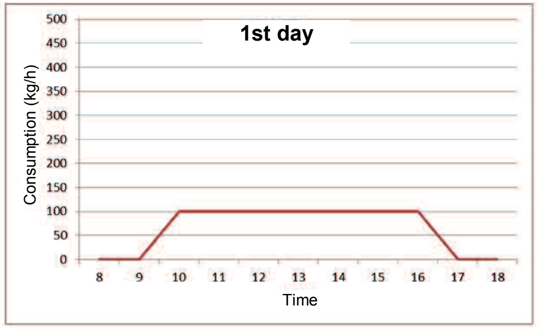
Compliance involving existing ammonia equipment.

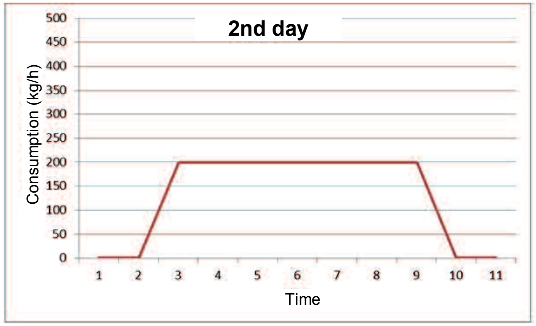
e. Confirmation of Environmental Regulation Values (Amount of Exhaust Gas, NOx)

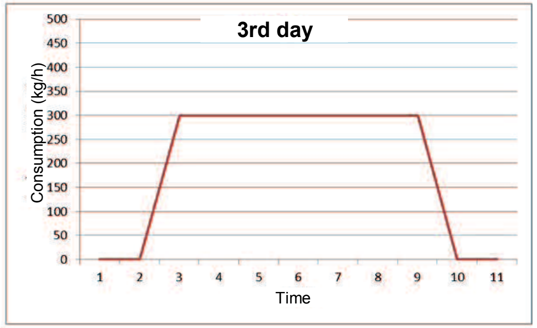
To be carried out within the scope of the previously-submitted "Instructions Regarding Soot".
However, instantaneous excessive NOx emissions shall be determined upon negotiation with government organizations in advance.

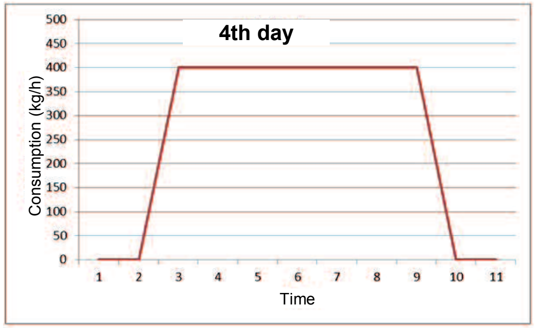
4-3-9. Preliminary Investigation Issues

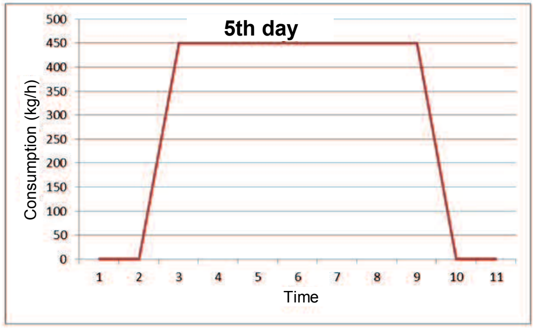
f. Investigation of Mixed Fuel Combustion Patterns

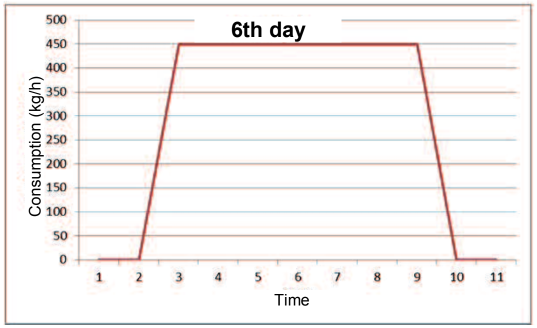


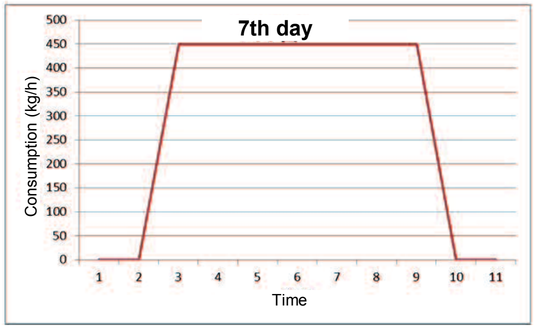












g. Investigation of Materials Compatible with Ammonia

- **Ammonia is not compatible with fluororubber and copper materials.**
- **After investigating the materials used in the existing BOG system, it was determined that the existing equipment cannot be utilized as it contained materials that were not compatible with ammonia.**

Results of investigating the materials of parts such as gaskets and seals in the existing BOG system

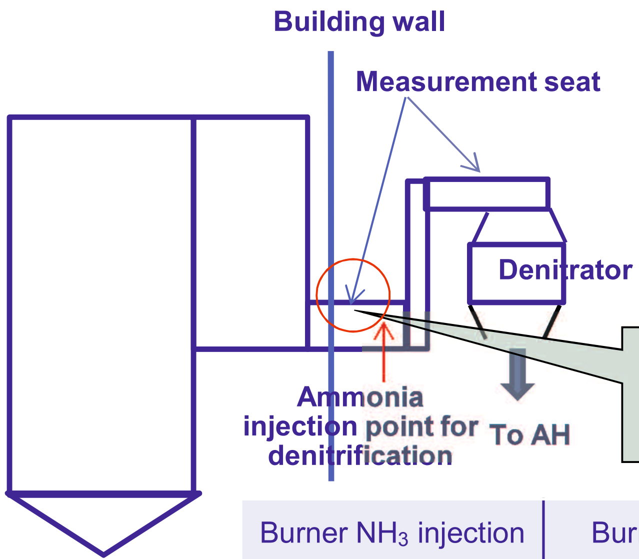
	Gas emergency trip valve	Gas burner main valve	Gas leak check valve	Pressure regulating valve
O-ring	Viton	Viton	Viton	NBR
Evaluation	Not applicable	Not applicable	Not applicable	Permissible

Reference: https://www.packing.co.jp/SIRYOU/packing_rubber_ptfe/a.htm

	Pressure gage	Limit switch	Gas main pipe pressure test seat seal
Material	Copper	Silicone rubber	Brass
Evaluation	Not applicable	Not applicable	Not applicable

4-3-11. Preliminary Investigation Issues

h. Investigation of the Analysis of Unburnt Ammonia in the Exhaust Gas



- Decrease of NOx concentration due to NOx reduction at the burner (change in inlet NOx) + Decrease of NOx due to denitration ⇒ NH3 volume
- Decrease in NH_3 volume due to unburnt NH_3, temporary decrease in outlet NOx

Under consideration based on the manual analysis of unburnt ammonia in the exhaust gas before ammonia injection.

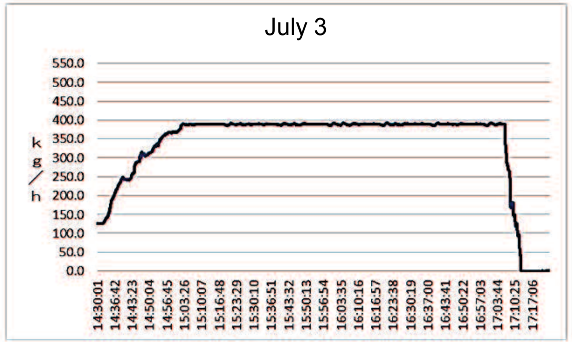
Burner NH_3 injection	Burner NOx	Unburnt NH_3	Inlet NOx	Volume of denitrated NH_3	Outlet NOx
Not present	Base	—	Base	Base	Set value
Present	Base	Not present	Base	Base	Set value
Present	Base	Partially present (small)	Base	Small decrease	Small temporary decrease
Present	Base	Present (large)	Base	Large decrease	Large temporary decrease
Present	Decrease (reduction effect)	Not present	Decrease due to reduction	Decrease due to reduction	Set value
Present	Decrease (reduction effect)	Partially present (small)	Decrease due to reduction	Small decrease	Small temporary decrease
Present	Decrease (reduction effect)	Present (large)	Decrease due to reduction	Large decrease	Large temporary decrease

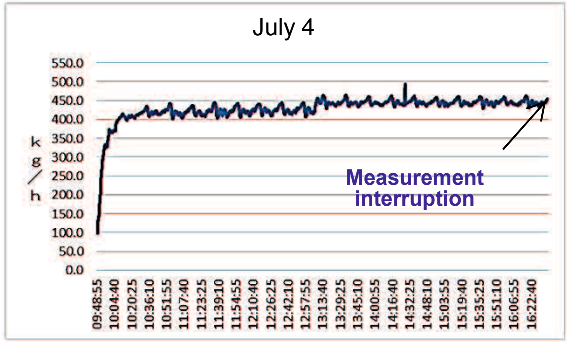
5. Test Results

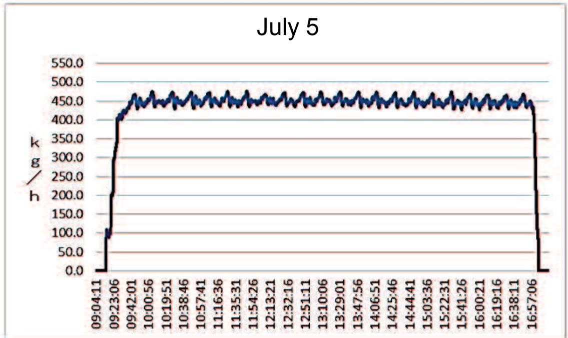
5-1. Schedule (Actual)

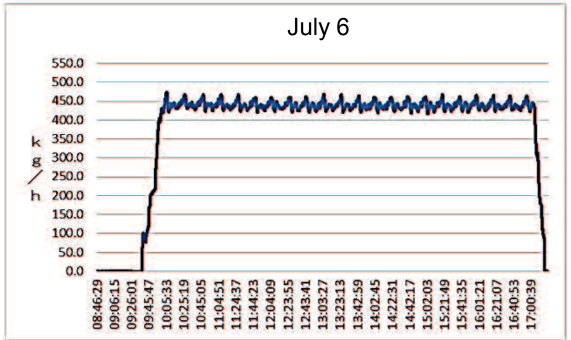
Total ammonia consumption: Approx. 20 tons

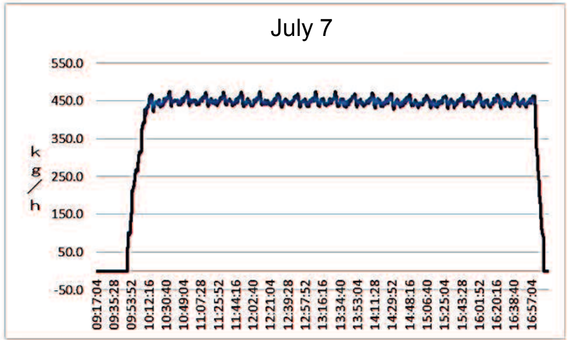
	NH_3 volume kg/h	Start of mixed fuel combustion	Achievement time	Decrease time	End of mixed fuel combustion	Remarks
July 3	(390)	12:59	15:03	17:06	17:00	Defective flowmeter indicator
July 4	425	9:48	10:24	-	-	
	450	-	13:07	16:31	17:00	
July 5	450	9:14	9:43	16:56	17:04	Initial NOx meter inspection
July 6	450	9:38	10:10	17:00	17:15	
July 7	450	9:50	10:12	17:01	17:10	
July 8	450	9:38	10:08	16:42	16:52	
July 9	450	9:29	9:43	11:42	11:49	

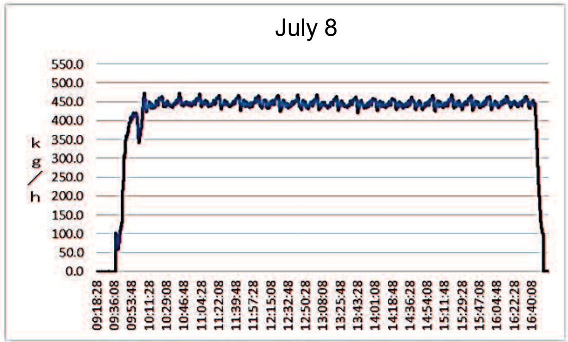


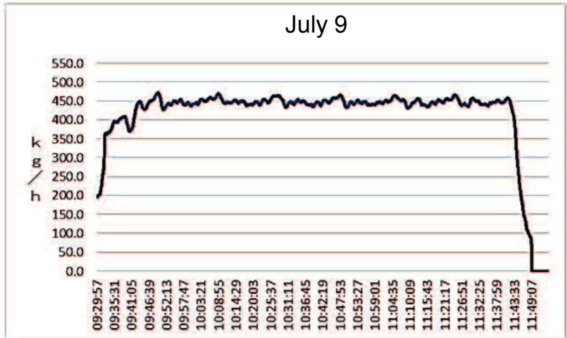










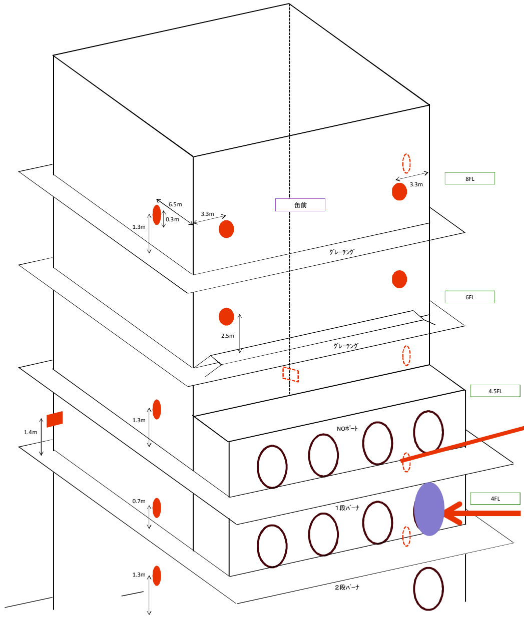


5-2. Summary

■ No particular issues were identified.

Item		Action	Result of inspection	Remarks
Inspection of running state (Pressure, temperature, flow rate)	Power generation output	Instrument monitoring	No problem	* Performed at 155 MW and 120 MW
	Boiler body (in-furnace camera monitoring, in-furnace visual inspection, metal temperature checks)	CRT monitoring, on-site monitoring	No problem	7.3, 7.4
	Coal system	CRT monitoring, on-site monitoring	No problem	7.5 * Ammonia mixed fuel combustion amount ≈ Reduction in coal amount
	Burner characteristics (added ammonia system)	CRT monitoring, on-site monitoring	No problem	7.6
	Smoke duct system	CRT monitoring, on-site monitoring	No problem	7.7
	Air preheater	CRT monitoring, on-site monitoring	No problem	7.7
	Denitrator	CRT monitoring, on-site monitoring	No problem	7.7
Exhaust gas measurement	NOx, boiler outlet NH_3, CO_2, etc.	CRT monitoring, manual analysis	No problem	7.8, 7.9, 7.10 * NOx: No change * Boiler outlet NH_3: Almost zero * CO_2: Slightly decreasing trend
Ammonia flow rate		Confirm consumption using a flowmeter	No problem	7.6
Coal grade analysis		Confirmation of acceptance grade	No problem	* Mount Owen 60%, Boggabri Premium 40% 7.11
Ash component analysis	Ash melting point (softening point), etc.	Manual analysis	No problem	(reference) As it is after ammonia injection to the denitrator
Measures to prevent ammonia leakage		Measurement using a gas detector (handheld type)	No leaks	

5-3-1. In-Furnace Combustion State



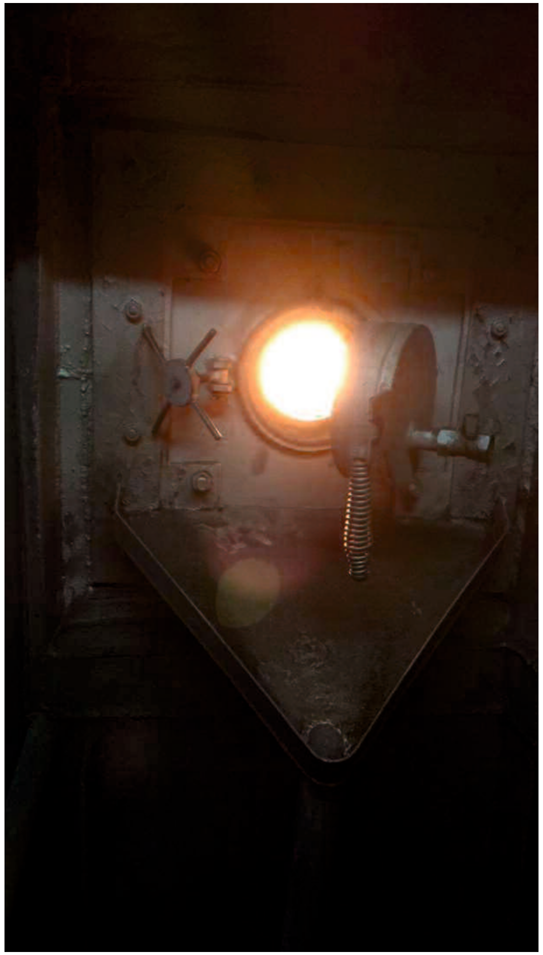
Rear

Unit 2 boiler observation hole locations

○●: Observation hole

OFA

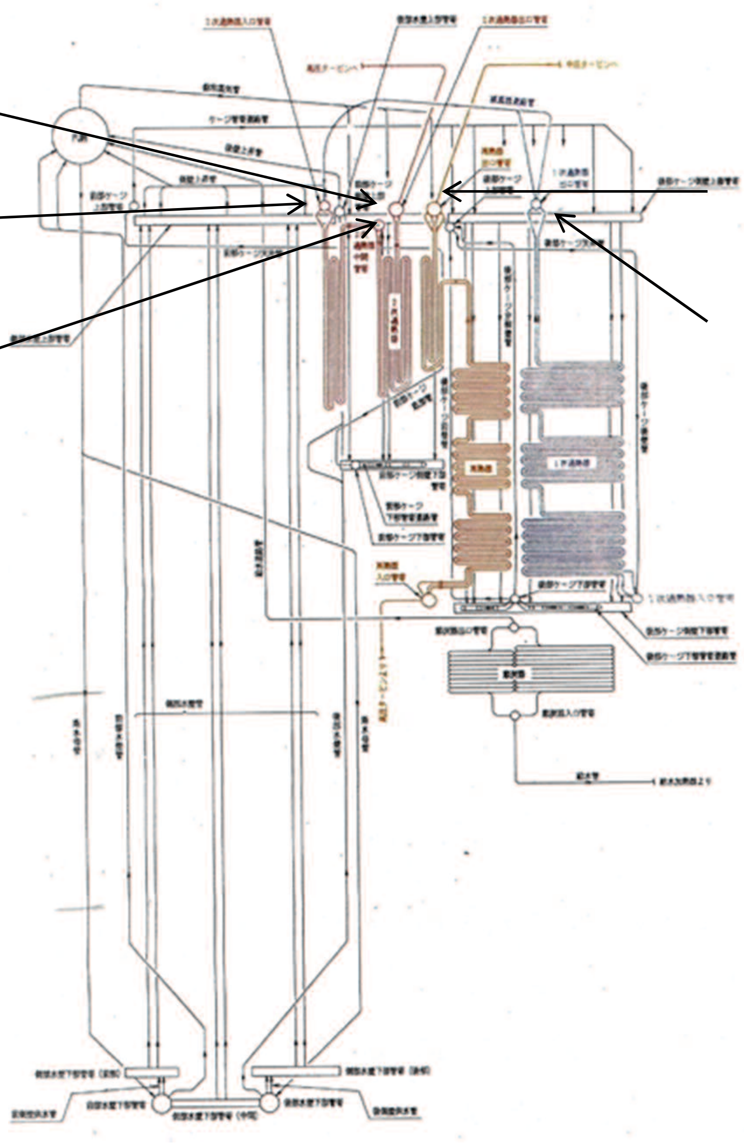
Combustion burner (Stage 1 A)



Measured using a radiation pyrometer (Portable radiation thermometer: IR-AH manufactured by Chino): 1,210°C

5-3-2. Boiler Metal Temperature Measurement Locations

- Secondary superheater outlet
- Secondary superheater inlet
- Secondary superheater intermediate



- Reheater outlet
- Primary superheater outlet

5-3-3. Boiler Metal Temperature

■ Almost no change

450 kg/h mixed fuel combustion

Combustion of coal only

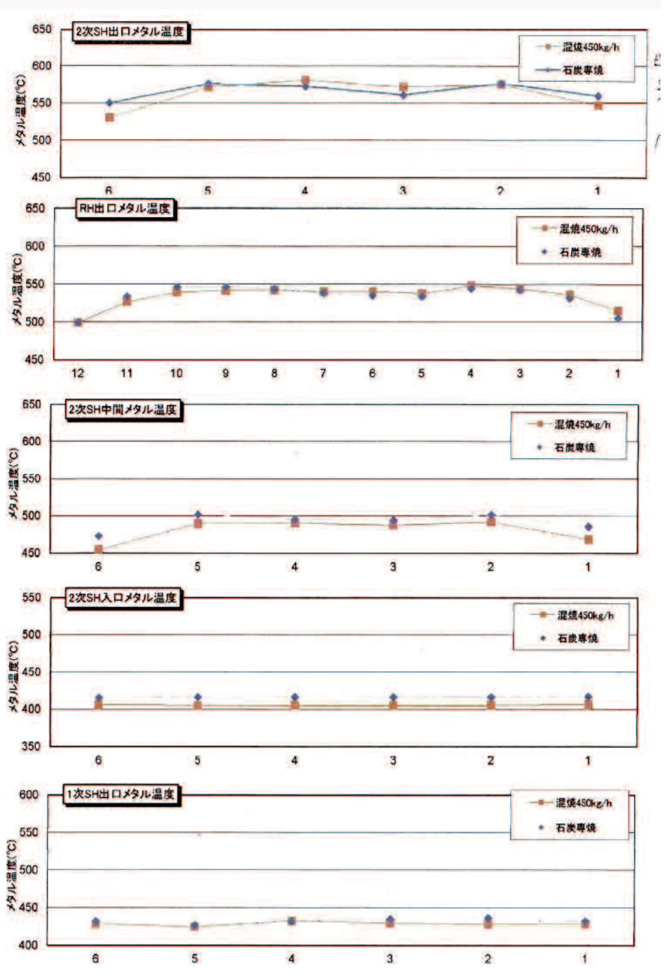
Secondary SH outlet Metal temperature

RH outlet Metal temperature

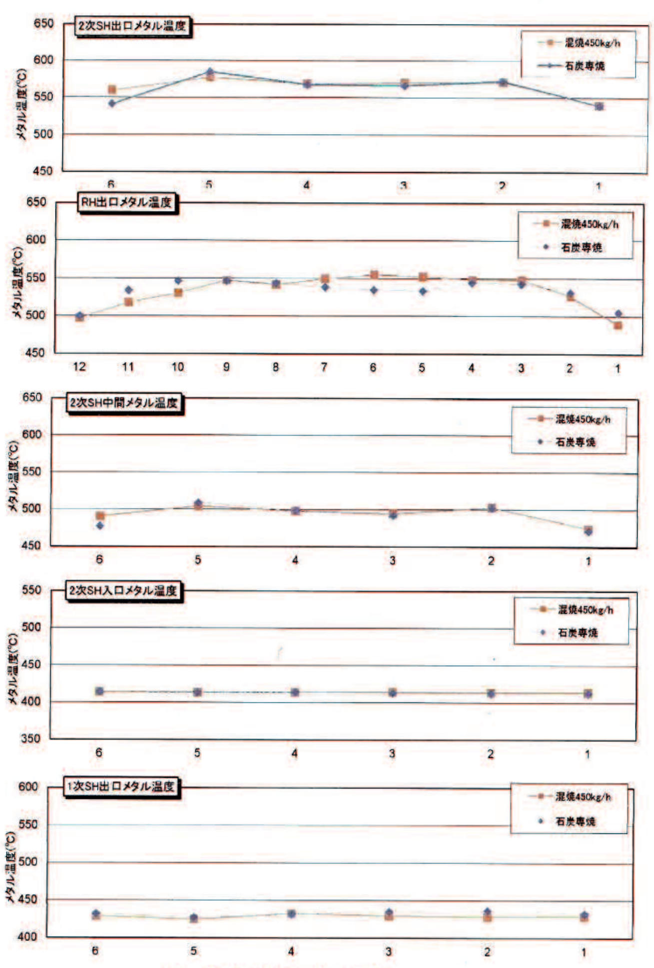
Secondary SH intermediate Metal temperature

Secondary SH inlet Metal temperature

Primary SH outlet Metal temperature



メタル温度分布記録（負荷：155MW）



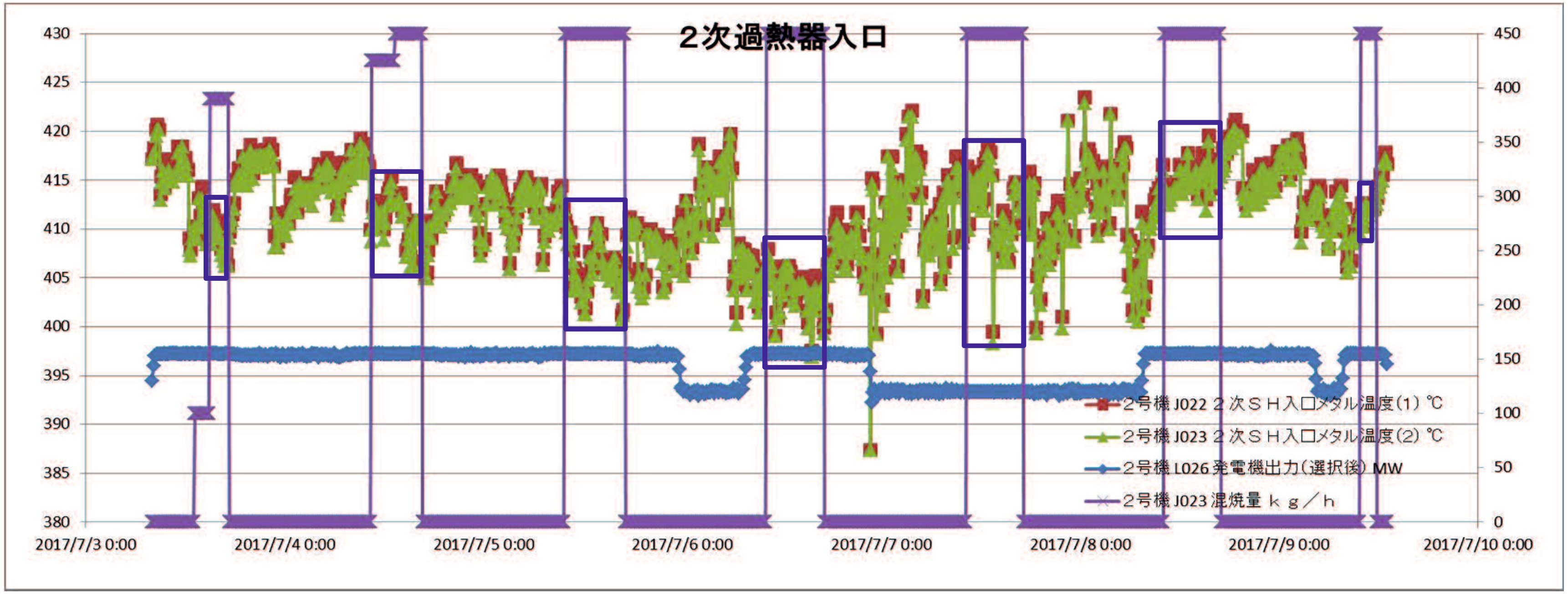
メタル温度分布記録（負荷：120MW）

Furnace left　　Furnace right　　Furnace left　　Furnace right

Energia

5-3-4. Boiler Metal Temperature (Secondary Superheater Inlet (Right End))

- **Almost no change**



Warning value: 530°C

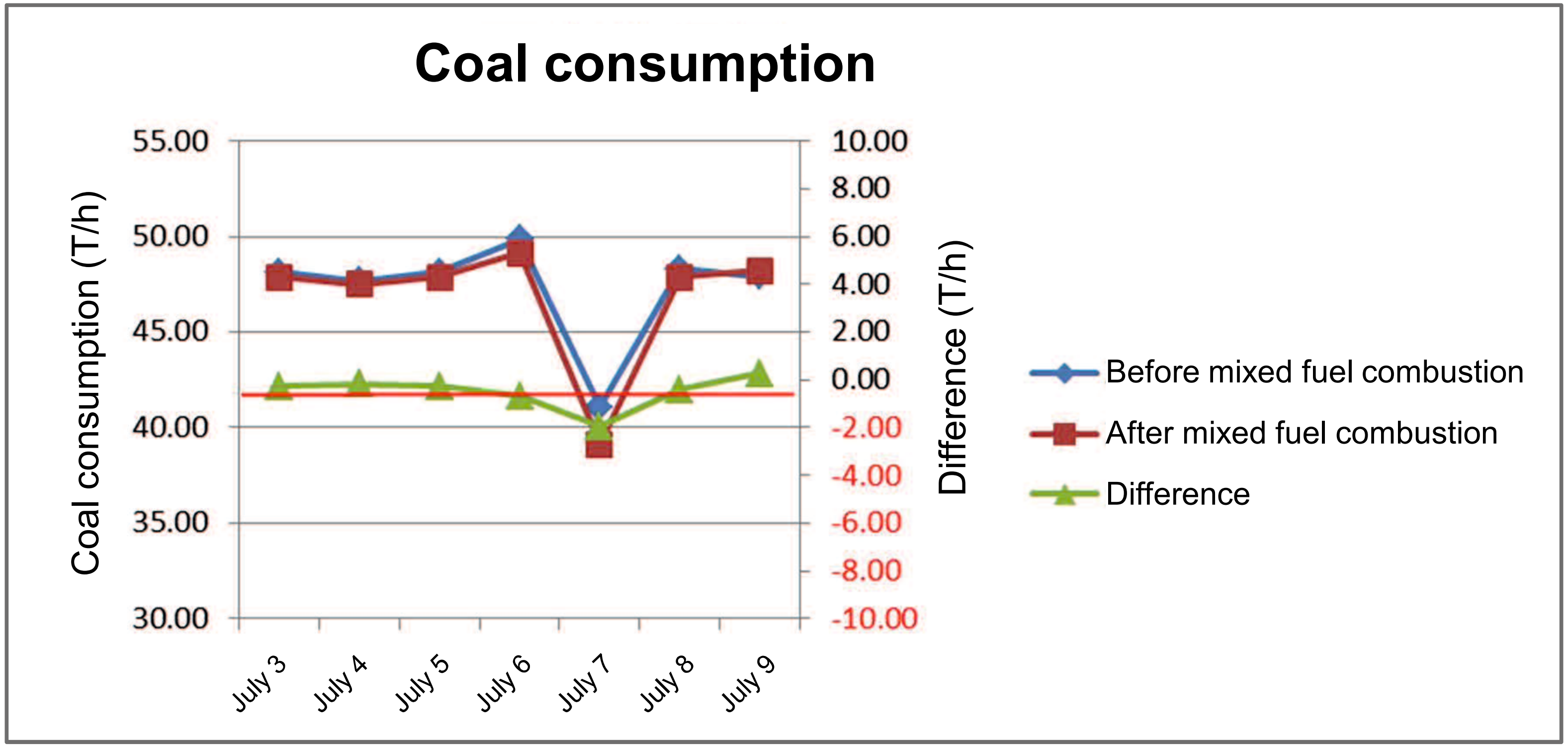
Left axis scale: Metal temperature (°C)

Right axis scale: Generator output (kW), mixed fuel combustion amount (kg/h)

5-3-5. Evaluation of Coal Amount (Dry Basis)

- **The ammonia combustion amount (450 kg/h) is almost the same heating value decrease in the amount of coal (500 kg/h (dry)).**

Type of coal: Mount Owen 60%, Boggabri Premium 40%



Unit: T/h

	July 3	July 4	July 5	July 6	July 7	July 8	July 9
Before mixed fuel combustion	48.14	47.67	48.14	49.84	41.07	48.29	47.94
After mixed fuel combustion	47.88	47.50	47.88	49.16	39.11	47.87	48.20
Difference	-0.26	-0.17	-0.26	-0.68	-1.96	-0.42	0.26

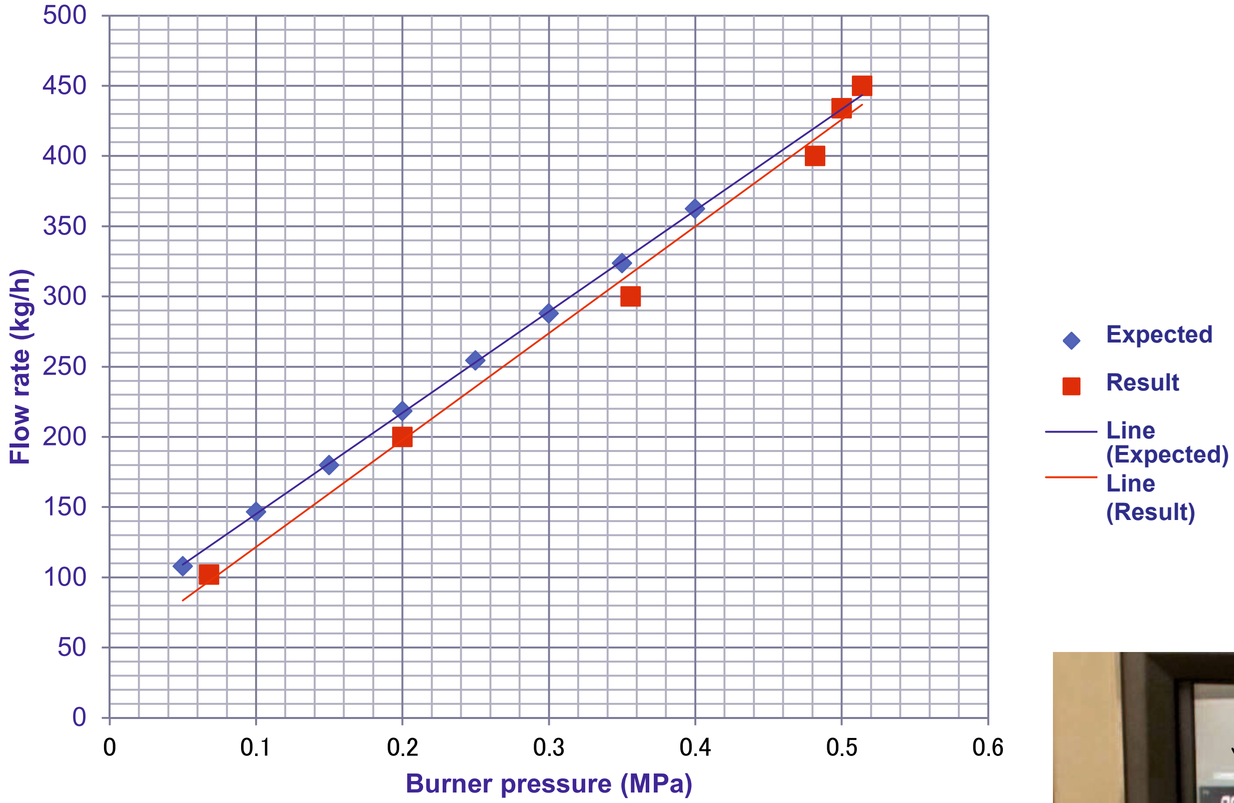
Average

July 4, 5, 6, 8	155MW	-0.38
July 7	120MW	-1.96
Complete schedule	-	-0.50

Energia

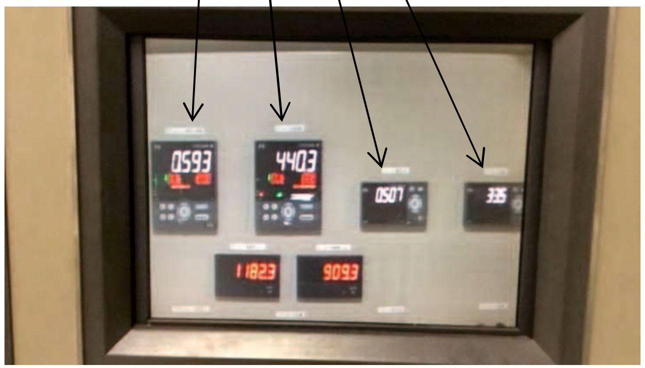
5-3-6. Burner Characteristics

- **The burner characteristics fell slightly below the planned values due to the pressure loss caused by modifications made to the BOG burner.**



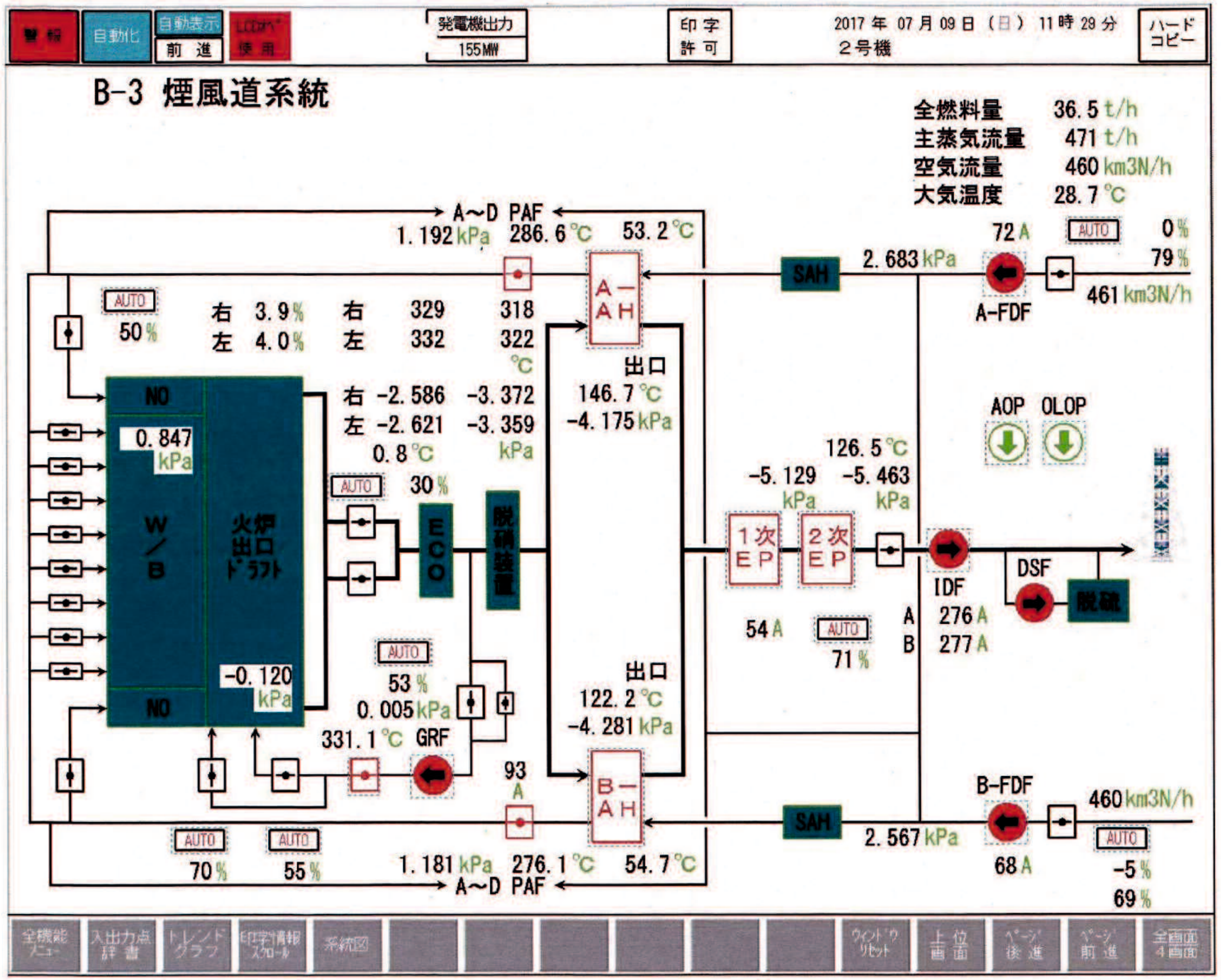
Monitoring by the central control room

- **Pressure before the pressure regulating valve (MPa)**
- **Ammonia flow rate (kg/h)**
- **Burner pressure (MPa)**
- **Ammonia temperature (°C)**



5-3-7. Status of the Smoke Duct System (Air Preheater, Denitrator, etc.)

■ **No abnormalities**

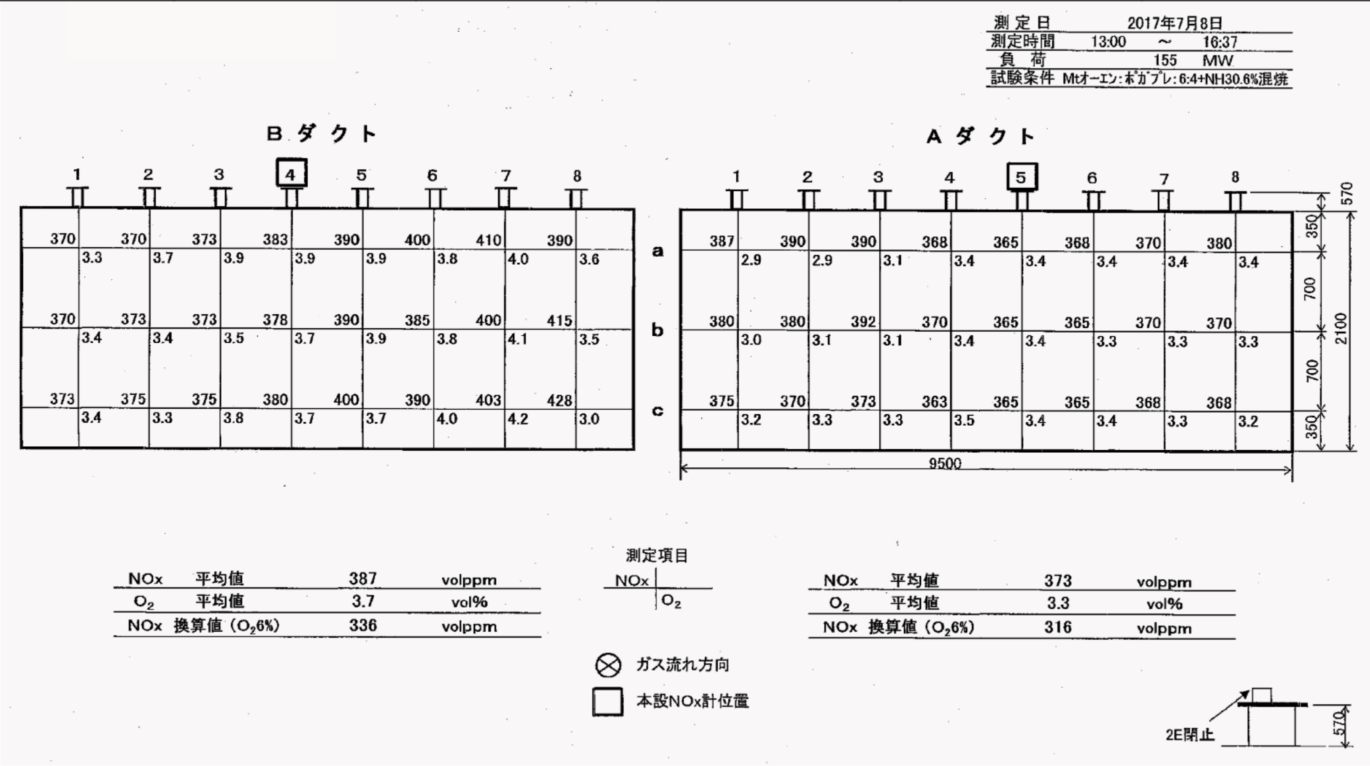


Energia

5-3-8. Boiler Outlet NOx Values (Traverse - All Points)

■ Almost no difference from the permanent instrument

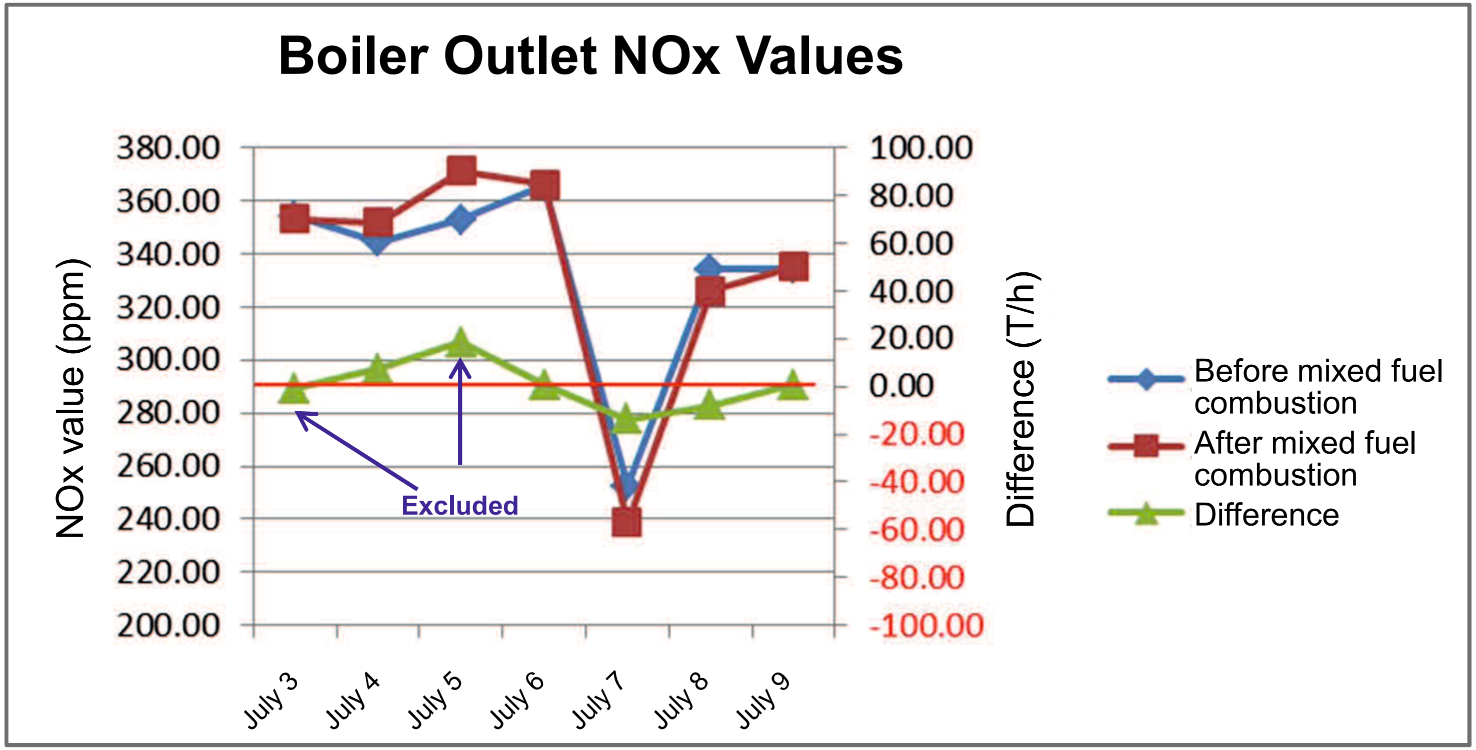
	Permanent instrument		Traverse - All points		Difference	
	A	B	A	B	A	B
NOx value (ppm)	314	336	316	336	-2	0



Energia

5-3-9. Boiler Outlet NOx Values (Comparison)

- **-8 to +7ppm at 155 MW (Average of 0 ppm), -14 ppm at 120 MW (Expected result from other company's tests + 10 ppm)**



*** Trends showing decreasing air volume (lower O_2) and decreasing NOx values**

Unit: ppm

	July 3	July 4	July 5	July 6	July 7	July 8	July 9
Before mixed fuel combustion (ppm)	354.06	344.53	352.81	365.47	252.50	334.06	334.38
After mixed fuel combustion	353.16	351.84	371.25	366.16	238.75	326.13	335.00
Difference	-0.91	7.31	18.44	0.69	-13.75	-7.94	0.63

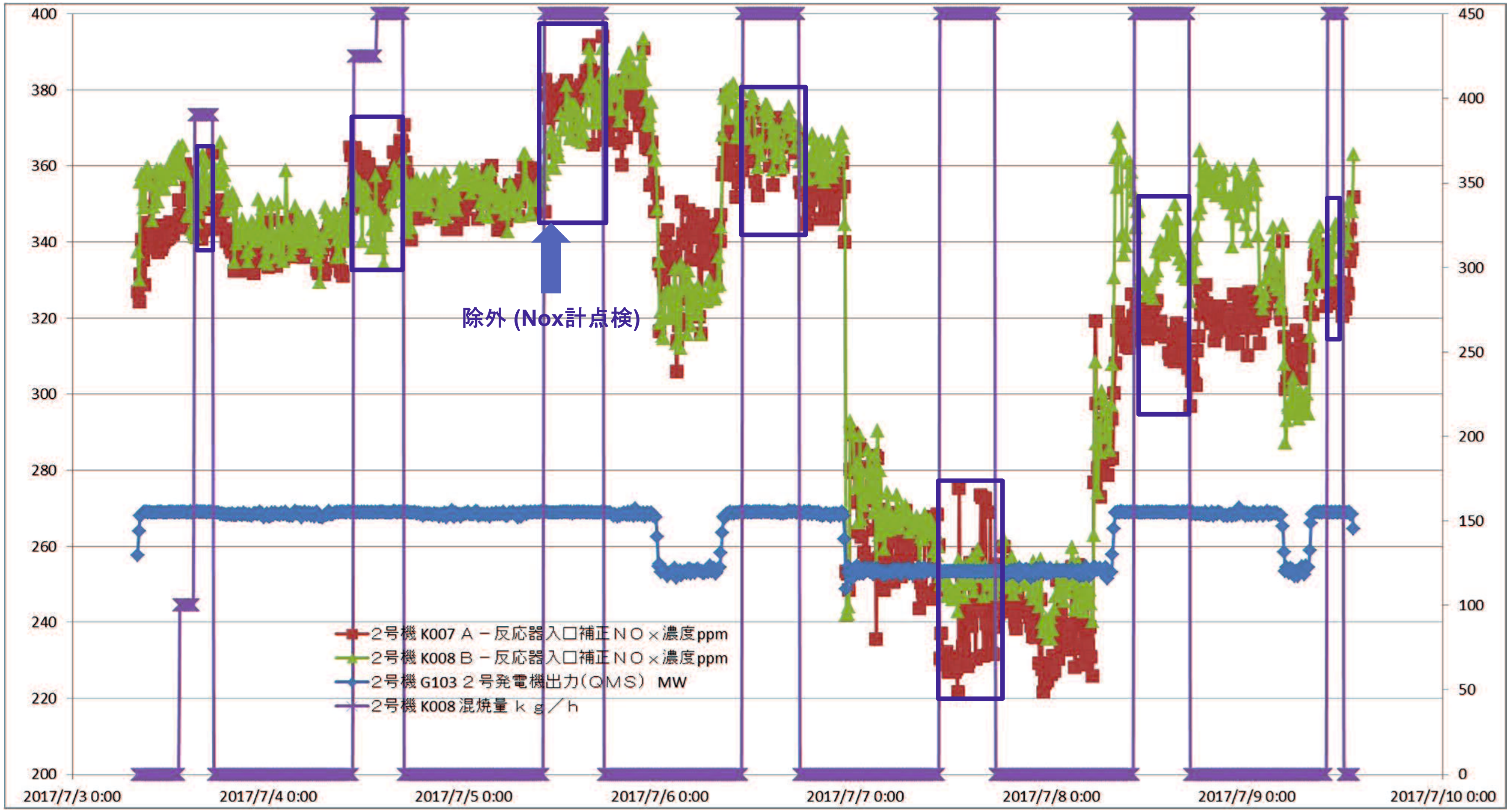
Excluded (various adjustments) (July 3) **Excluded (NOx meter inspection)** (July 5) **120MW** (July 7)

Average Unit: ppm

July 4, 6, 8, 9	155MW	0.17
July 7	120MW	-13.75

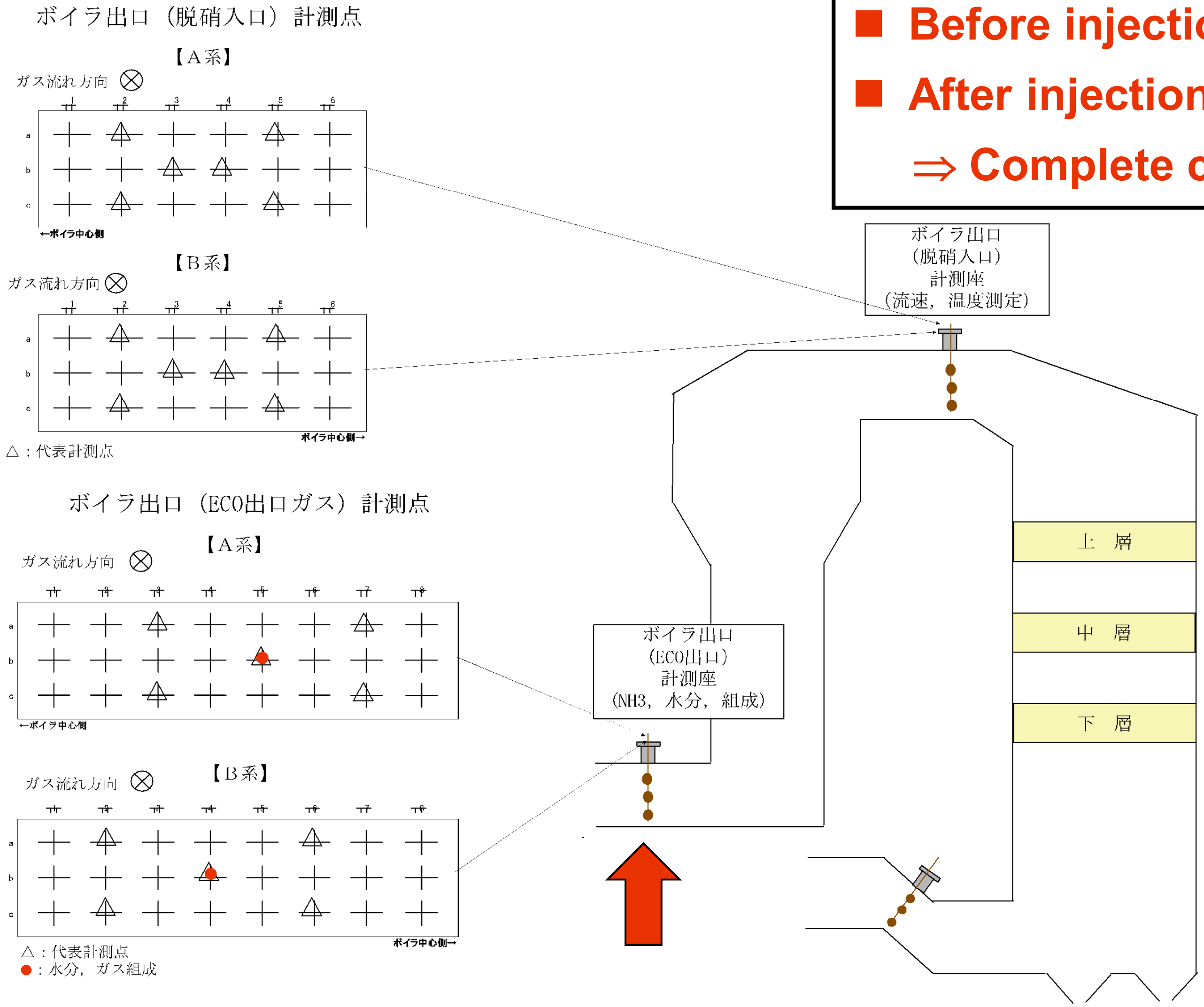
5-3-10. Boiler Outlet NOx Values (Time History)

■ **No major changes**



Energia

5-3-11. Measurement of Boiler Outlet Ammonia Concentration



- **Before injection: 0.3 ppm**
- **After injection: 0.1 to 0.4 ppm**

  ⇒ Complete combustion

Energia

5-3-12. Fuel Properties

■ Liquid ammonia

Purity	Moisture content	Oil content
99.98%	0.016%	<1.0ppm

■ Coal

Coal type	Moisture content	Calorific value	Total sulfur content	Proximate analysis (%)				Nitrogen content	Pulverized coal	Caking state	Melting point	Grindability
	%	kJ/kg	%	Moisture content	Ash content	Volatile matter content	Fixed carbon (content)	%	%		°C	
Mount Owen (60%)	7.6	29,620	0.63	3.0	11.6	33.7	51.7	1.57	40.2	Strong caking	>1450	58
Boggabri Premium (40%)	8.2	29,540	0.36	4.0	8.9	34.8	52.3	1.60	38.0	Strong caking	>1450	67

6. Patent Applications

6. Patent Applications

Application number	Title of invention	Applicant
PCT/JP2017/023634	Generating facilities	The Chugoku Electric Power Co., Inc.
PCT/JP2017/023635	Generating facilities	The Chugoku Electric Power Co., Inc.
PCT/JP2017/32407	Combustion method	The Chugoku Electric Power Co., Inc.
PCT/JP2017/34586	Combustion equipment and method	The Chugoku Electric Power Co., Inc.
PCT/JP2017/40643	Combustion state determination system	The Chugoku Electric Power Co., Inc.

7. Increasing the Mixed Fuel Burning Ratio

7. Increasing the Mixed Fuel Combustion Ratio

- **To further increase the mixed fuel combustion ratio, the following items must be further investigated.**

  - **Boiler trip countermeasures**
    Automatic fuel cutoff.

  - **Method to discharge and treat ammonia outside the system**
    Use of abatement and denitrification equipment.

8. Ammonia and Coal Mixed Fuel Combustion Image

8. Ammonia and Coal Mixed Fuel Combustion Image