SAFE WOOD PELLET STORAGE WORKSHOP

Case Studies on Major Incidents that Resulted from Runaway Self-Heating Consequences and Lessons Learnt

September 3, 2025 Copenhagen, Denmark

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Workshop Sponsors

Ørsted

WOOD PELLET ASSOCIATION OF CANADA

FutureMetrics LLC

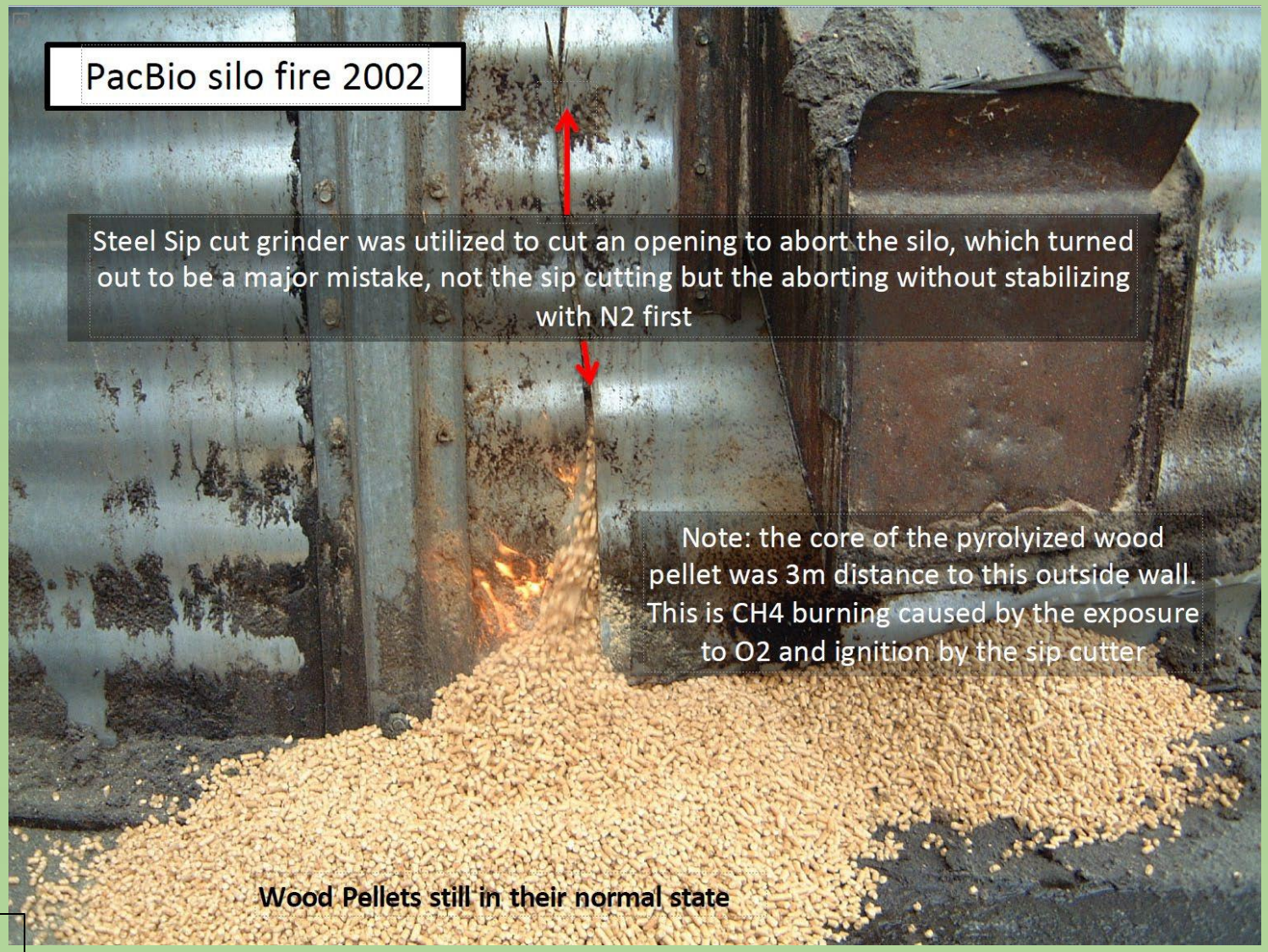
“First Experience” – 2002

Mishandled

- Assuming it to be a normal fire within the silo, aborting the silo was initiated
- Our first clue that an excessive amount of CH4 is generated by the smoldering pyrolysis of a wood pellet fire. A small flame was ignited by steel sip cut grinder when cutting a new opening in the steel silo.
- The top of the silo was blown off when the aborted pellets exposed the smoldering clump providing the heat and oxygen to ignite the CH4 within the silo.

Lesson Learnt

- Wood Pellet Fire incidents MUST be stabilized before aborting a silo and/or warehouse

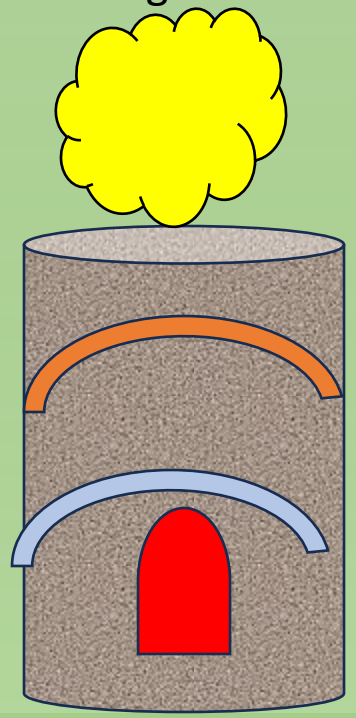


CAUSE OF THE FIRE – EXTERNAL HOT MATERIAL

So what caused the explosion???

Lesson Learnt

- Pyrolysis of the smoldering pellet generate CH4, CO, CO2, H2 gases.
- Lowering (aborting) the level of wood pellets in silo down to the smoldering pellets allowed O2 to make contact with the smoldering pellets releasing CH4 causing the ignition and subsequent explosion.
- Smoldering pellets glue together and become clumps that cause bridging and blockage when aborting the silo



“Second Experience” – 2017

Utilized Lessons Learnt

- Research at the Swedish SP Technical Institute conducted experiments and produced a report “Silo Fires” by Henry Persson on how to correctly deal with wood pellet silo fires.
- Best practices for dealing with wood pellet fire incidents found N2 injection to be the must effective to stabilize the smoldering pyrolysis of the pellets before safely discharging silo’s, minimizing personnel danger and damage to the silo(s) and/or surrounding faculties.
- Volume and flow rates for N2 injection where also calculated and verified.
- Restricting O2 and injecting N2 into the silos head space proved to have positive results, although utilizing medium or high density foam spray was identified as an option to assist with N2 losses from the top of the silo and potential fire.

CAUSE OF FIRE – BELIEVED TO BE SELF-HEATING

PacBio silo fire 2017

Concluding results of the Swedish Research were followed and a safe outcome was the result. NO injury’s or loss of life and NO loss of assets.

Daigas Case Study:
Silo Fire at Sodegaura Biomass Power Plant

Sep. 3, 2025

Daigas Gas and Power Solution Co., Ltd.

FutureMetrics, LLC.

Agenda

1. Overview of Sodegaura Biomass Power Plant
2. Facility information about storage site
3. Incident and activity
4. Probable causes and countermeasures
5. Summary

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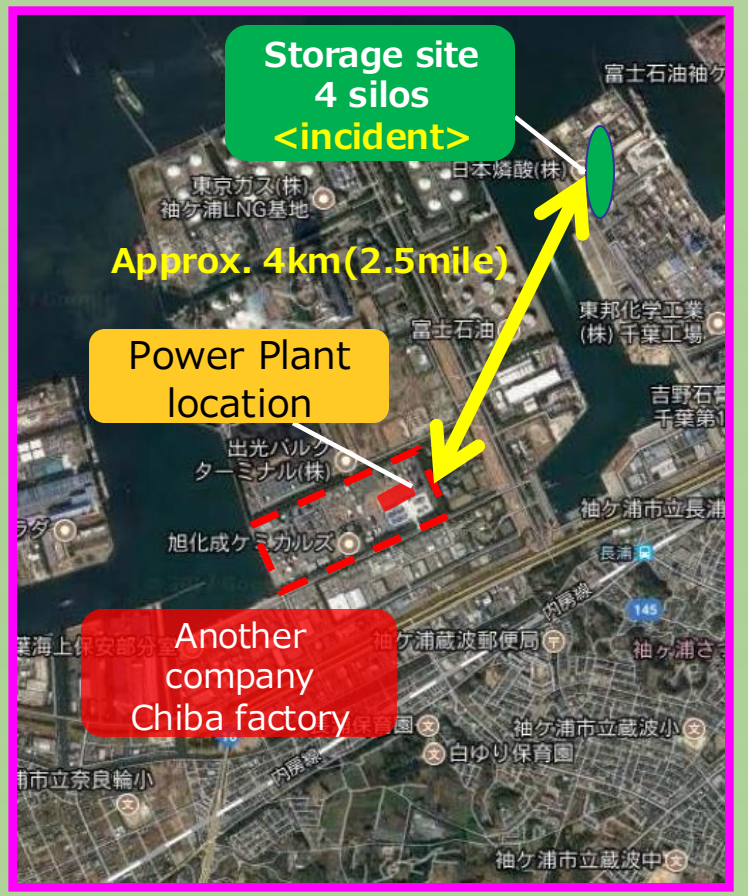
Overview of Sodegaura Biomass Power Plant

- **The power plant in operation in July 2025, located in Sodegaura city ,Chiba prefecture.**
- **The power output is 75 MW.**
- **Pellet storage site is located a little far from power plant.**

Company (Operator)		Sodegaura Biomass Power Co., Ltd. (SBP)（Daigas Group）
Location of HQ		Osaka ,Japan
ShareHolder		Daigas G&P Solution co.,Ltd. 100%
Power Plant	Operation start	July 2025
	Location	Sodegaura city , Chiba prefecture
	Area	Approx. 30,000㎡
	Output	**75 MW**
	Boiler type	Circulating Fluidized Bed (CFB)
	Turbine type	Reheat Condensing Turbine
	Fuel	**Wood pellet 100%**（approx.300kton／y）
	Cooling method	Industrial water with cooling tower
Pellet Storage site	location	Sodegaura city , Chiba prefecture
	capacity	Max 40,000 ton (10,000 ton × 4 silos)
	Area	Approx. 9,000㎡
	Facilities	**ocean going vessel Berth and Silos**



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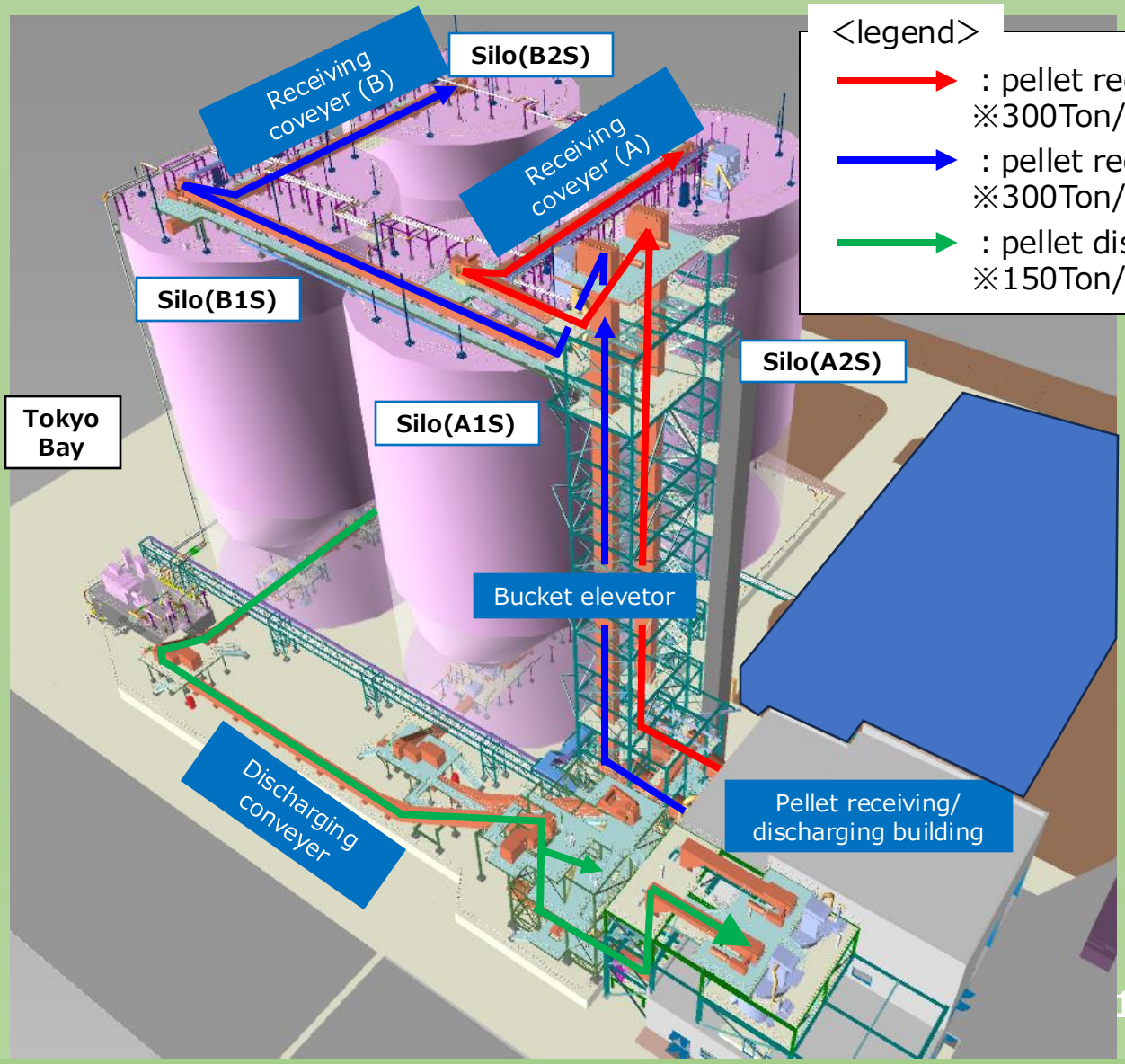
Storage Site Outline



<legend>
: pellet receive(A)
※300Ton/Hr
: pellet receive(B)
※300Ton/Hr
: pellet discharge
※150Ton/Hr

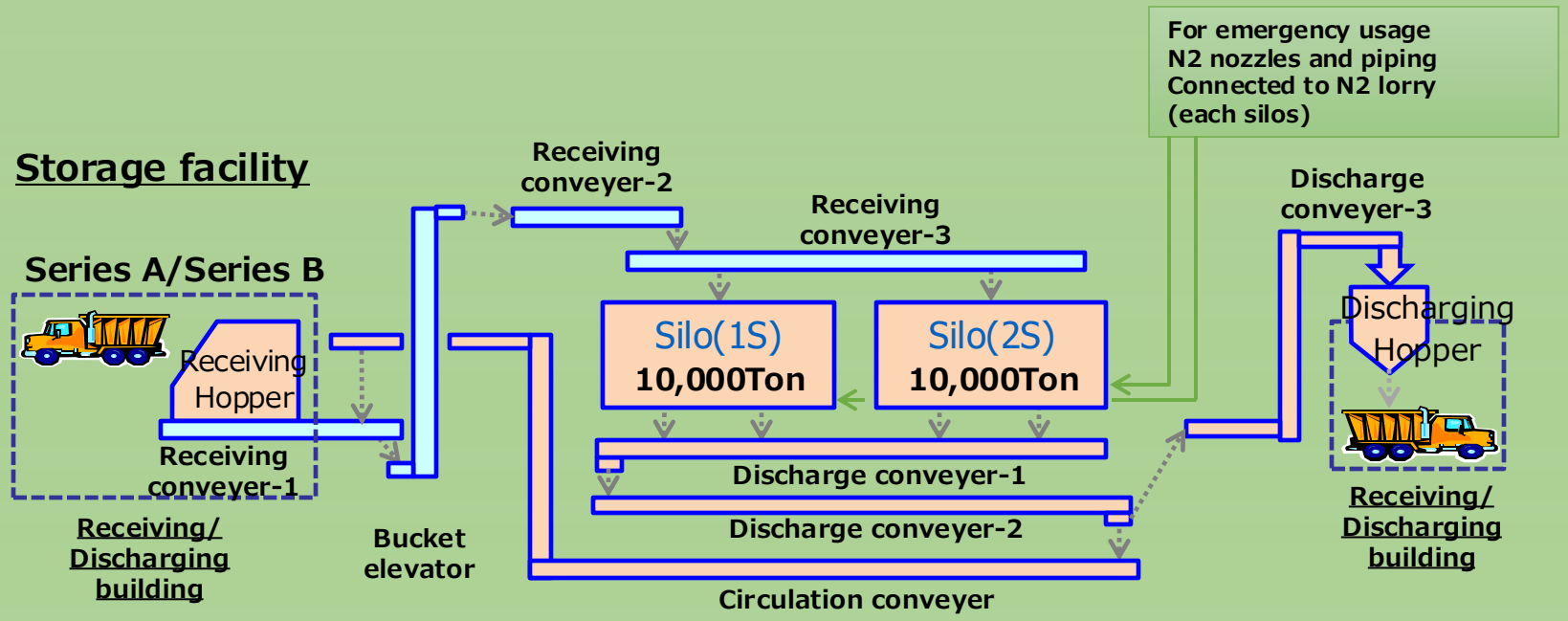
SBP Storage site outline	
Operation start	Jul. 2022
Stored fuel	White wood pellets
Silo Spec.	**Concrete silo : 4 silos** **Capacity : 10,000Ton(approx.15,000m³)/silo** **Diameter : 25.1m、Height : 46.5m**
Conveyer spec.	①receiving; 2 series（Max. 300 t/h） ②discharging; 2 series（Max. 150 t/h）
Other facilities	Pellet Receiving/Discharging building N_2 supplying Nozzle(For pellet fire counter) Fire extinguishing facility (Water Spray, Outdoor Hydrant)

Pellet receiving area

Pellet discharging area

Equipment Configuration

- A nitrogen lorry line is permanently installed to supply nitrogen to each silo in case of emergency.
- Fire extinguishing system capable of spraying water on each silo, conveyor transfer area, and warehouse building.
- Fuel circulation operation is possible when an abnormality is detected in stored fuel.
- The silos are monitoring the condition of stored fuel with gas concentration and thermometers.

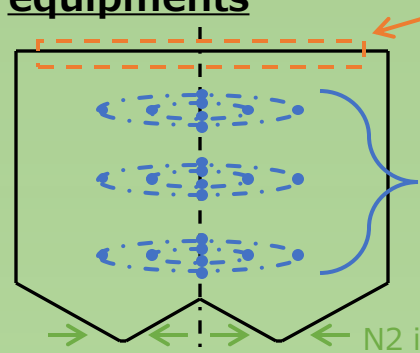


Specification of silo	capacity : 10,000Ton ×4 Dia : 25m,Height : 46.5m
Instruments, Prevention equipments	Thermometer Gas concentration monitor N2 injection nozzles Sprinkler (silo,etc)

Fire extinguishing water facility

Fire Cistern →
- each silos
- Rec/disc. building
- conveyer connection points

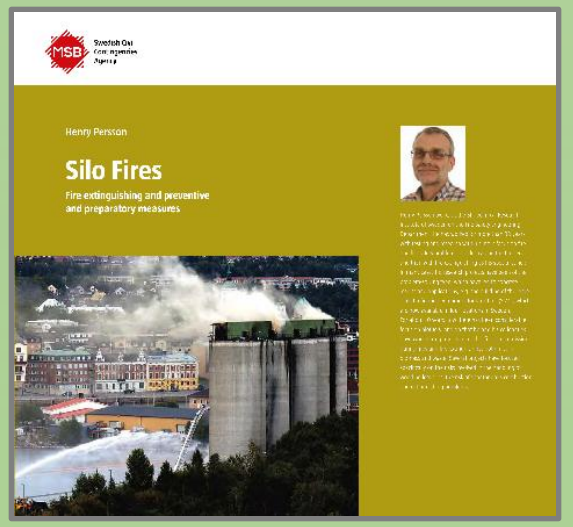
equipments



Features regarding preventive measures for storage site

- Fire extinguishing equipment: Fire prevention ordinances, and consulted with the local fire department
- Silo fire prevention (*Silo Fires)*

1. Nitrogen line installed
2. Monitoring instruments (thermometers, gas detectors) permanently installed
3. Ventilation in silo
4. Construction of circulation line



https://www.msb.se/sv/Produkter--tjanster/Publikationer/Publikationer-fran-MSB/Silo-fires-fire-extinguishing-and-preventive-and-preparatory-measures/

- Preparing for Dust Explosions and Sparklers Inside Conveyors

1. Takes into account conveyor speed and dust deposition

➡ Chain conveyor is adopted.

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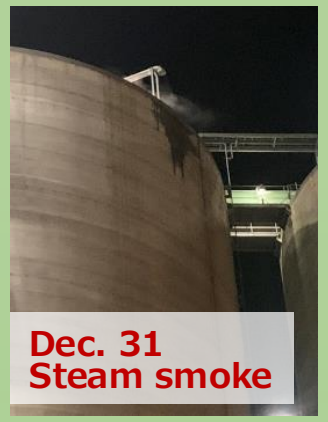
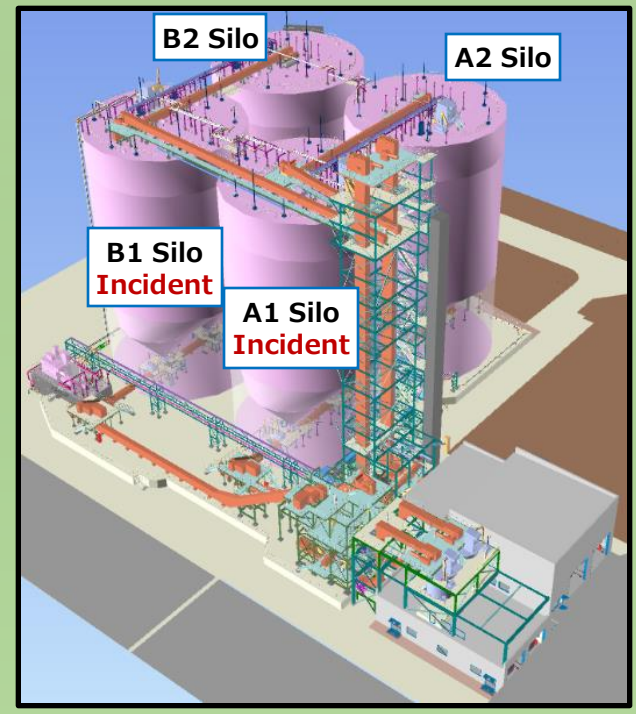
Incident overview

White smoke was observed from A1 and B1 silos of the 4 silos.



Date	Time	Events
Dec.31, 2022	8:58	The abnormal gas concentration in A1 silo was detected.
	night	Steam smoke from A1 silo was observed.
Jan.1, 2023	AM	A nitrogen lorry was arranged.
	12:30	N2 injection in A1 silo was started.
	22:00	N2 injection was stopped.
	22:12	White smoke was observed from A1 silo.
	22:31	Notify the fire department.
Jan.2, 2023	midnight	Water was sprayed inside A1 silo.
	morning	Nitrogen had been injected in A1 silo.
Jan.4, 2023	15:10	White smoke was observed from B1 silo.
		Nitrogen had been injected in each silos to calm down the



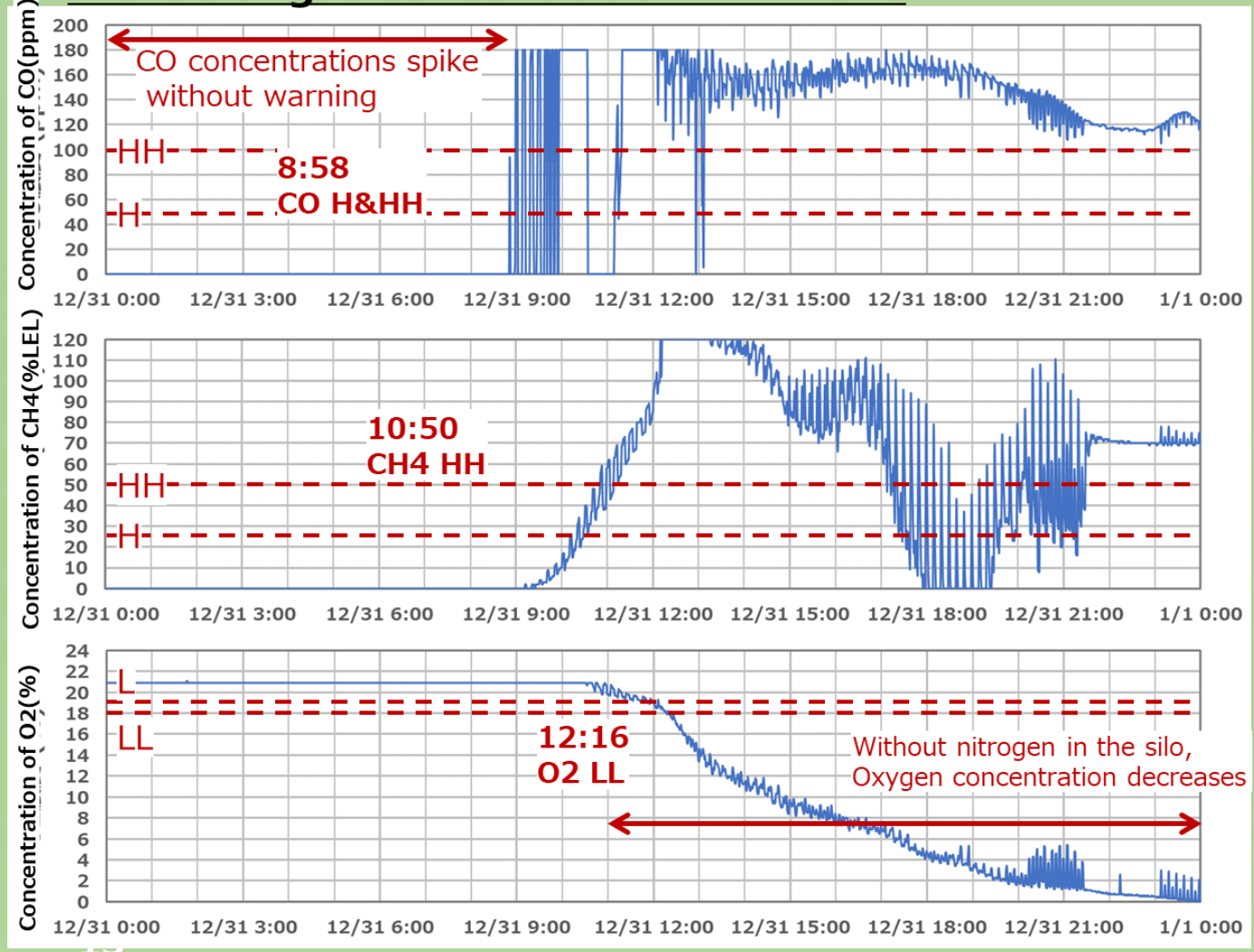
Background of the smoldering fire

● Suddenly the gas concentration increased on 31st Dec. 2022.

・Wood pellets had been stored in the silos for 6 months, because of the troubles on power plant commissioning.
・Temperature and gas concentrations in the silos had been monitored.
・Continuous ventilation had been performed to reduce CO concentration.

・Suddenly the gas concentration increased on 31st Dec. 2022.
・Temperature in the silos had been showing normal temp.

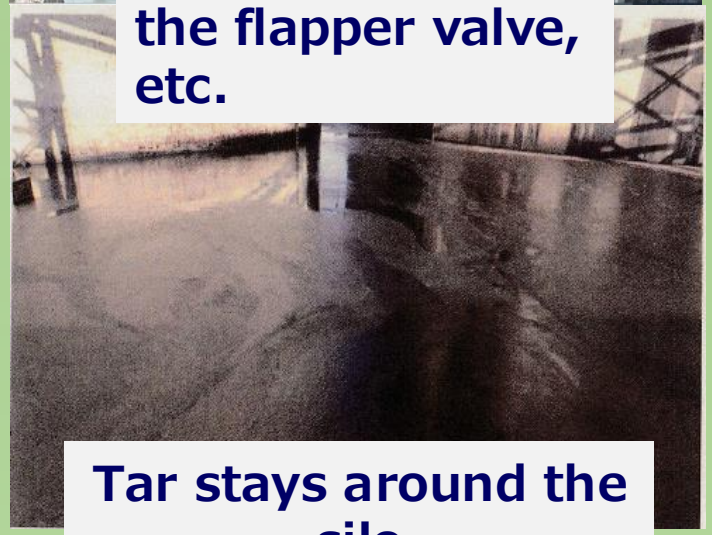
Trends of gas concentration in A1 Silo



Condition of silo after fire

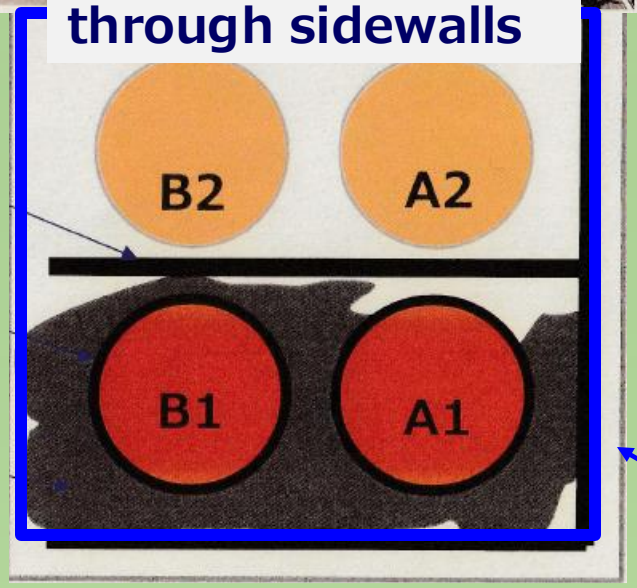
- White smoke was generated from the tops of the A1 & B1 silos, and tar adhered to the tops and walls of the silos and the surrounding area, causing an odor. In addition, the area around the silos became a high CO concentration environment, which greatly hindered firefighting activities.

White smoke is rising through the flapper valve, etc.



Tar stays around the silo

Tar, etc. spills through sidewalls



Temporary wastewater treatment facilities

dike to prevent leakage

Air respirator

Nitrogen-filled firefighting

● Internal condition of silo was checked using fixed-point photos and thermo-cameras.

◎fixed-point photos ◎thermo-cameras

Jan. 6

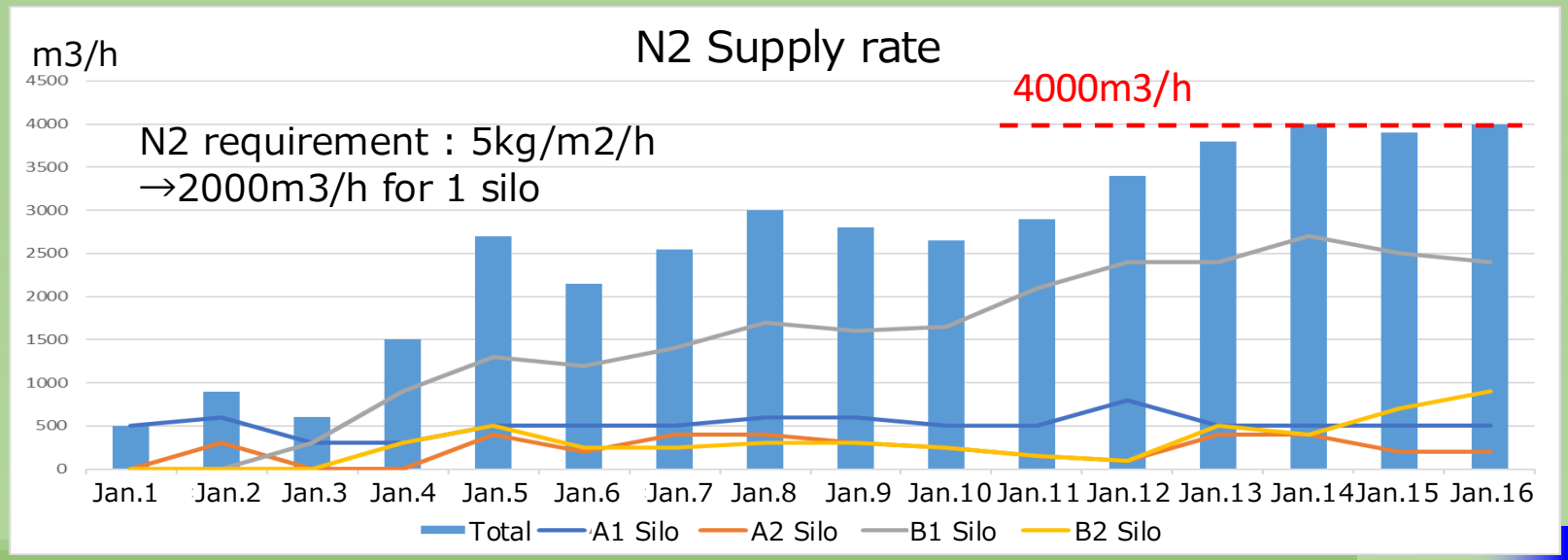
Jan. 13

Feb. 5

Feb. 5

Mar. 8

Mar. 8



May 1 fire declaration

- On May 1, at 11:00 a.m., the fire chief of the Sodegaura City Fire Department inspected the storage site and the fire was declared extinguished.
- Emergency measures under Article 29 of the Fire Service Law were lifted during firefighting activities.

Inspection of the fire scene by the fire chief and declaration of extinguished

Fire Service Law, Article 29 (Japanese Law)
Fire officials or fire brigade members may, when necessary to extinguish a fire, prevent the spread of fire, or save lives, use, dispose of, or restrict the use of firefighting objects and the land where such objects are located, where a fire is about to break out or has broken out.

It took 4 months from the confirmation of white smoke in the silo to the declaration of extinguished.

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Probable Causes and Issues of the Silo Fire

- We conducted the analysis of the cause of the silo fire from various perspectives
- The possible causes of the fire may include self-heating of wood pellets, fermentation, external ignition sources, dust explosions, etc..
- After further investigation and analysis, the following items were evaluated as probable causes of the fire.

  Details of the investigation and analysis will be presented in the next section.

◆Self-heating of the stored wood pellets

◆Issues with the operational rules for long-term storage

- We will introduce the issues we noticed in terms of equipment and management through our experience in firefighting activities.

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Spontaneous combustion mechanism of wood pellets (generally)

When local moisture concentration occurs during wood pellet storage due to moist air inflow or condensation, heat of fermentation by microorganisms is generated, which, when stored, further generates heat through spontaneous oxidation and is considered to lead to ignition.

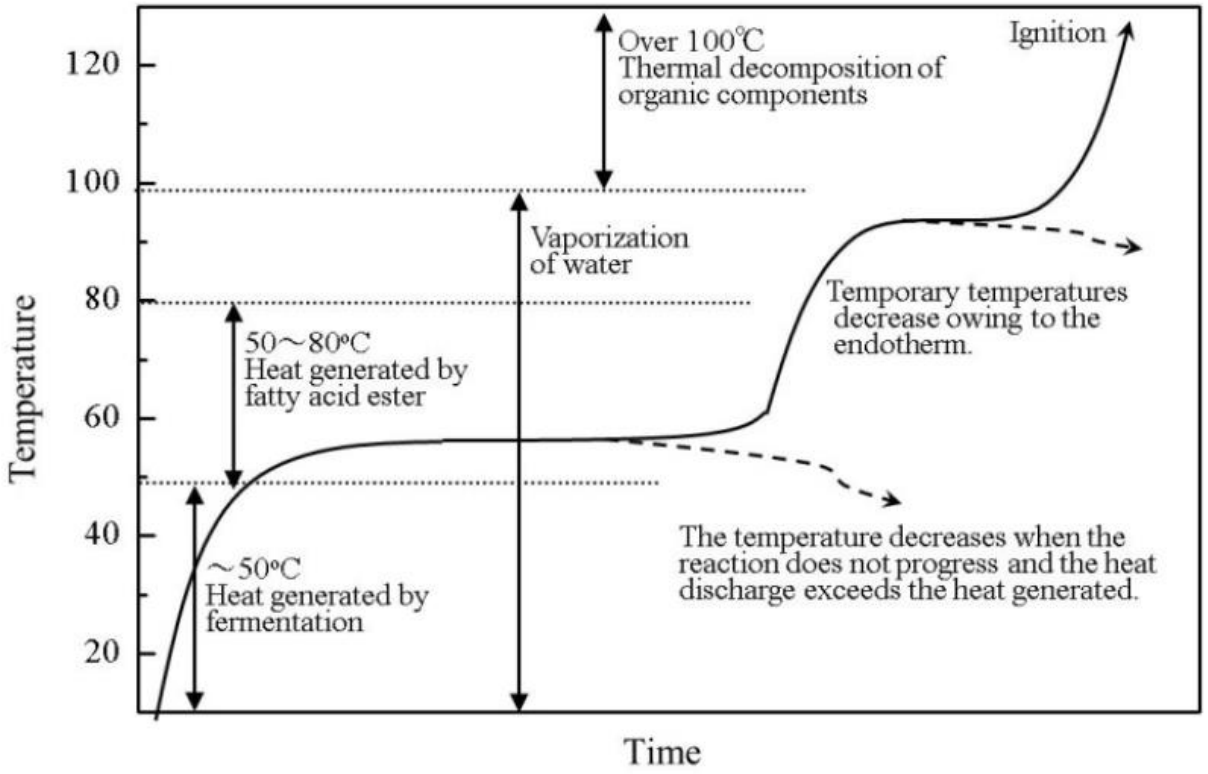

Figure 16. Combustion mechanism of biomass fuels.

*Source ; N.Murasawa and H.Koseki,
Investigation of Heat Generation from biomass fuels, Energies 2015, 8, 5143-5158

Self-heating processes may be due to:
- **biological metabolic reactions**
- **exothermic chemical reactions**
- **heat-producing physical processes (e.g., moisture adsorption)**

<First approach>
Analysis of the effects and behavior of moisture in silos.

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Humidity History in Silos

◆When pellets are received

Unloading of pellets is suspended when it rains → Prevents entering external moisture from unloader to silo.

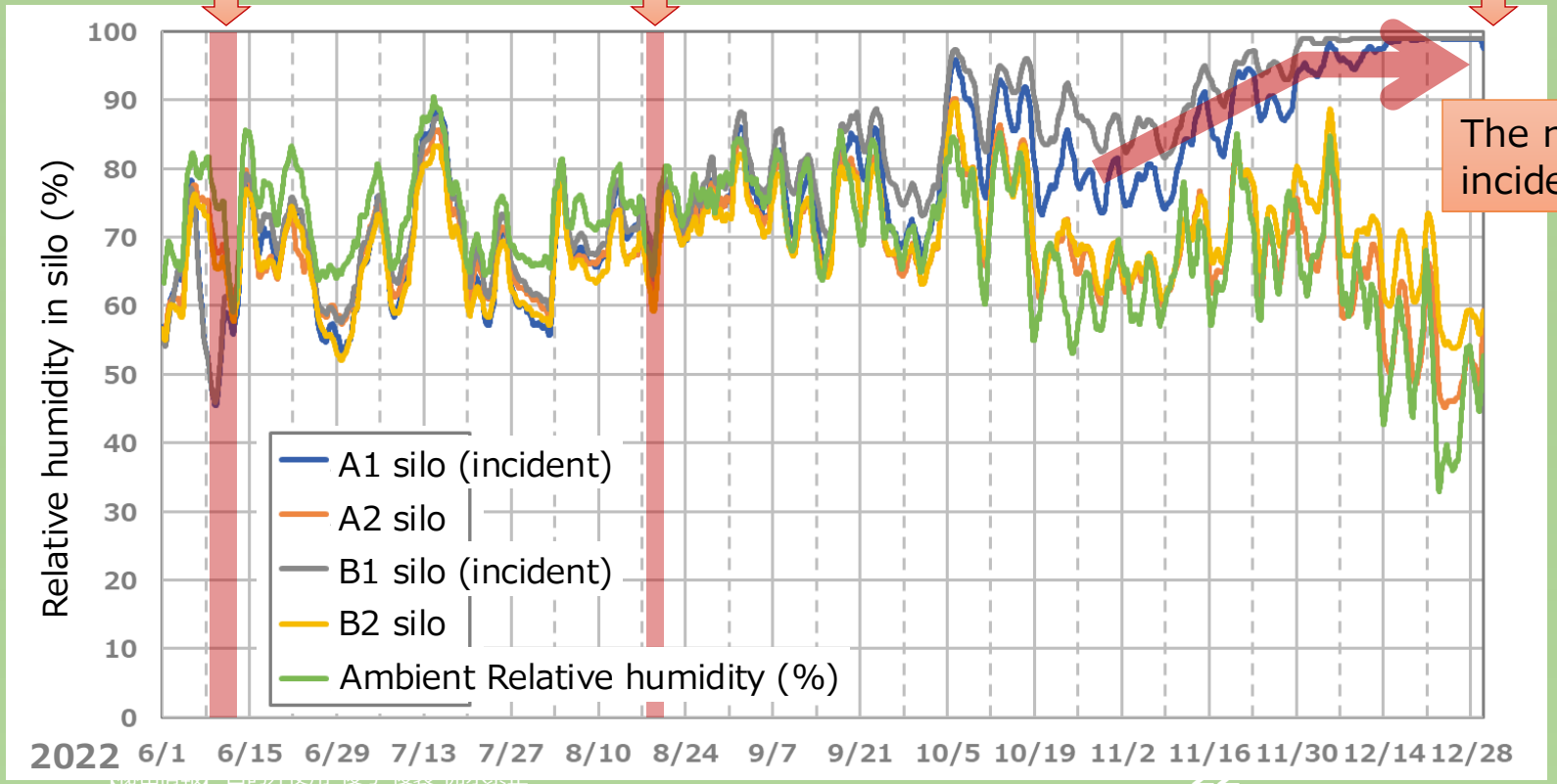
◆During pellet storage

No signs of moisture entering from the outside → humidity increased caused by self-heating of wood pellets in the silo.

June
Unloading to A1 and B1 silo
Total moisture:5%

August
Unloading to all silos
Total moisture : 7.3%

Jan. 1st
Incident



<Second approach>
Evaluation of self-heating by ISO

The relative humidity only increased in the incident silos.

Note : The gas concentration and bulk temp. did not detect any abnormal values until the incident occurred.

Test Results : Self-heating characteristics of wood pellets

- Evaluated the self-heating characteristics of wood pellets based on ISO, and confirmed that the self-heating characteristics are 1~2 orders of magnitude higher than the previous findings in the low temperature range.
- Also, the self-heating property of **fresh** wood pellets was confirmed to be higher than that of stored pellets(**aging pellets**).

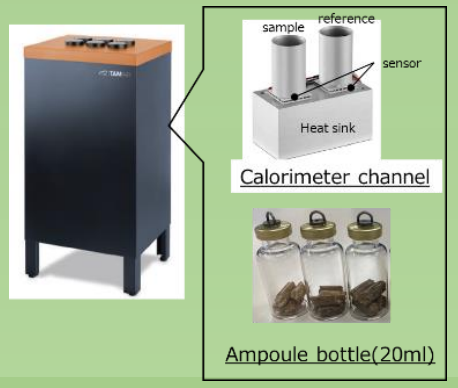
ISO 20049-1 Solid biofuels
- Determination of self-heating of pelletized biofuels -

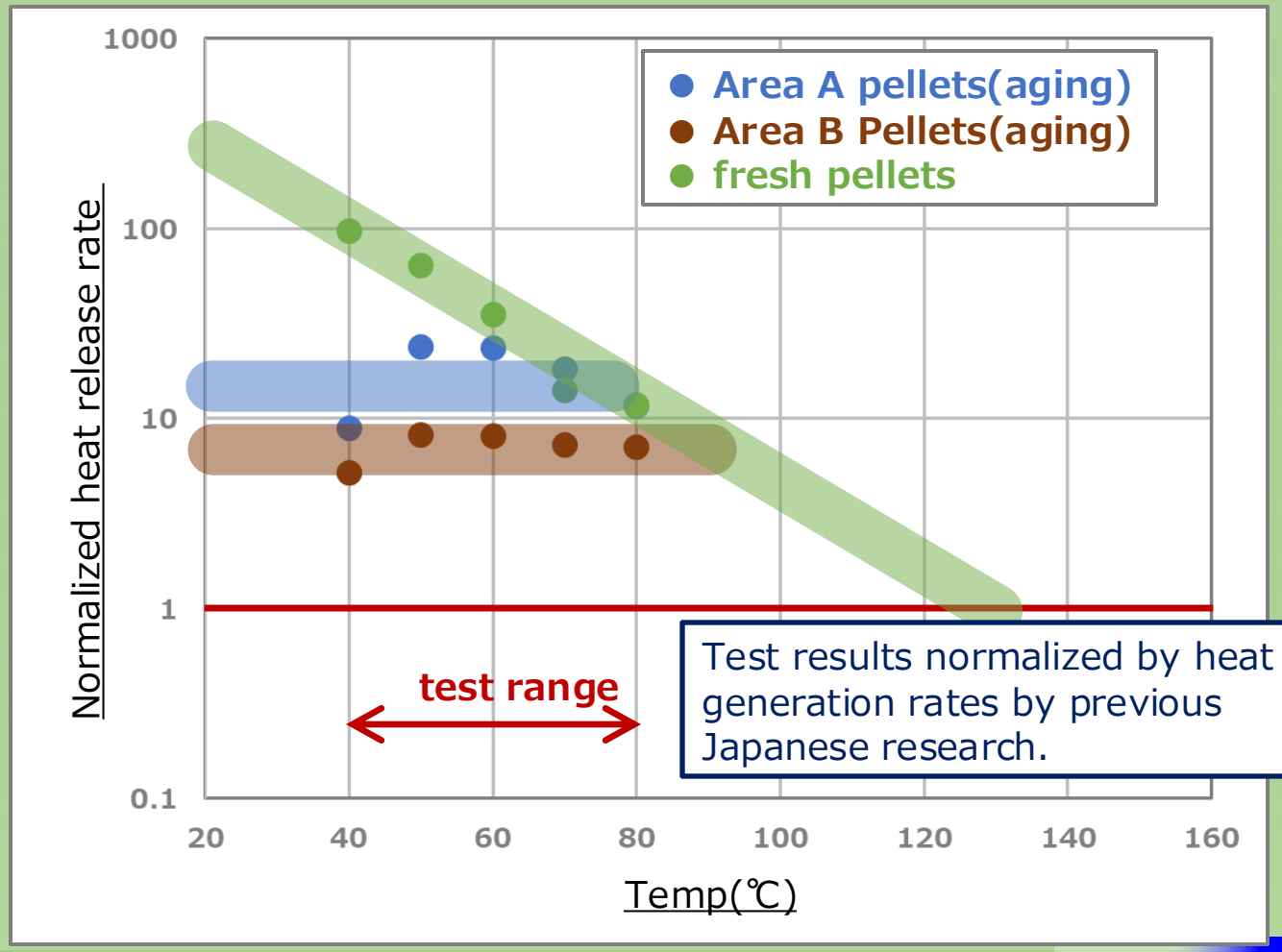

INTERNATIONAL STANDARD ISO 20049-1

Solid biofuels — Determination of self-heating of pelletized biofuels —

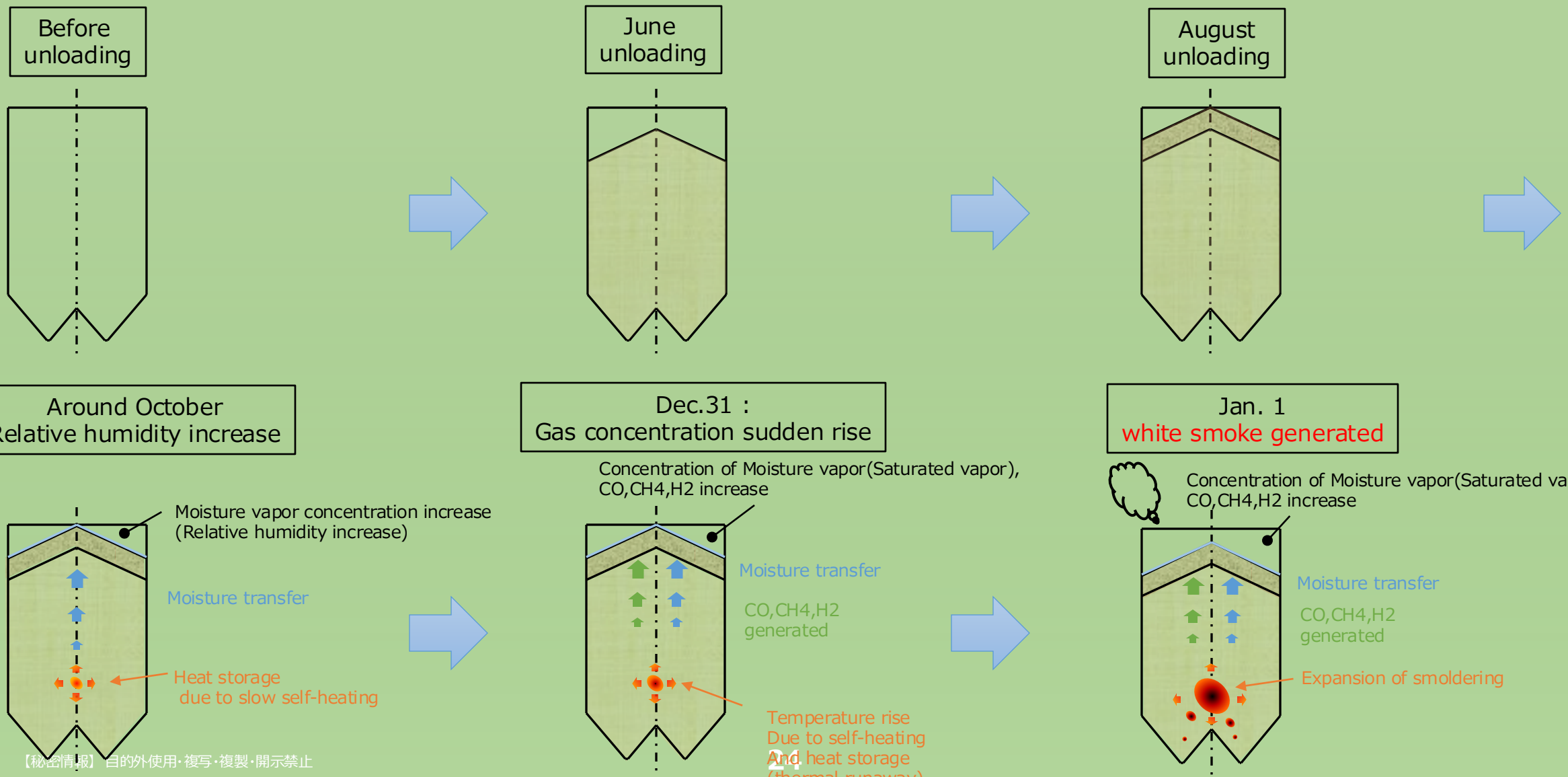
Part 1: Isothermal calorimetry

Experimental equipment
(Isothermal calorimetry)





Smoldering fire mechanism estimation



Probable Cause of Silo Fire and Countermeasures

Probable causes of silo fire

- Self-heating of the stored wood pellets
- Issues with the operational rules for long-term storage

Countermeasures

- Revise silo operation strategy
- Installation of nitrogen generator

Silo operation strategy

<Before the fire>

Concept	Method	Response to abnormalities
Condition Monitoring	1. Constant monitoring temp. and gas concentration.	1. Ventilation operation 2. Cooling by pellet circulation operation 3. Injecting N2 inside silos by N2 lorry 4. Spraying water inside silo (last resort)

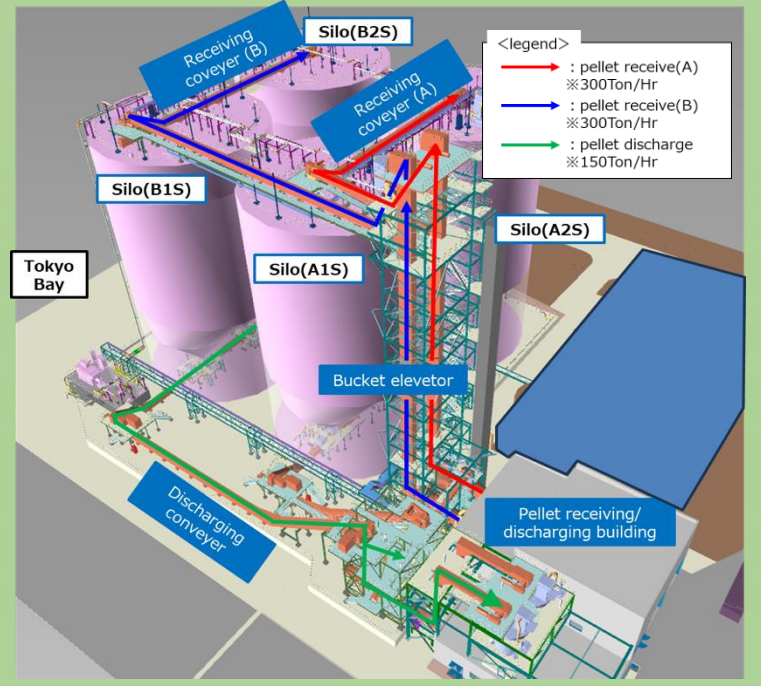
<post-fire>

Time Management	1. Storage time management 2. Complemented by temp., gas conc. and humidity monitoring	1. When storing for a certain period, N2 is supplied to suppress temperature increase. 2. When the storage time exceeds the specified time, start circulating ope.. 3. If abnormalities of monitoring value is detected, N2 gas replacement

Issues identified in terms of equipment, etc., based on the fire experience.

No.	Issues	Improvement methodology
1	• Silo fires require large amounts of nitrogen immediately	• Permanent installation of nitrogen production equipment on site • Confirmation of the nitrogen supply system in the neighborhood (lorry charge station , temporary vaporizer, nitrogen hose and connection method)
2	• High CO environment around silos (difficulty to approach)	• Re-arrangement and automation of valves and equipment that need to be operated in an emergency • Improvement of silo airtightness • Deployment of portable gas detectors • Deployment of SCBA (air breathing apparatus)
3	• Placement of important equipment on top of the silo	• Relocation of important equipment
4	• Specifications of gas detector in silo	• Adoption of multi-range gas analyzer • Revision to gas analysis method not affected by oxygen concentration (when N2 injecting, concentration of O2 decreasing)
5	• Prevention of tar and wastewater runoff	• Review of water collection methods in silo area (prevention of external runoff) • Preparation of treatment methods for tar-containing wastewater

Panoramic view



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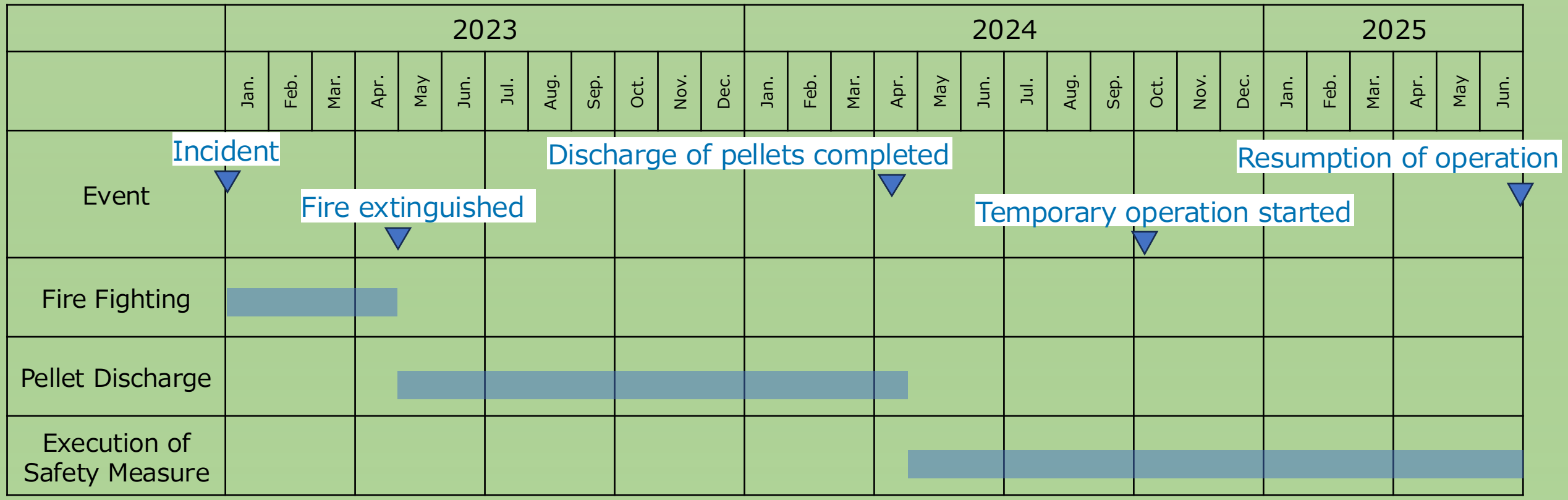
Summary : Activity Record and Our Message

- 2023 Jan.- Apr. Fire Fighting Activity
- 2023 May – 2024 Apr. Discharge of Fire-Causing Pellets
- 2024 May – 2025 Jun. Execution of Safety Measure and Repair Work

Activity Record in Storage Site



We would like to inform you that it takes a considerable time to restart operation after an incident.

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- Thank you -

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