Energy for a New Era

JERA Power Taketoyo GK

Fire Accident at Taketoyo Thermal Power Station

Recurrence Prevention Measures

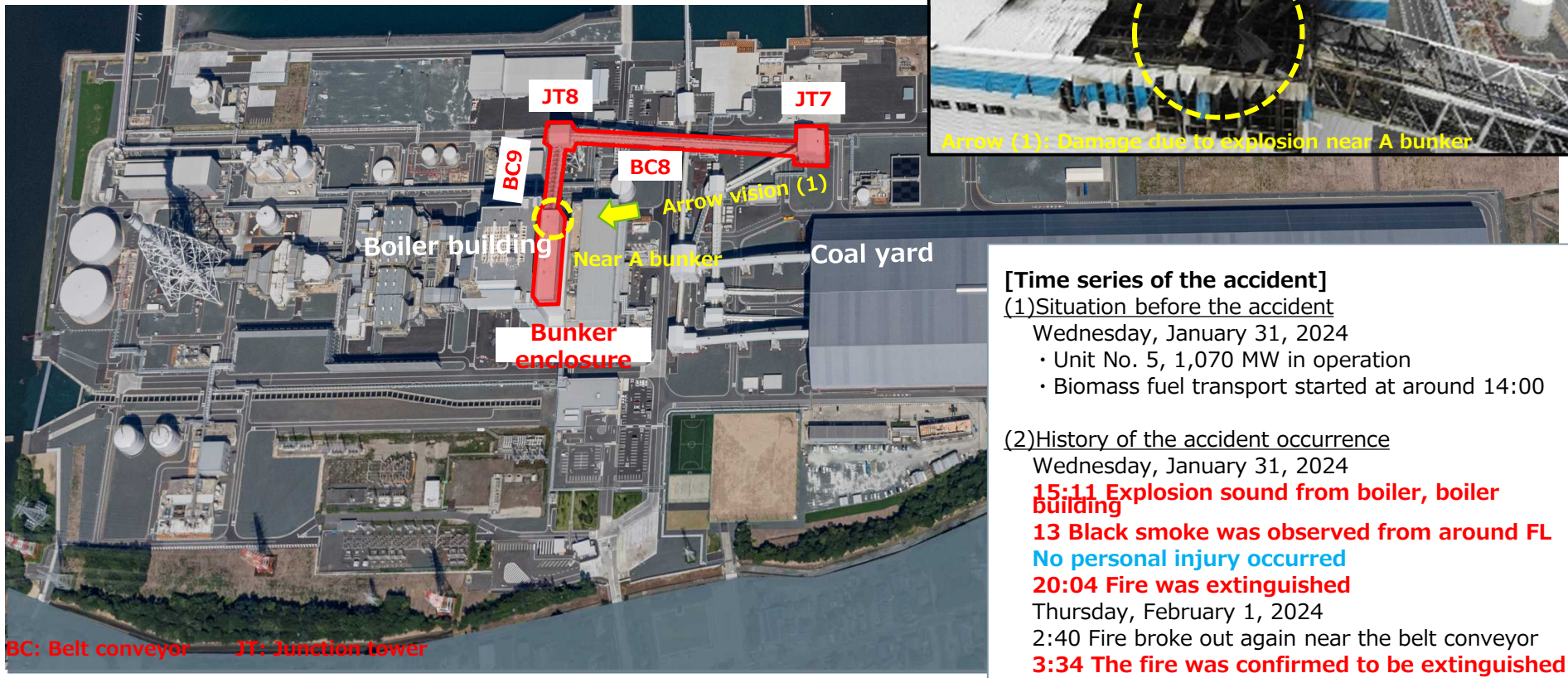
September 3, 2024 (The 4th meeting)

Fire Accident Investigation Committee at Taketoyo Thermal Power Station

Outline of the Accident (1/2)

- Based on video data, the ignition point is considered to be near A bunker.
- The event is considered to be a dust explosion caused by biomass fuel.
- There was no significant damage to facilities other than the bunker enclosure to JT7.

Range of damage to main facilities by fire



[Time series of the accident]

(1)Situation before the accident

Wednesday, January 31, 2024

- Unit No. 5, 1,070 MW in operation
- Biomass fuel transport started at around 14:00

(2)History of the accident occurrence

Wednesday, January 31, 2024

15:11 Explosion sound from boiler, boiler building

13 Black smoke was observed from around FL

No personal injury occurred

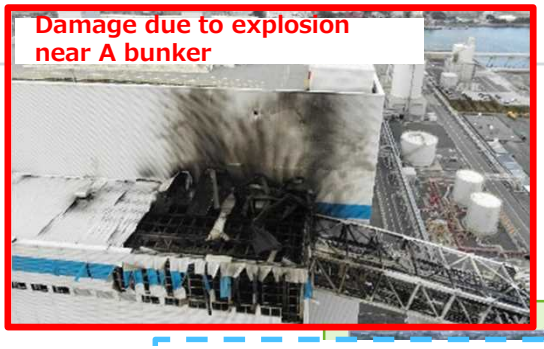
20:04 Fire was extinguished

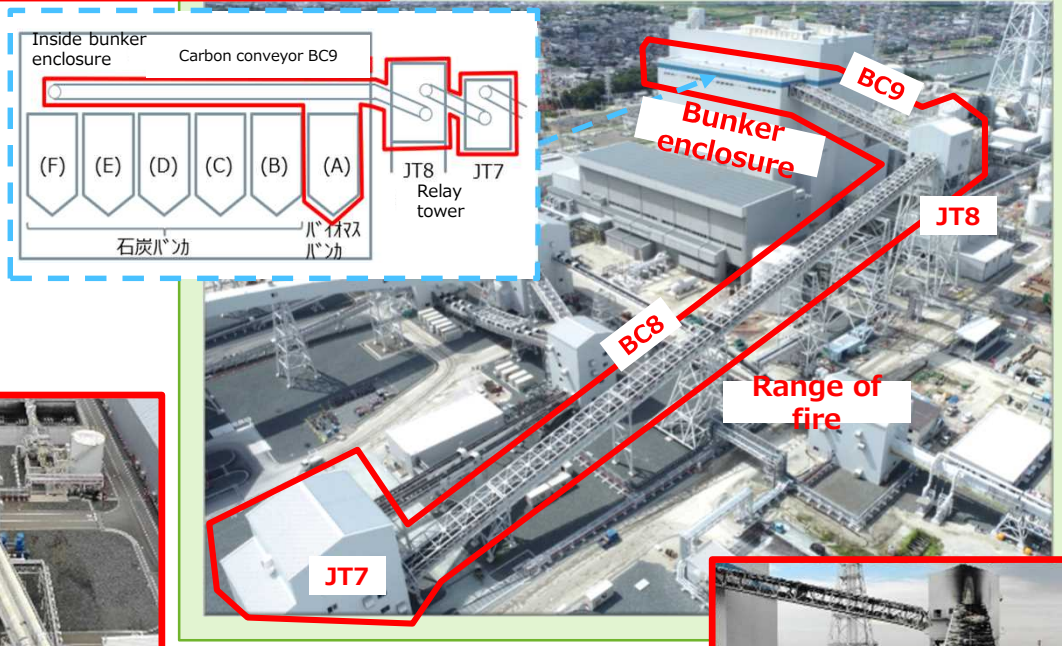
Thursday, February 1, 2024

2:40 Fire broke out again near the belt conveyor

3:34 The fire was confirmed to be extinguished.

Outline of the accident (2/2)

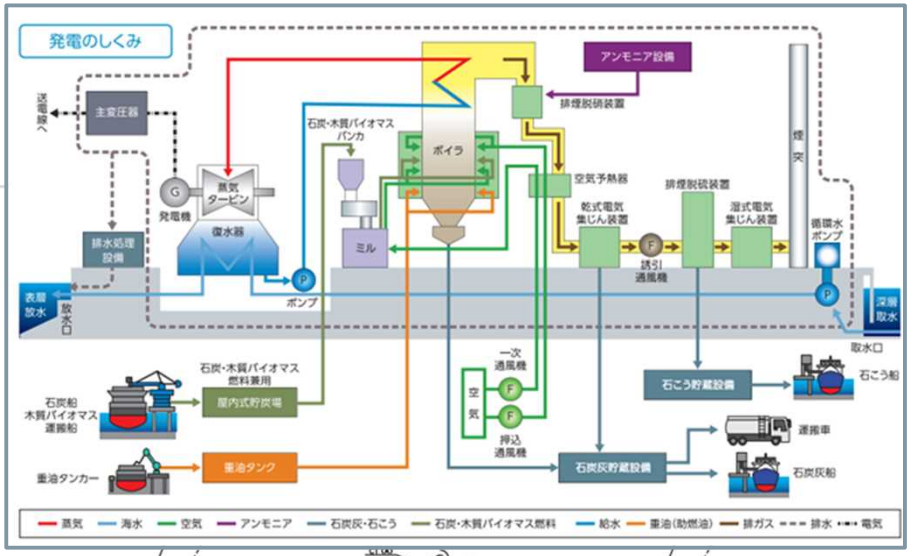


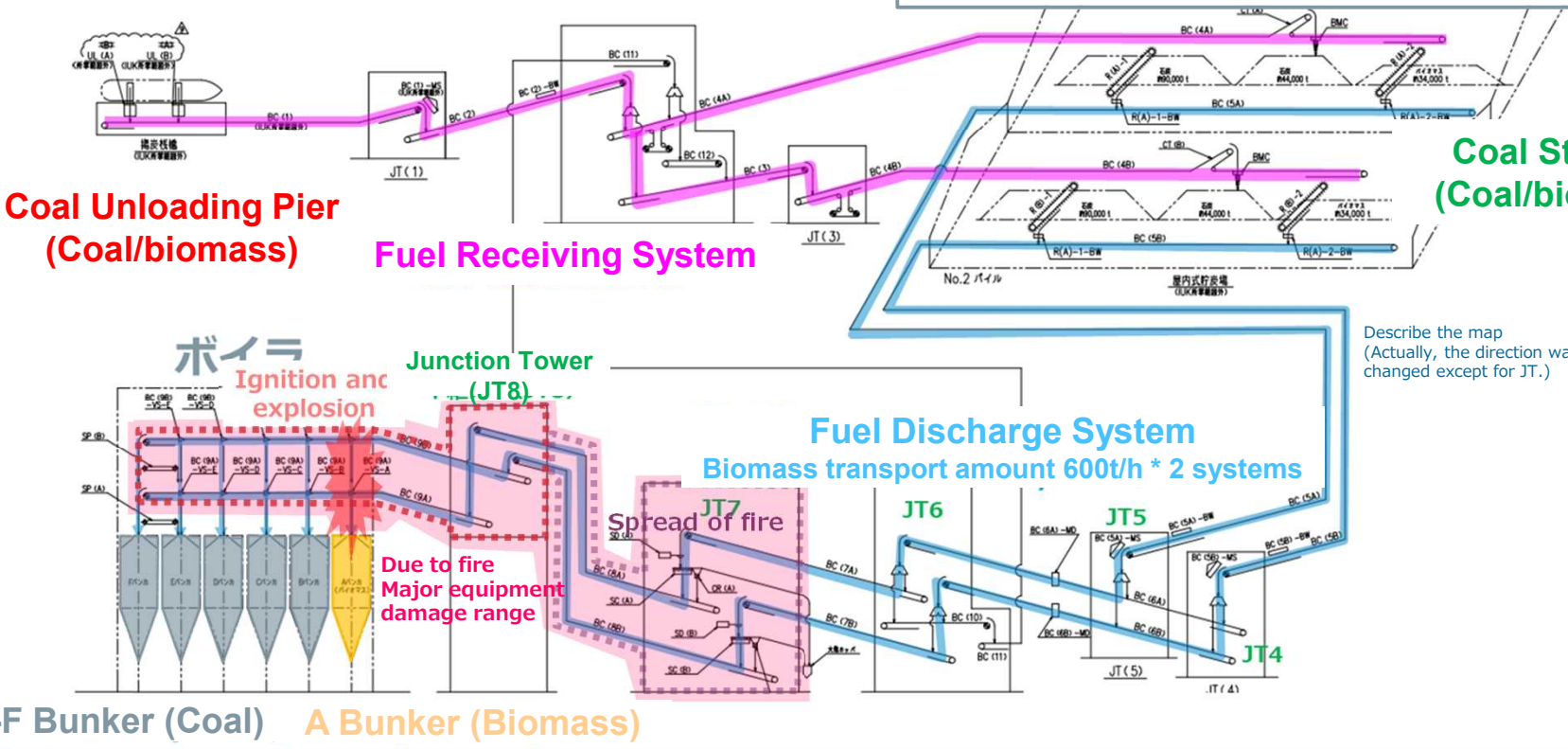


BC: Belt conveyor JT: Relay tower

Outline of facilities

○Fuel : coal and biomass fuel
○Belt conveyor for fuel transportation (BC) can be used for both coal and biomass.
(2 systems of 600 t/h biomass fuel transportation)
○Fuel is discharged from coal storage to bunker (temporary storage facility) adjacent to boiler.
→Used as fuel for boiler
○Junction tower (JT) is a transfer section of conveyor, installed to change direction and angle of conveyor transportation.





Summary of the results of deliberations by the Accident Investigation Committee up to the 3rd meeting

Mechanism of the accident (multiple causes)

Dust

Increase of biomass dust in the transport channel due to **high-speed mass transport**

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Increase of dust concentration beyond the lower explosion limit from the inside of the bunker to the upper part of the projectile chute

Ignition source

Scraper is **fixed at a lower position than normal**

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Friction between belt and cover plate **increased**.

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Dust accumulated in areas that are difficult to inspect and clean.

＋

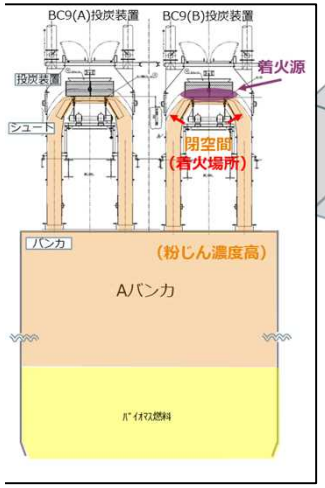
Heat generated by **friction ignites accumulated dust.**

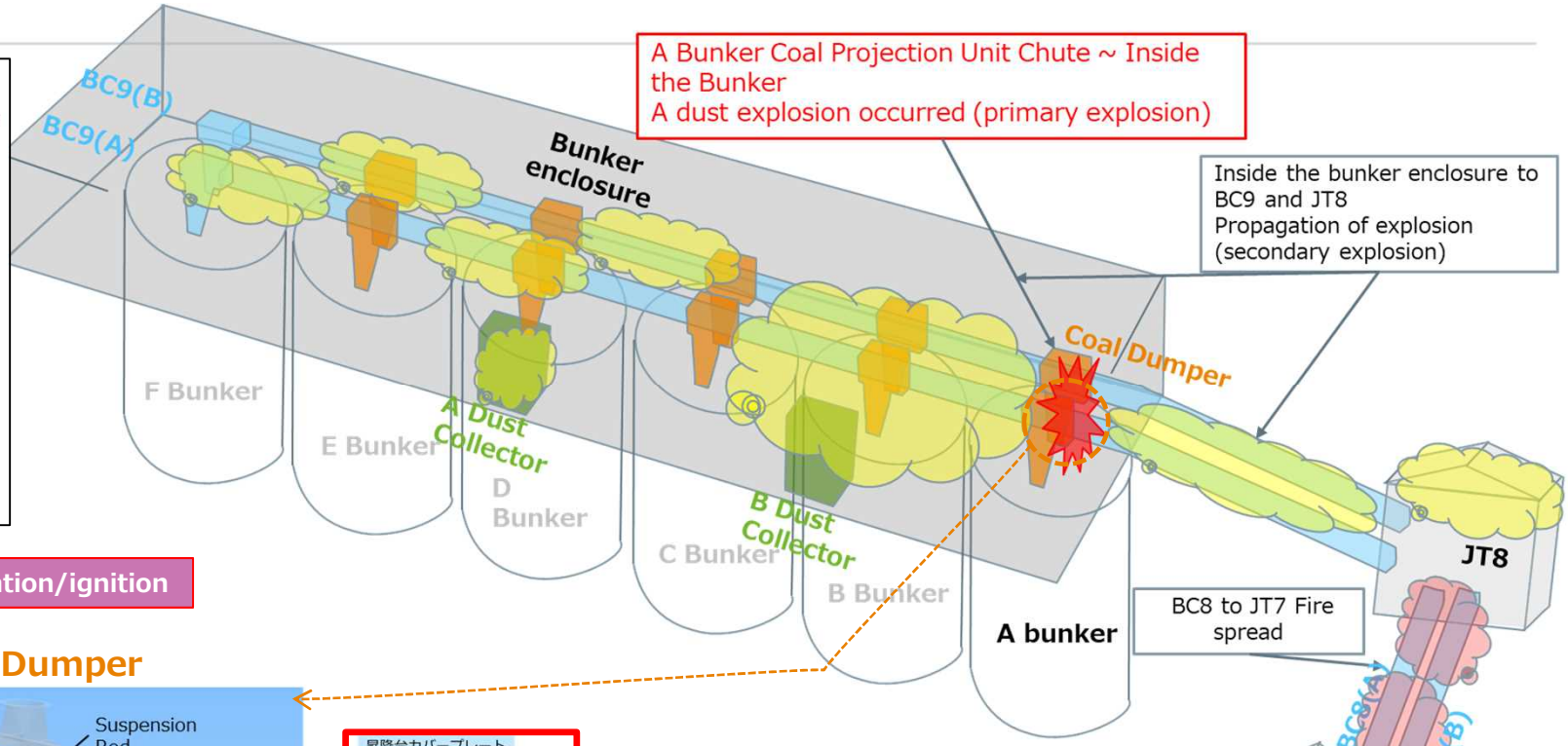
Occurrence of a primary explosion

→ Occurrence and propagation of a secondary explosion caused by dust scattering in a bunker enclosure

- This event was **caused by the inherent characteristics of biomass fuel (white pellets).**
- **Due to differences in fuel properties, similar accidents do not occur with coal.**

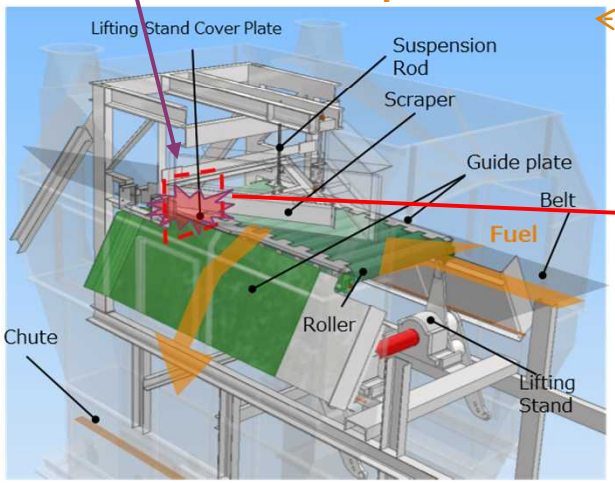
Mechanism of the Accident (Overall)

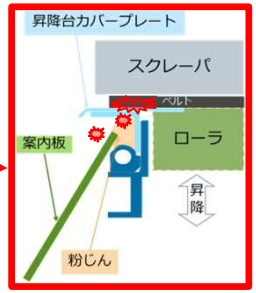




Friction heat generation/ignition

Coal Dumper





Friction heat generation
Accumulated dust ignites
(Dust accumulates in narrow spaces that are difficult to clean)

Details of this report: Summary of recurrence prevention measures

Fourth accident investigation committee September 3

Basic policy of countermeasures

- **To reduce "ignition source risk caused by multiple causes" and "dust concentration"**
- **In the event of an explosion sign, control it before a fire or explosion occurs.**
- **To prevent the occurrence of similar events, including smoke events that have occurred in the past.**

Specific measures

Current/Past Accident events	Cause	Countermeasures
Due to friction Heat generation/spark **generation**	**Ignition source**	・Biomass delivery equipment is **equipped with a dedicated air carrier to eliminate mechanical friction and Removal and elimination of the use of coal Dumper.** ・Conveyor equipment to transport biomass fuel is **reduced in speed** to reduction of risk of ignition by friction
Increase in biomass **dust**	**Dust**	・The biomass discharging facility was **equipped with a dedicated air conveyance facility, and dust floated.** **Coal casting equipment, which tends to accumulate, was disused.** ・The **conveyance speed** of the conveyor facility that conveys biomass fuel **is lowered to reduce dust generation,** ・**increase the capacity of dust collectors** at locations where dust is generated (connections and coal yards).

+

To prevent the spread of explosions, fires and secondary explosions, safety devices are installed throughout the biomass conveyance facility.

Past smoke events and the cause of this accident

The specific measures described in the previous page prevent recurrence of this event and past events.

Fire and explosion accident

Cause (Complex)	
Ignition source	・Scraper was **fixed in the lowered position**. ・**Friction** between belt and cover plate **increased**. ・Friction generated heat in the cover plate and **ignited accumulated dust** in the difficult to clean area.
Dust	・**High-speed mass transport** of biomass fuel **increased biomass dust** in the transport channel. ・The dust concentration from the inside of the bunker to the upper part of the projectile chute **increased above the lower explosion limit**.

Past smoke events

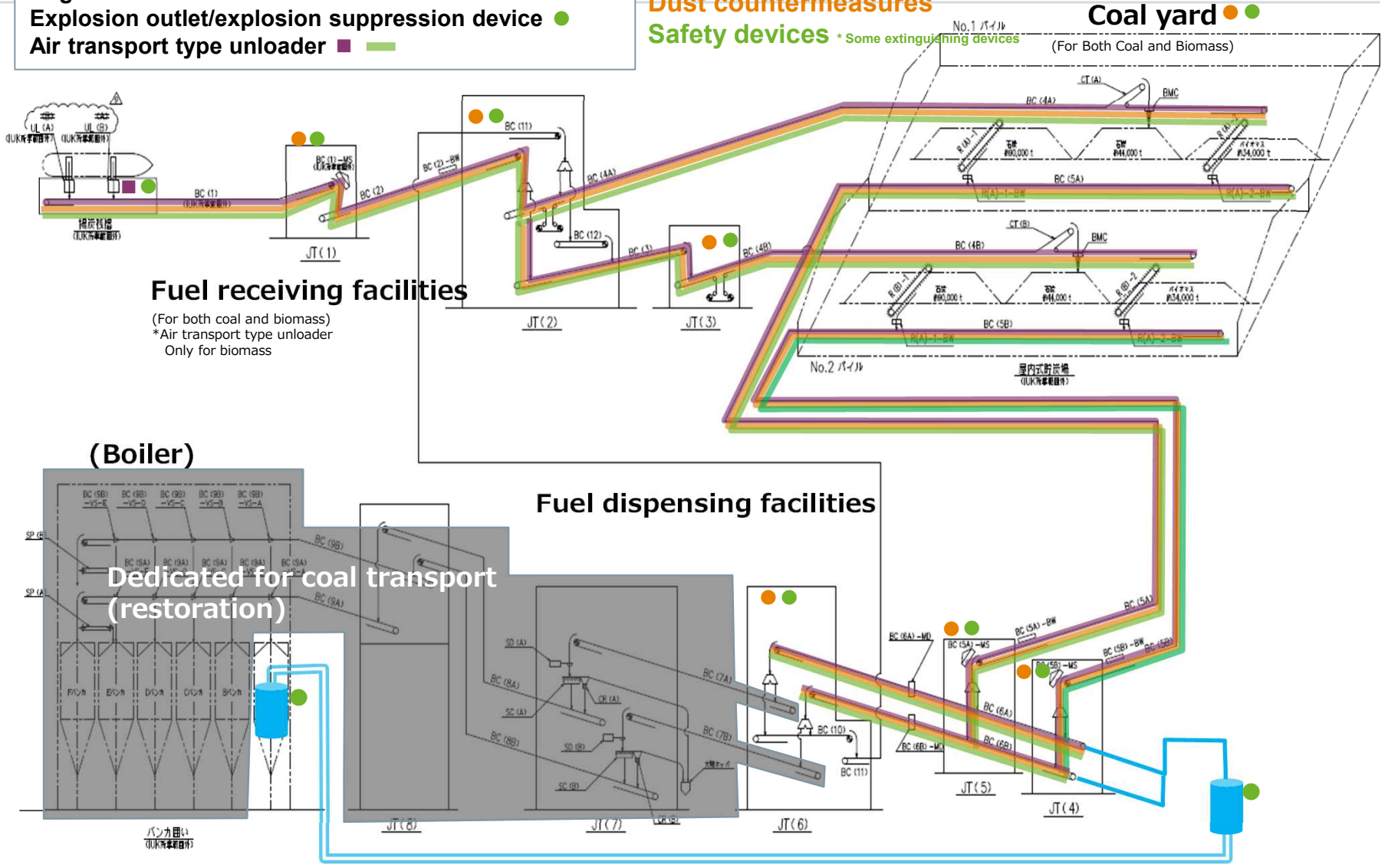
Past smoke events	Cause		Countermeasures
Outgoing transport equipment (BC9) Smoke (August 3, 2022)	Ignition source (Friction)	・Split pin at the end of the shaft connecting the scraper guide plate has come off. ・**Heat generated due to friction** between the slipped shaft and the belt	・Split pin inspection and integrity check
	Dust	・**Biomass dust accumulated on the floor ignites** and generates smoke	・Cleaning and inspection of the lower part of the scraper Reinforcement of visibility
Disposal and transport equipment (JT8) Smoke (September 29, 2022)	Ignition source (Friction)	・Pat when the belt conveyor drive unit brake operates **Sparks generated by friction**	・Review of brake operation circuit
	Dust	・**Biomass dust accumulated** on the floor ignites and generates smoke	・Cleaning of JT and strengthening of monitoring
Smoke generated by receiving and transporting equipment (BC1) (January 23, 2023)	Ignition source (Friction)	・Foreign matter bites into lower carrier roller of belt conveyor and **sparks are generated by friction** with the roller.	・Increase gap between roller and frame to prevent biting. ・Review of temperature monitoring device settings
	Dust	・**Biomass accumulated** on carrier roller frame and casing **Mass dust ignited and emitted smoke**	・Cleaning after cargo handling and strengthening of monitoring

Overall details of recurrence prevention measures

[Overview of Fuel Transfer Facility]

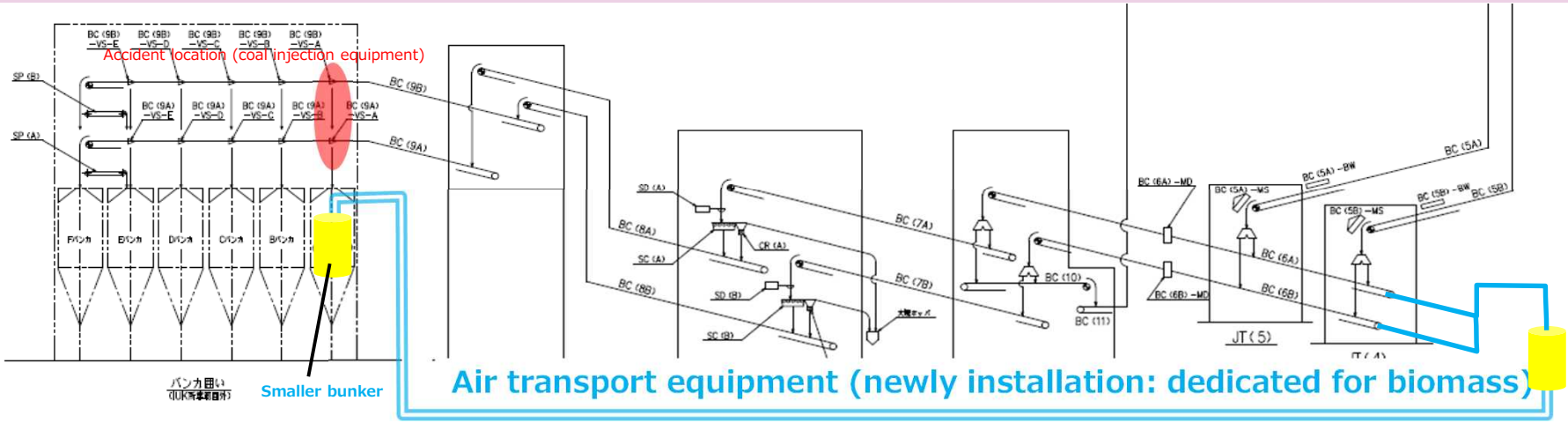
Biomass dedicated air transport system
Belt conveyor transport speed reduction
Augmention dust collector
Explosion outlet/explosion suppression device
Air transport type unloader

Ignition source and dust countermeasures
Ignition source countermeasures
Dust countermeasures
Safety devices * Some extinguishing devices

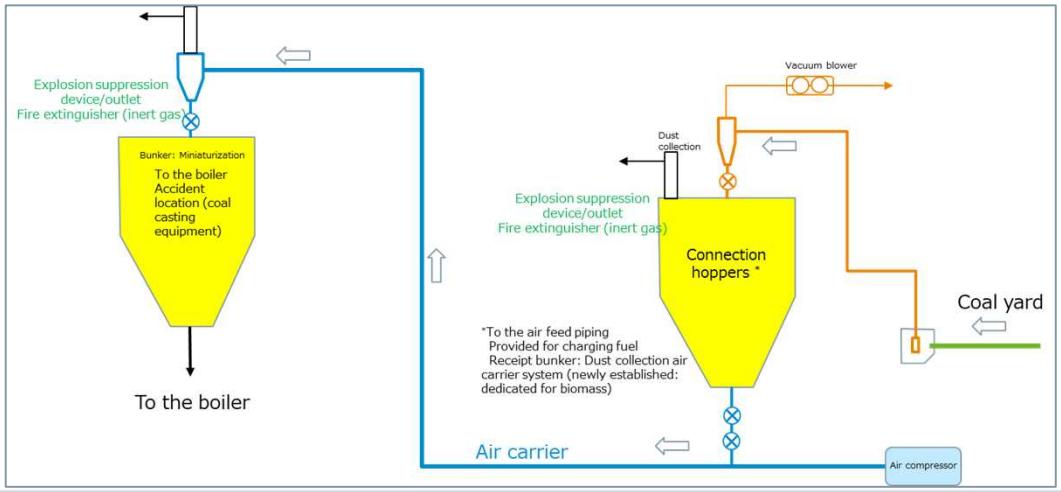


Recurrence prevention measures (1)
Biomass dedicated air carrier

- **Biomass was transported by air to eliminate the risk of friction and heat generation by eliminating moving parts.**
  Coal Dumper, in which dust floats and accumulates, was eliminated.
- **Connection hoppers and receiving bunkers were equipped with explosion suppression devices and fire extinguishing equipment.**



< Schematic drawing of pneumatic feed system >



Recurrence prevention measures (2)
Reduction of conveyor speed (1/2)

- The current conveyor belt speed (receiving side: **4 m/s**) is higher than the overseas results
- The conveyor speed is considered to be **related to both "increase of dust" and "heat generation due to friction"** which were the causes of the accident.
  Evaluation of the relationship with conveyor speed was conducted using test equipment.

[Test procedure]

・By combining 2 conveyors of 42 m length and circulating fuel, pulverization due to impact during transit and temperature rise due to friction were evaluated.
・Tests were conducted by changing the speed of 2 conveyors at 1~4 m/s.

[Test results]

Tests	Test description	Test results
Fine powder rate	Sampling fuel in circulation and measuring fine powder rate Fine powder rate: Weight percentage of powder passed through approximately 3mm sieve	**The fine powder rate was almost the same at 1m/s and 2m/s, but remarkably increased at 4m/s.**
Friction Heat generation	Temperature rise is measured when roller of conveyor is forcibly fixed and rubbed against belt. (* Temperature rise is hardly observed when roller is not fixed.)	Heat generation caused by friction with fixed roller **increases almost in proportion to increase of conveying speed**.

[Evaluation]

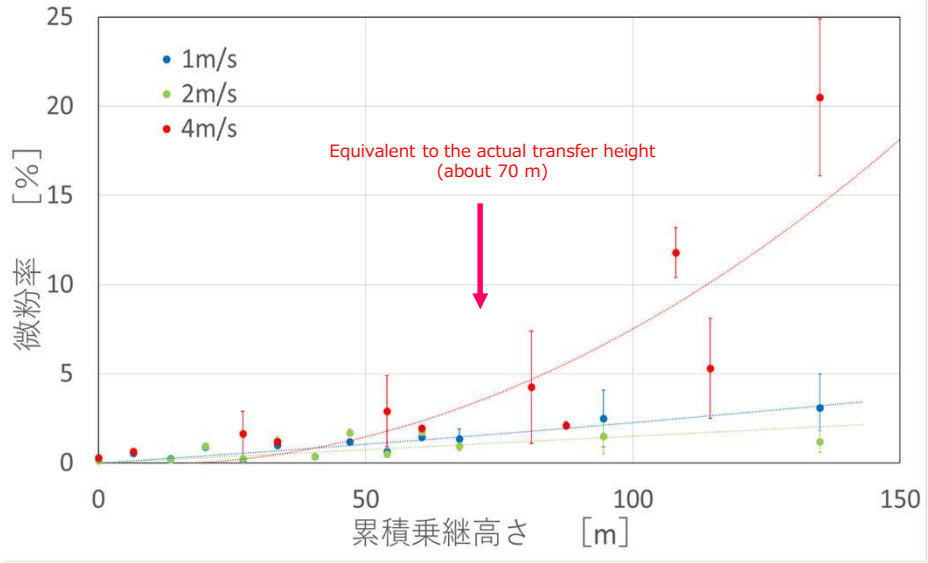
・By reducing the conveying speed from 4 m/s to **2 m/s or less, the total amount of dust can be reduced**.
・Heat generation and temperature rise due to friction **can be reduced by about half by reducing the speed by half**.

→From the above, from the viewpoint of reducing the amount of biomass dust and the risk of frictional heat generation, the **conveyor belt speed should be reduced (2 m/s or less).**

(It is considered to be safe at a transport speed of 2 m/s or less, but we will confirm and verify it from 1 m/s in the actual machine.)

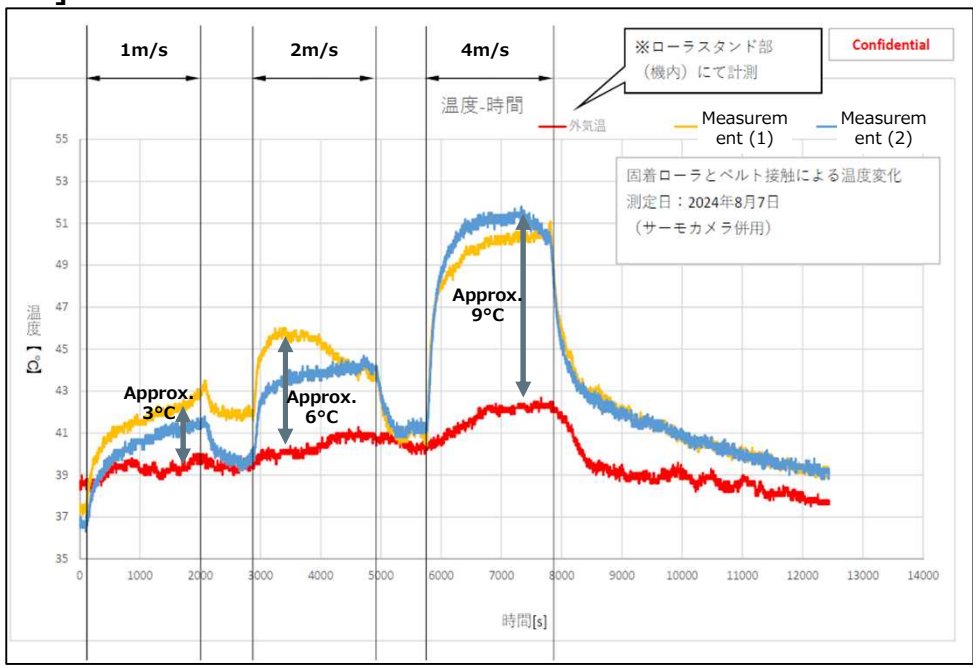
Recurrence prevention measures (2)
Reduction of transport speed (2/2)

[(1) Fine particle rate test]



The fine particle rate is almost the same at 1 m/s and 2 m/s, but at 4 m/s, the fine particle rate remarkably increases due to the collision of fuel with the chute at the junction.

[(2) Friction heating test]



・Temperature rise due to friction is almost proportional to the conveying speed
・The temperature reached by frictional heat generation is about 40~50°C, which is sufficiently lower than the biomass fuel ignition temperature
value sufficiently low compared to

*Heat generation due to friction is generally determined by the following equation. It is proportional to the coefficient of dynamic friction, load, and relative speed

$Q = \mu \cdot W \cdot v/J$ [cal/s] (μ: coefficient of dynamic friction W: load v: relative speed J: work equivalent of heat)

It is considered that even under frictional conditions where the coefficient of dynamic friction and load increase and the temperature rises close to the ignition temperature, the **temperature rise can be almost halved by halving the conveying speed**.

Recurrence prevention measures (3) Installation of safety devices

- **In the unlikely event of an explosion sign, an explosion suppression device or an explosion outlet/fire extinguishing vent should be installed to prevent a fire or explosion.**
- **Safety devices should be installed on belt conveyors and connections of biomass transfer facilities, dust collectors, bunkers, etc.**

Features of safety devices

Explosion suppression device

Detects the pressure wave of the primary explosion and immediately sprays fire extinguishing agent to prevent secondary explosions

Explosion outlet/fire extinguishing vent

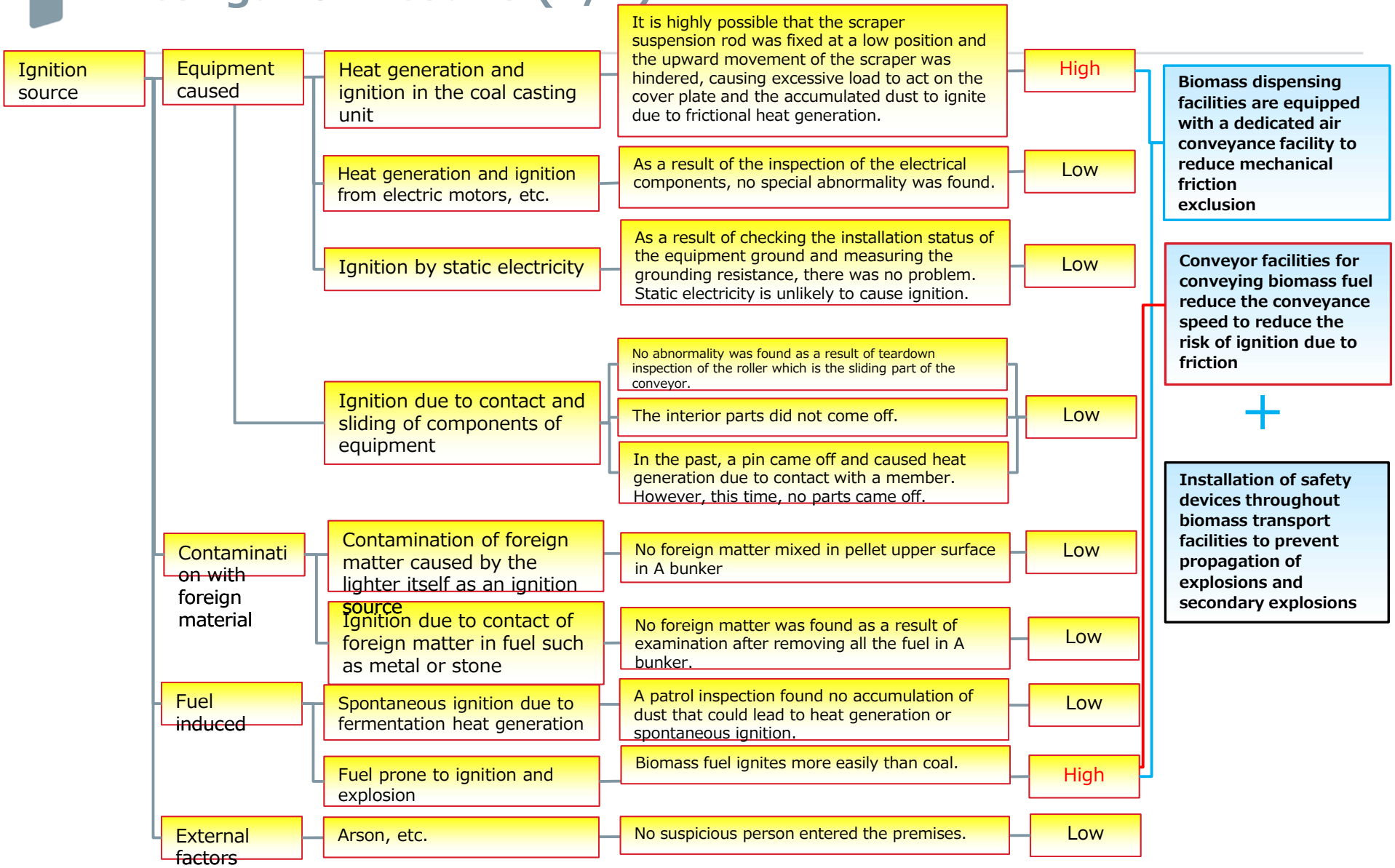
Prevents damage to equipment by releasing the pressure from the primary explosion through the outlet
Extinguishing vents prevent flame loss

Comparison between biomass fuel and coal

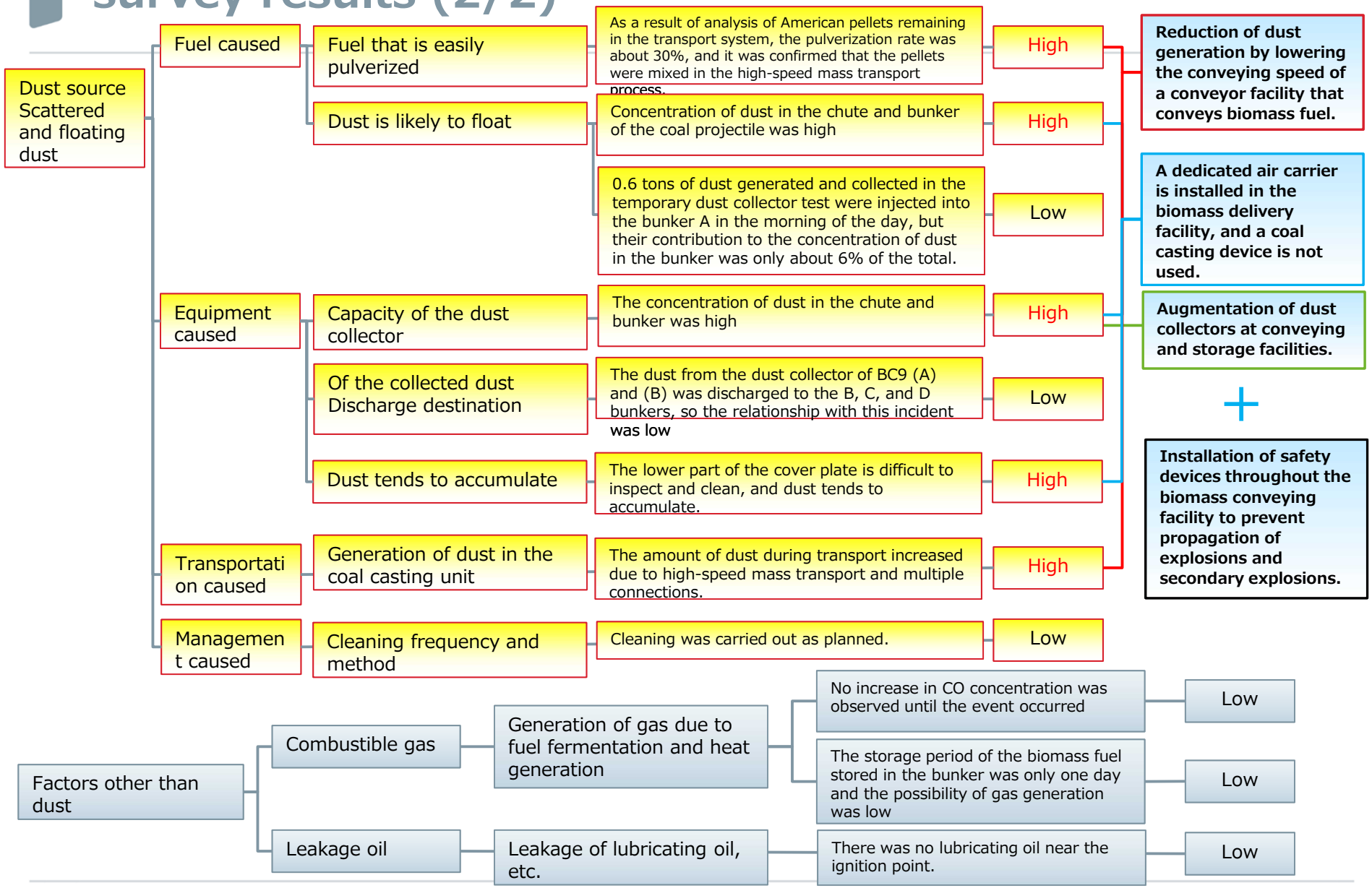
In the case of using only coal, the accident similar to that in this case did not occur, and it is considered that there is no safety problem.

	Biomass	Coal	Evaluation
Dust concentration	• White pellets have a large amount of fine particles in the fuel • Due to particle size distribution, many small particles **tend to scatter** • The amount of dust increases due to transportation and transit, and the **dust concentration in the system is high** • **Lower explosion limit concentration: Small** (about 95 g/m 3) • Measured values (transit buildings, etc.) Up to 80 g/m3	• Coal fines are **about 1/5 of** white pellets • In terms of particle size distribution, there are many large particles, and surface moisture makes them **difficult to scatter**. • **The dust concentration in the system is the same as that of white pellets. Approx. 1/500** • **Lower Explosion Limit High (Approx. 230 g/m 3)** • The measured dust concentration in bunkers and silos during coal transport is extremely low at approximately 2~7 mg/m3.	**Coal has little risk of dust generation and ignition heat generation, and the dust concentration in the channel is considered to be below the lower explosion limit. Therefore, similar accidents are not considered to occur.**
Ignition source	• **Dust accumulates easily** • **Easy to ignite** (**Minimum ignition energy 12 mJ or less**) • **High risk of spontaneous ignition** due to fermentation heat generation during long-term deposition	• Less dust deposition • **Difficult to ignite** Minimum ignition energy of coal is white pellet 10 times or more **Minimum ignition energy** of **300 mJ or more** • The risk of heat generation during long-term deposition is lower than that of biomass.	
Example of accident (including other companies in Japan)	**There are several cases of dust explosion.**	**In conveyor equipment** **There are no cases of dust explosion.**	

Factor analysis, investigation items, and investigation results (1/2)



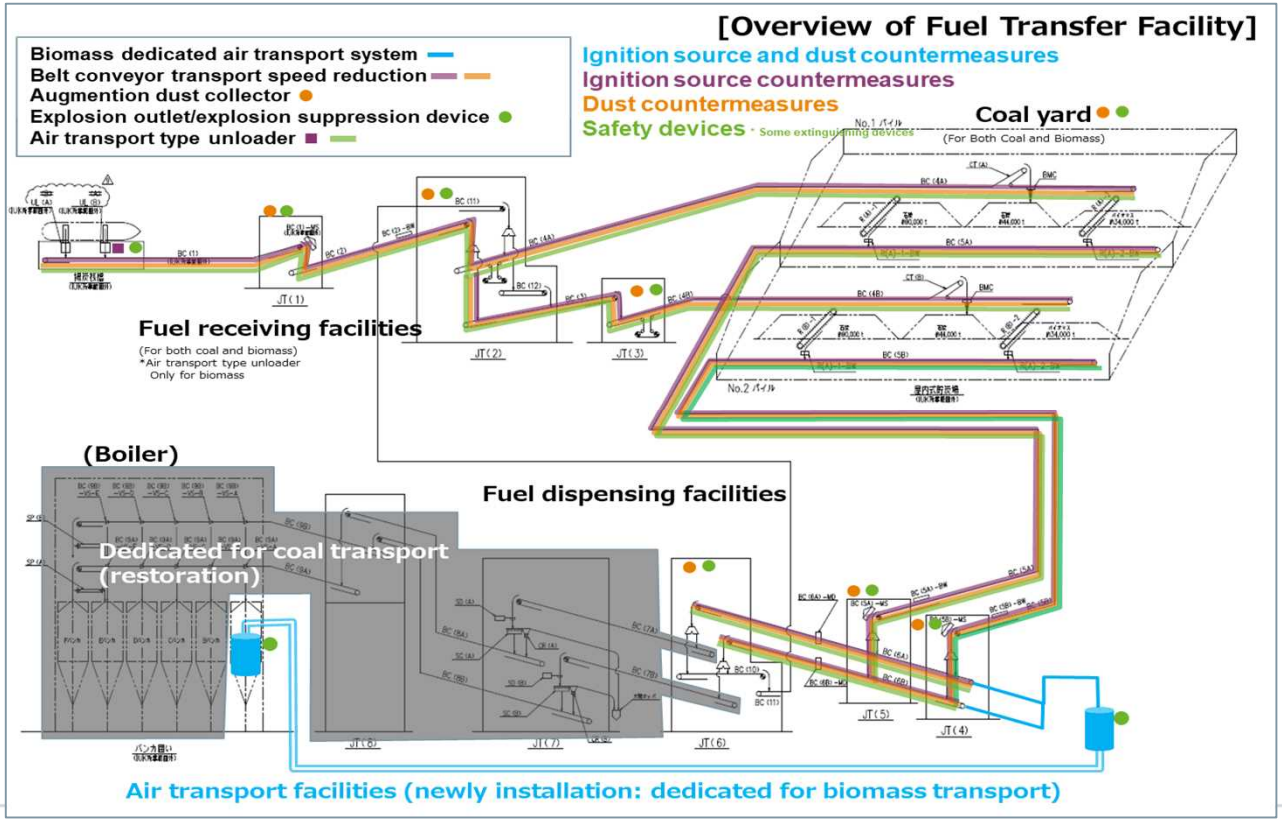
Factor analysis, survey items, and survey results (2/2)



Summary

[Recurrence prevention measures]

- **The fuel delivery facility where the fire occurred will stop using both coal and biomass fuel, and will be used exclusively for transporting coal. Regarding transportation of biomass fuel, a dedicated air transportation facility will be installed, and the risk of mechanical friction and heat generation will be eliminated by eliminating moving parts by transporting biomass by air, and the use of a coal casting device will not be used.**
- **As for the fuel receiving facility, an air transportation type unloader dedicated to biomass fuel will be added, and the transportation speed of biomass fuel will be reduced.**
- **Installation of safety devices such as an explosion suppressor at the biomass fuel transportation facility**



Fire accident response schedule at Taketoyo Thermal Power Station