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Turbine bearing housing fire accident due to hydrogen inflow into nitrogen line of dry gas seal

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Outline

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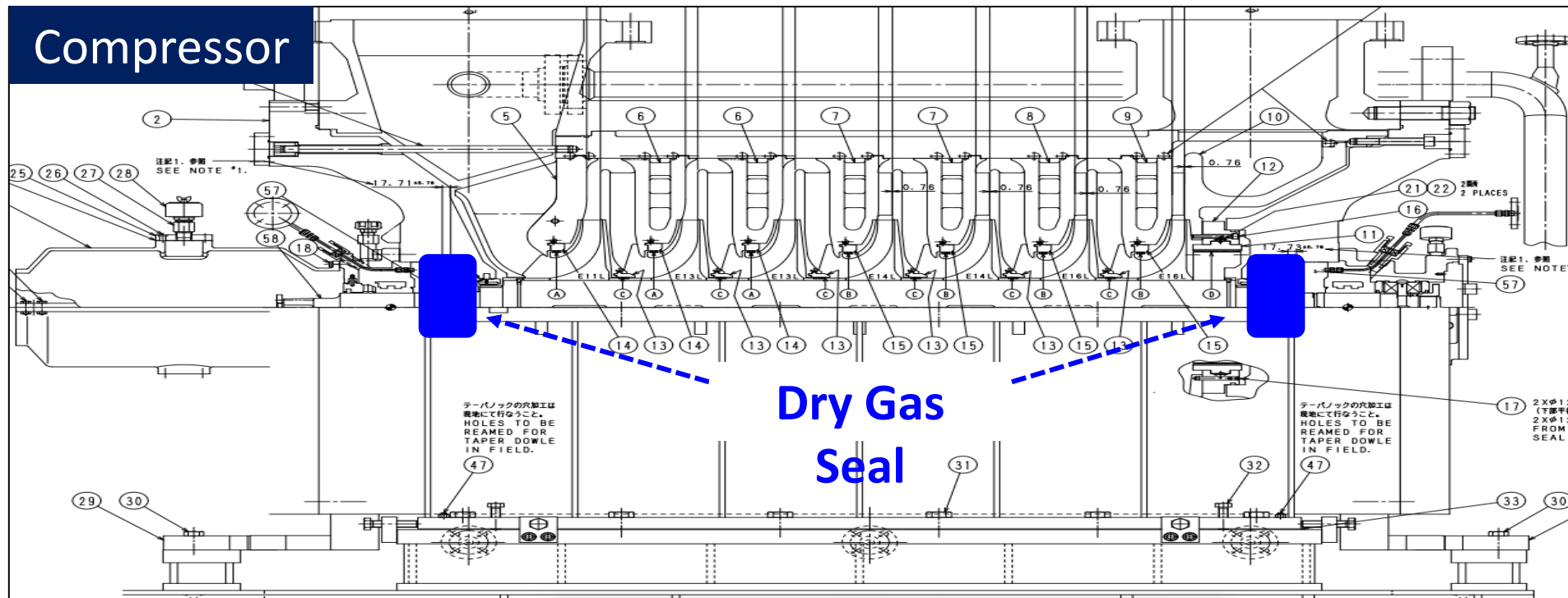
Abstract

- **Fire incidents occurred in the turbine bearing housing** at every start-up since the original wet type seal in the compressor was replaced with a dry gas seal (DGS). The first investigation focused on leakage of the lube oil in the turbine bearing housing. However, despite various measures, the fires continued to occur.
- After repeated attempts to find a root cause, it was realized there were incorrect operation procedures and valve passing problem in the DGS, and which caused **hydrogen inflow into the nitrogen line(separation gas) of the compressor DGS and finally migration into turbine bearing housing.**

This case study details the root cause analysis results and the countermeasures.

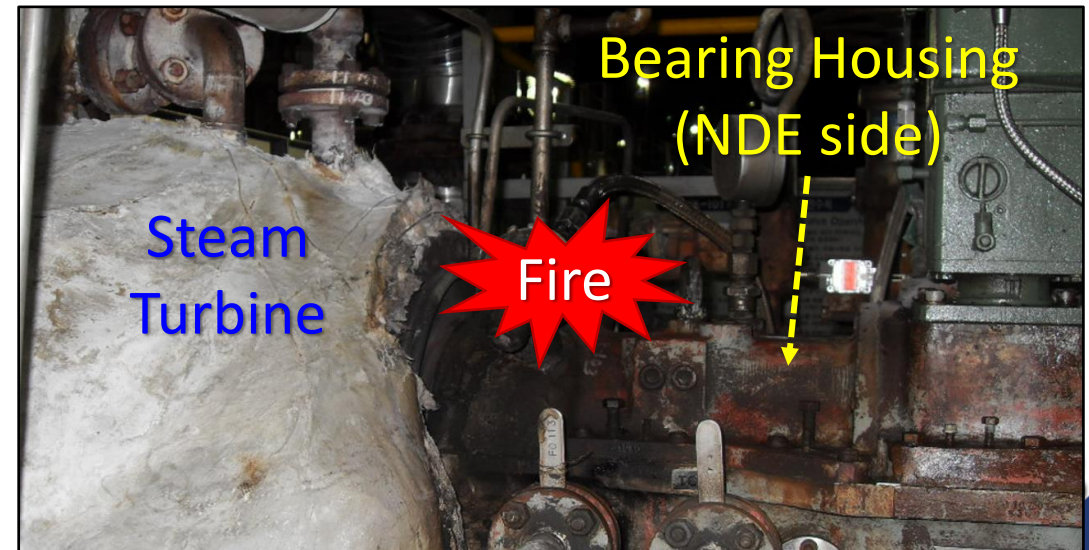
Equipment Data

1. **Process** : No.1 CCR(Continuous Catalyst Regeneration) Unit
2. **Compressor**
 - 1) Recycle Gas Centrifugal Compressor, Hydrogen(87%) service
 - 2) Seal Type Modification : **Wet Seal** → **Dry Gas Seal** (2012)
3. **Steam Turbine** : Condensing Turbine Type, speed 8,145rpm



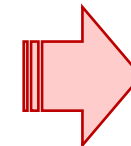
Background

- Frequent fire accidents in the steam turbine bearing housing occurred every start-up, which resulted in urgent shutdown (by manual stop).
- In an initial investigation that focused only on the fire location, oil leakage from the bearing housing was regarded as the cause. However, despite various measures and modifications to prevent oil leaks, the fires continued to appear during start-up.
- After a thorough investigation, two abnormal phenomena were observed and the root cause found in the compressor DGS.
 - 1) H₂ detected in bearing housings (compressor and turbine) and oil reservoir.
 - 2) H₂ detected in the N₂ line, although there are two isolation valves (closed) and one check valve in the H₂/N₂ common line.



Compressor DGS & Turbine Oil Seal Purge System

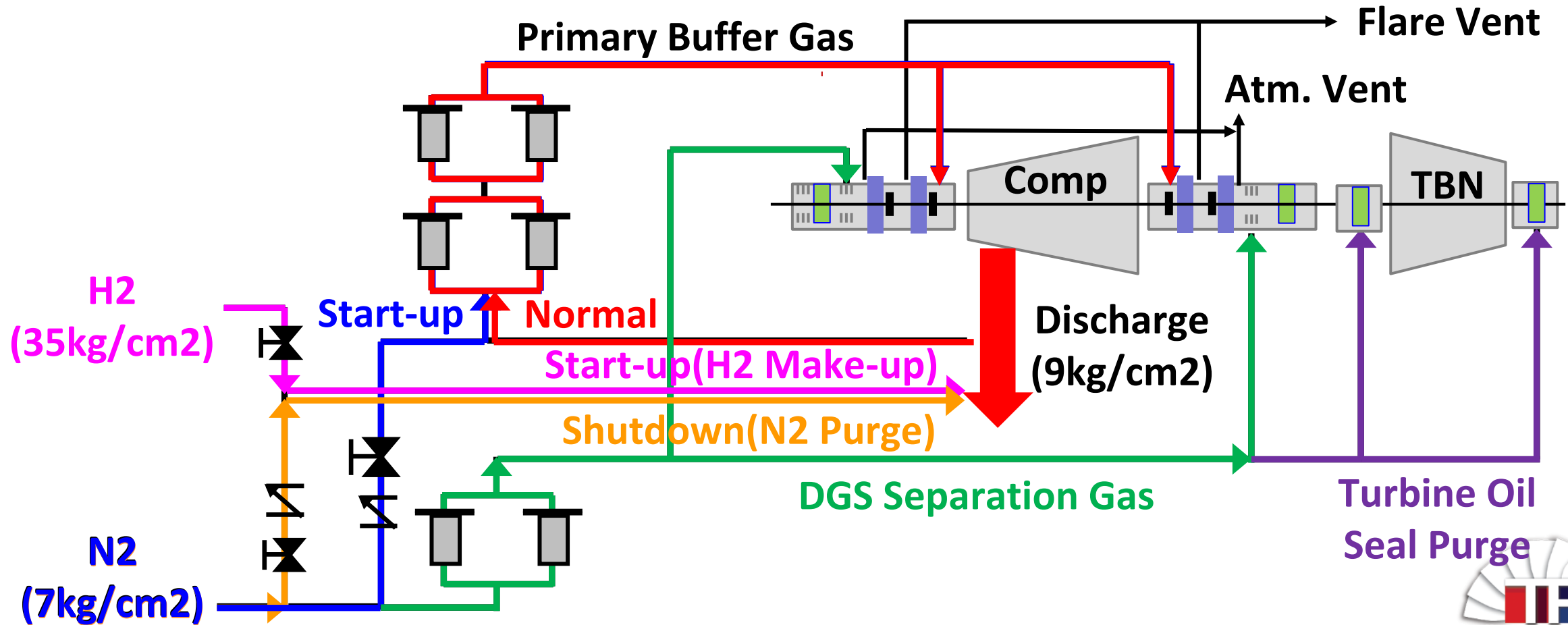
Item	Function	Source	Color (Next Slide)
Primary Buffer Gas	Prevent process gas inflow into the gas seal face	Start: Nitrogen Normal: Hydrogen (discharge gas)	N2 : Blue H2 : Red
Separation Gas	Prevent bearing oil inflow into DGS	Nitrogen	Green
Hydrogen Make-up	For start-up	Hydrogen	Pink
Nitrogen Purge	For shutdown	Nitrogen	Orange
Turbine Oil Seal Purge	Prevent oil leak from bearing housing	Nitrogen	Purple



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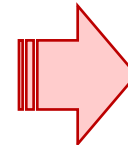
Compressor DGS & Turbine Oil Seal Purge System

- The header line of **Hydrogen make-up** and **Nitrogen purge** is connected to a common line.
- The header of separation gas and turbine oil seal purge is connected to a common line.



Event #1 – Cause and Effect

- **Immediate Cause : H₂(from compressor discharge) inflow into N₂ header line**
 - Primary buffer gas is supplied from N₂(back-up) during an initial start, and after compressor discharge pressure becomes higher than N₂ pressure, discharge gas(H₂) should be supplied to the primary buffer gas line. At this time, the block valve should be fully closed to prevent H₂ from passing over to the N₂ header.
 - **But in our case, the closing procedure of the valve was omitted when the discharge pressure > N₂ pressure, which resulted in H₂ reverse flow into the N₂ header and further migration into the turbine bearing housing.** Consequently, the fire occurred in the turbine bearing housing.
 - One check valve in the common line of H₂ and N₂, but it was by-passed.



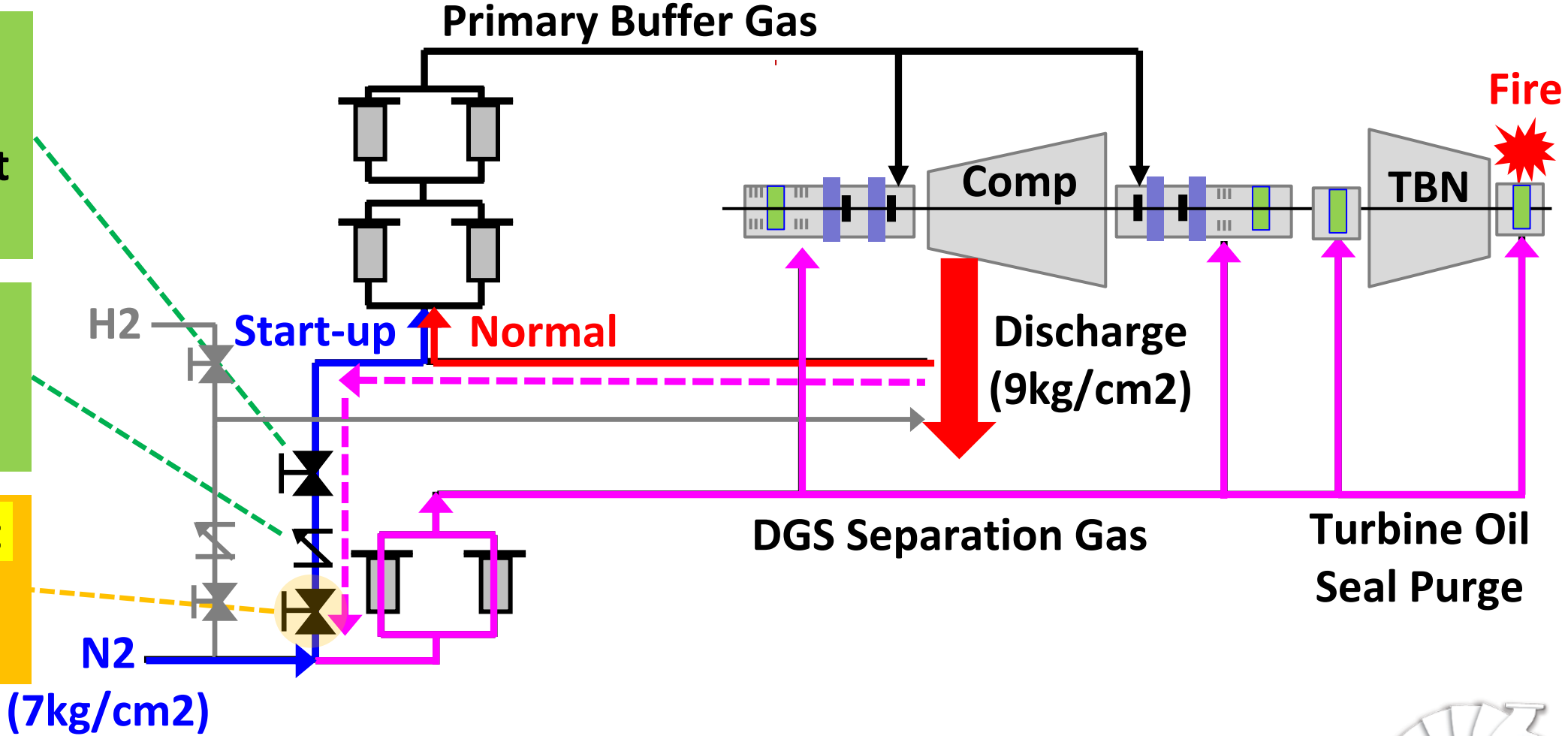
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Event #1 – Operation Leading to Fire

Cause #1
Reverse flow caused by not closing valve

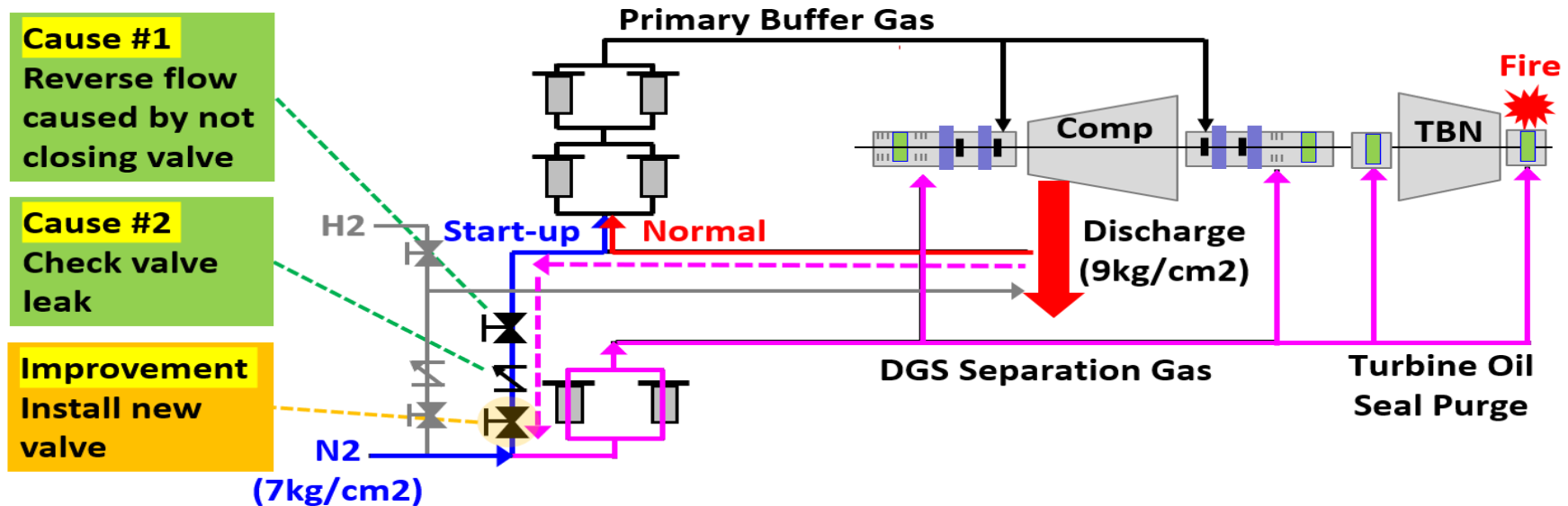
Cause #2
Check valve leak

Improvement
Install new valve



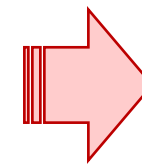
Event #1 – Root Cause and Recommendations

No.	Root Cause	Recommendation
1	<p>Not closed the block valve between H2 and N2 at an appropriate time</p> <p>The lack of operator understanding for related system and working principle</p>	<p>Add specific valve close timing in start-up operation procedure</p> <p>Operator training on the dry gas seal system operation</p>
2	<p>Check valve leak(reverse flow)</p> <p>*Nothing was found in check valve overhaul, but it can potentially leak (prior experience)</p>	<p>Single block valve in common line(H2 & N2) can also leak → Install additional block valve (Double block valve and one check valve)</p>



Event #2 – Cause and Effect

- Immediate Cause : **H2(make-up for compressor start) inflow into N2 header line**
 - H2 make-up line for compressor start and N2 purge line for shutdown are connected to a common line.
 - There were two block valves and one check valve in the common line of H2/N2. However, in our case **H2 passed over all valves**, and H2 high pressure(35 kg/cm²) into the nitrogen line.

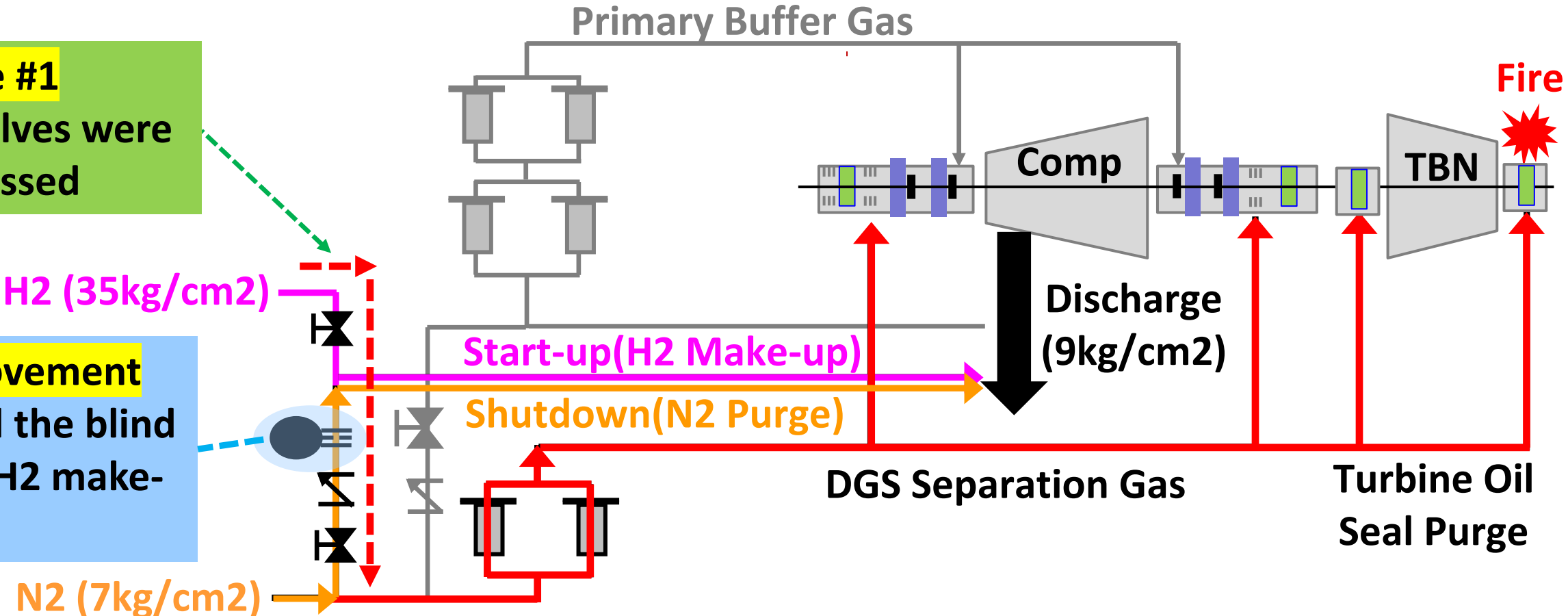


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Event #2 – Operation Leading to Fire

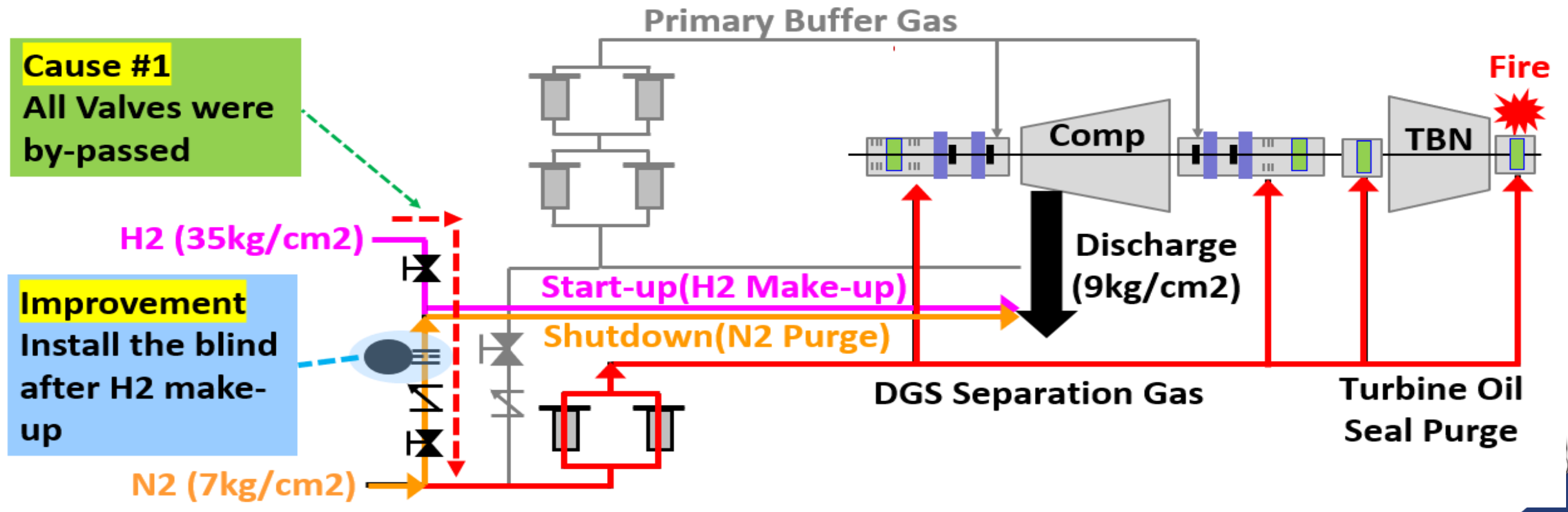
Cause #1
All Valves were by-passed

Improvement
Install the blind after H2 make-up



Event #2 – Root Cause and Recommendations

No.	Root Cause	Recommendations
1	All valves were by-passed (two block valves and one check valve)	Revise operation procedure to install the blind between H2 and N2 after H2 make-up
2	Common line of H2 and N2	Detailed review required to prevent recurrence in new projects



Lessons Learned

- The case study may appear simple and easy; however, basic issues can often cause problems and obscure efforts to find root causes.
- When a fire occurs in the bearing housing, (assuming) oil leakage is the cause is a first and easy explanation. It is difficult to relate the incidents to issues with the DGS operation procedures.
- Further, start-up operation procedures and important check point were shared with operators for their full comprehension.

By sharing our case, we hope there will be no similar failures in other sites.

Thank you & Questions?

ACKNOWLEDGEMENTS

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