CASE STUDY

OISD/CS/2026-27/P&E/08 **Date: 01.06.2026**

INTRODUCTION

Title: Fire Incident in Crude and Vacuum Distillation Unit (CDU/VDU)
Location: Refinery
Loss/ Outcome: Property Damage

BRIEF OF INCIDENT

Following mechanical completion and pre-commissioning activities, the trial run of a Crude and Vacuum Distillation Unit (CDU/VDU) was carried out at approximately 50% of the design throughput capacity. Thereafter, the unit was kept under idle conditions, during which insulation, painting, and other associated activities were being carried out.

The unit was restarted after nearly 2 months. The Crude Distillation Unit (CDU) operation was stabilised at around 57% capacity, with all product streams routed to designated storage. The Vacuum Distillation Unit (VDU) was under process parameter adjustment.

During this phase, dense smoke followed by fire was observed at grade level in the crude versus vacuum residue preheat exchanger section of CDU.

Emergency shutdown of the unit was undertaken, and firefighting operations were initiated using fire tenders, monitors, foam and dry chemical powder. The fire was contained within a small area and was brought under control within about one hour. It was completely extinguished after approximately 2 hours and 40 minutes of firefighting operations. No injury or fatality occurred.

OBSERVATIONS / SHORTCOMINGS

1. Dripping of VR (predominantly reduced crude oil - RCO) stream was observed from the flanges of the diaphragm-type pressure gauge installed on the vacuum residue (VR) shell-side inlet line of the crude versus vacuum residue exchanger (located on ground level). The flushing ring assembly of the pressure gauge was also found loose.
2. The spiral wound gasket of the assembly was damaged and positioned off-center, indicating improper box-up and misalignment. Accordingly, the sealing integrity of the assembly seemed to be compromised. The compromised pressure gauge assembly was concluded as the source of the initial leakage of hot vacuum residue (predominantly reduced crude oil - RCO) at auto-ignition temperature.
3. A fish-mouth rupture (around 6”) was observed in the 2-inch flushing oil (FLO) line located just below the first platform of the technical structure (TS), approximately 5–6 meters above the fire initiation area. The line was provided for flushing the tube side of the CRUDE/HVGO CR EXCHANGER located on the first platform of the TS.

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4. The pressure indicator of the FLO line showed a rise from 23.4 kg/cm2 to 68 kg/cm2 between the citing of smoke and sudden intensification of fire, approximately 4 minutes after the initial outbreak, as per the CCTV footage. Then the FLO pressure dropped down to 2.3 kg/cm2. This implied that the FLO line got pressurized due to heating up in a blocked condition in the flame emanating from the ground floor. It then ruptured, adding FLO into the fire.
5. A flow indicator in the FLO line at battery limit indicated a continuous flow of around 56 m3/hr for about 45 minutes after the initiation of fire. The closing of the flow and dropping of pressure of the line to 0 kg/cm2 coincided with the shutting-off of the offsite pump and isolation of the battery limit valve of FLO.
6. DCS alarm flooding preceding and during the incident was noted. It was also reported that the alarm audio had been kept muted; consequently, the high-high pressure alarm associated with the flushing oil line was not noticed prior to rupture of the line.
7. Dripping and minor leakage of VR stream (predominantly RCO) was also noticed from the gland area of the vacuum residue (VR) inlet gate valve of the same crude versus vacuum residue exchanger. Displacement of the gland packing and gland follower assembly of the valve was identified. The eye-bolt nuts were found disengaged and outward thread deformation was noticed on the gland flange studs, indicating additional leakage through the gland opening during the incident.
8. The vacuum residue (VR) inlet isolation gate valve was found maintained in a partially open condition without backseat engagement, resulting in continuous process pressure acting on the gland packing arrangement and making the gland more susceptible to leakage.
9. Additional hydrocarbon leakages from exchanger flanges, valve glands, and associated piping above the fire affected area were also identified. The leakages were attributed to prolonged thermal exposure and thermal expansion effects.
10. Complete power shutdown of the CDU/VDU was carried out immediately after the incident as per operational instructions, resulting in loss of power supply to emergency response equipment, namely remote-operated firewater monitors of the unit as well as the oily water sewage (OWS) and the closed blow down (CBD) pumps. One strategically located 2000 GPM high-volume long-range monitor (HLRM), which could have effectively supported firefighting operations in the affected area, exhibited misdirected flow as directional adjustment towards the fire could not be carried out due to power loss.
11. The logging system through standard field and panel log sheets had not yet been fully implemented. Regular field parameter monitoring and abnormality recording systems were also not adequately established.
12. Critical control valves and control loops required for smooth operation were reportedly maintained in manual mode during startup and stabilization activities.

REASONS OF FAILURE / ROOT CAUSE

1. Improper box-up and misalignment of the flushing ring assembly of the diaphragm-type pressure gauge installed on the vacuum residue (VR) shell-side inlet line caused damage and improper seating of the spiral wound gasket, resulting in leakage of hot vacuum residue (predominantly RCO).
2. Causes for Escalation
   - Alarm flooding and muted alarm audio resulted in non-cognizance of the high-high pressure alarm prior to flushing oil (FLO) line rupture. Hence, the shutdown and isolation of the flushing oil line was delayed.

- Partially open condition of the VR inlet isolation valve increased susceptibility to gland leakage under fire exposure.
- Prolonged thermal exposure caused additional hydrocarbon leakage from flanges, valve glands, and associated piping

RECOMMENDATIONS

a. Integrity of gland packing assemblies, pressure gauge (PG) connections and temperature tapping (TT) connections should be ensured through proper inspection, assembly verification, maintenance and certification practices under the Gasket Stud Functional Committee (GSFC) system prior to startup.

b. Hydrocarbon lines susceptible to blocked-in thermal overpressure conditions, including fire case, should be reviewed and the feasibility of providing suitable overpressure protection devices such as Pressure Safety Valves (PSV) / Thermal Safety Valves (TSV), with safe relief routing arrangements, should be considered.

c. Alternate/emergency power supply arrangement should be considered for remote-operated high-volume firewater monitors to ensure their availability and operational control during emergency conditions. If unit drainage systems like Contaminated Rainwater Sewer/ Oily Water Sewer (CRWS/OWS) are pumped systems, then such pumps shall be provided with similar power supply.

d. Prior to startup of newly commissioned units, structured field logbooks and standard logging systems shall be implemented for systematic monitoring of field parameters, abnormalities, startup observations and shift handover activities, in line with the guidance provided in Informative Annexure-10 of OISD-GDN-206.

e. Alarm management and rationalization review of point databases for all process units and utility systems should be carried out prior to startup to prevent alarm flooding and ensure timely identification of critical alarms, in line with Clause 7.6.5 of OISD-GDN-206.

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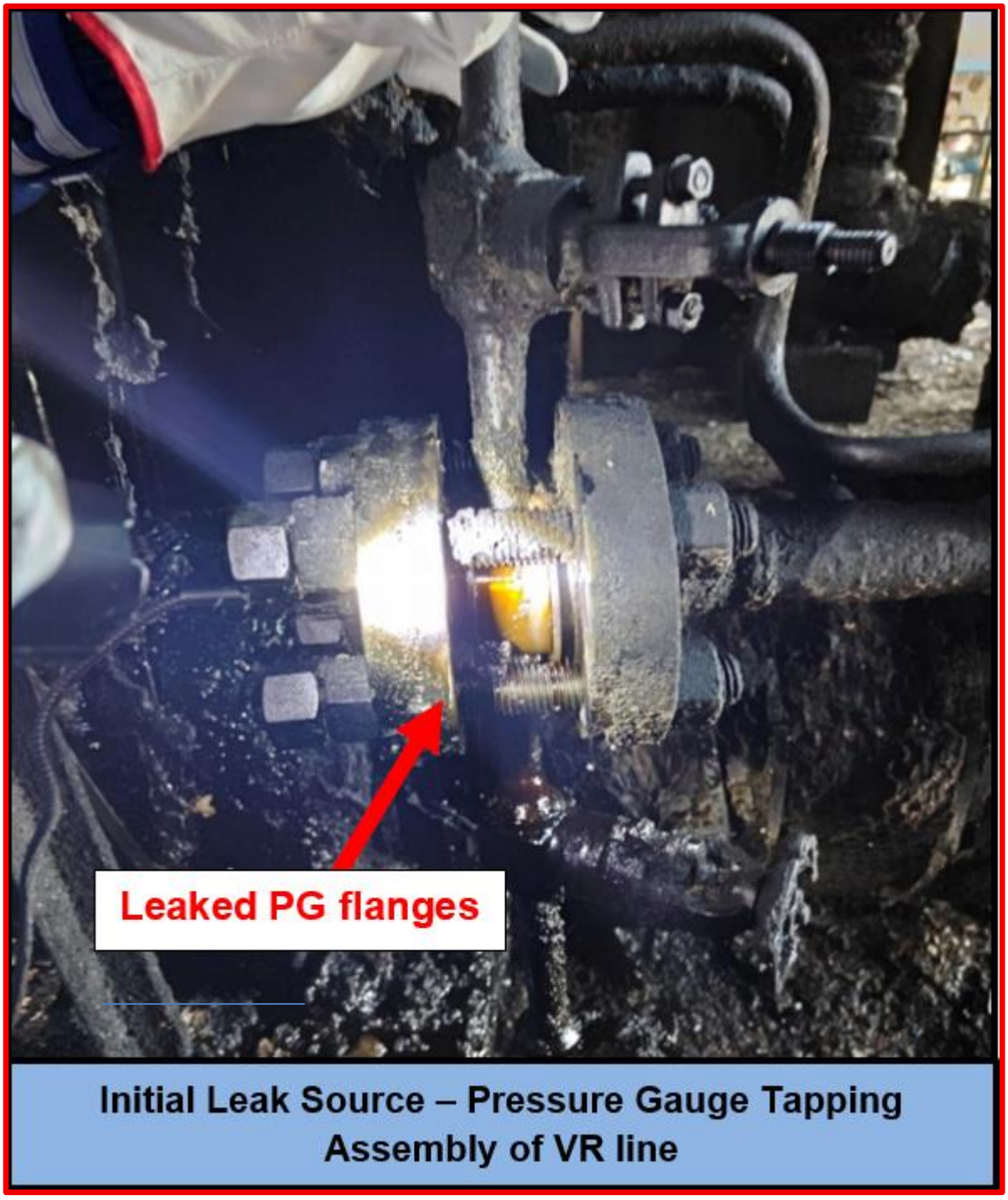
PHOTOGRAPHS



Initial Leak Source – Pressure Gauge Tapping Assembly of VR line

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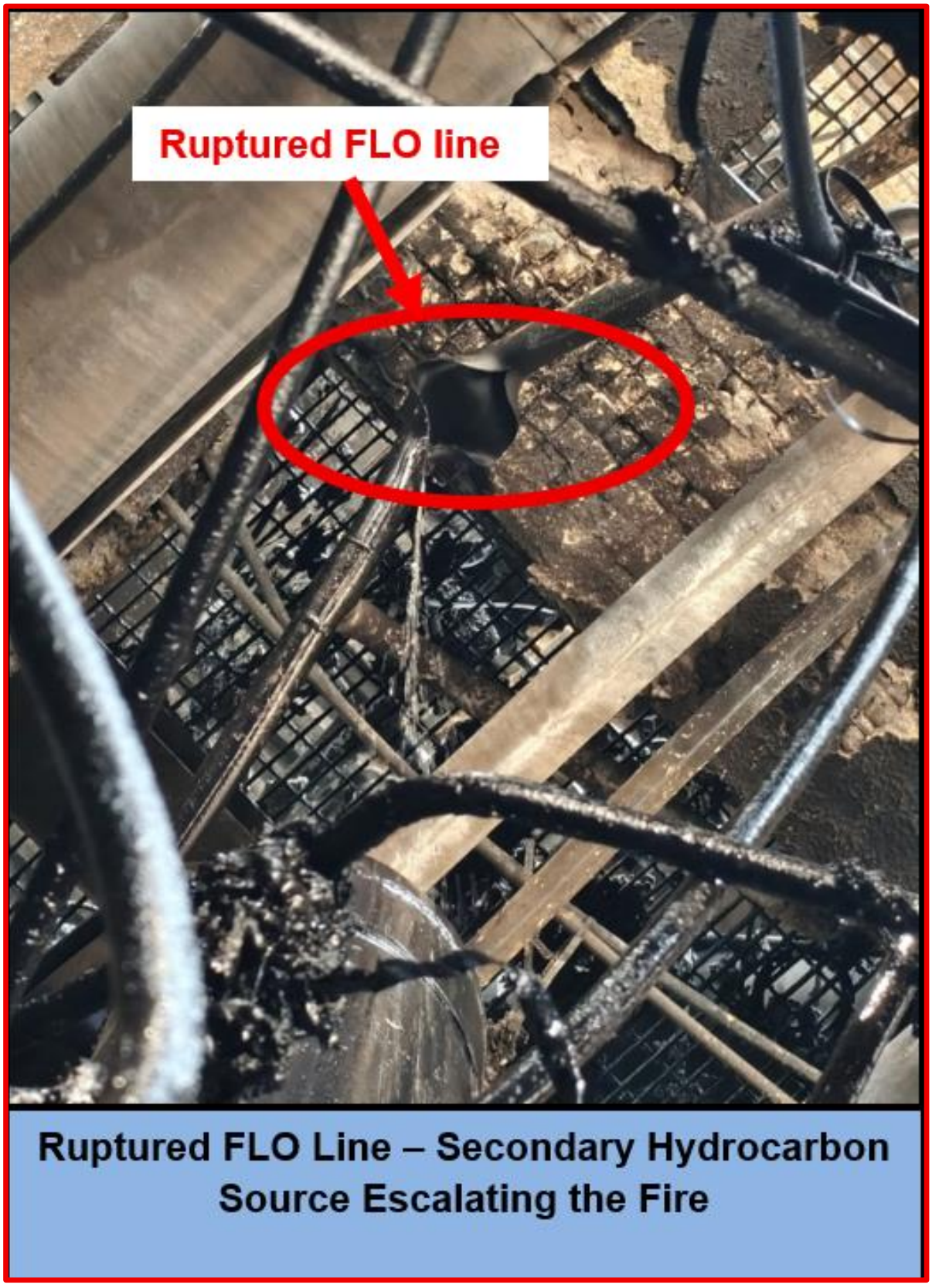

Ruptured FLO Line – Secondary Hydrocarbon Source Escalating the Fire

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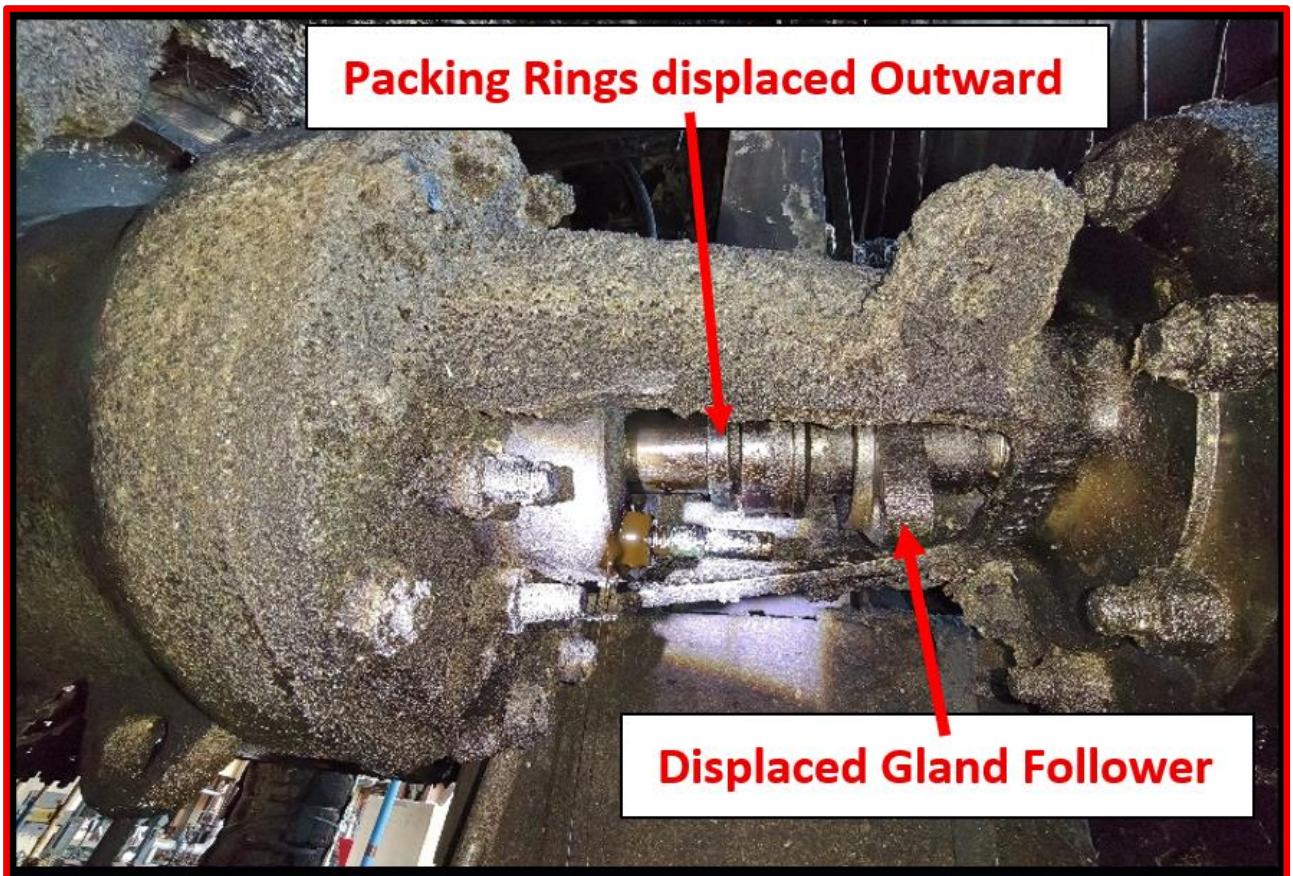

Failed Valve Gland Assembly – Additional VR Leak Source Sustaining the Fire



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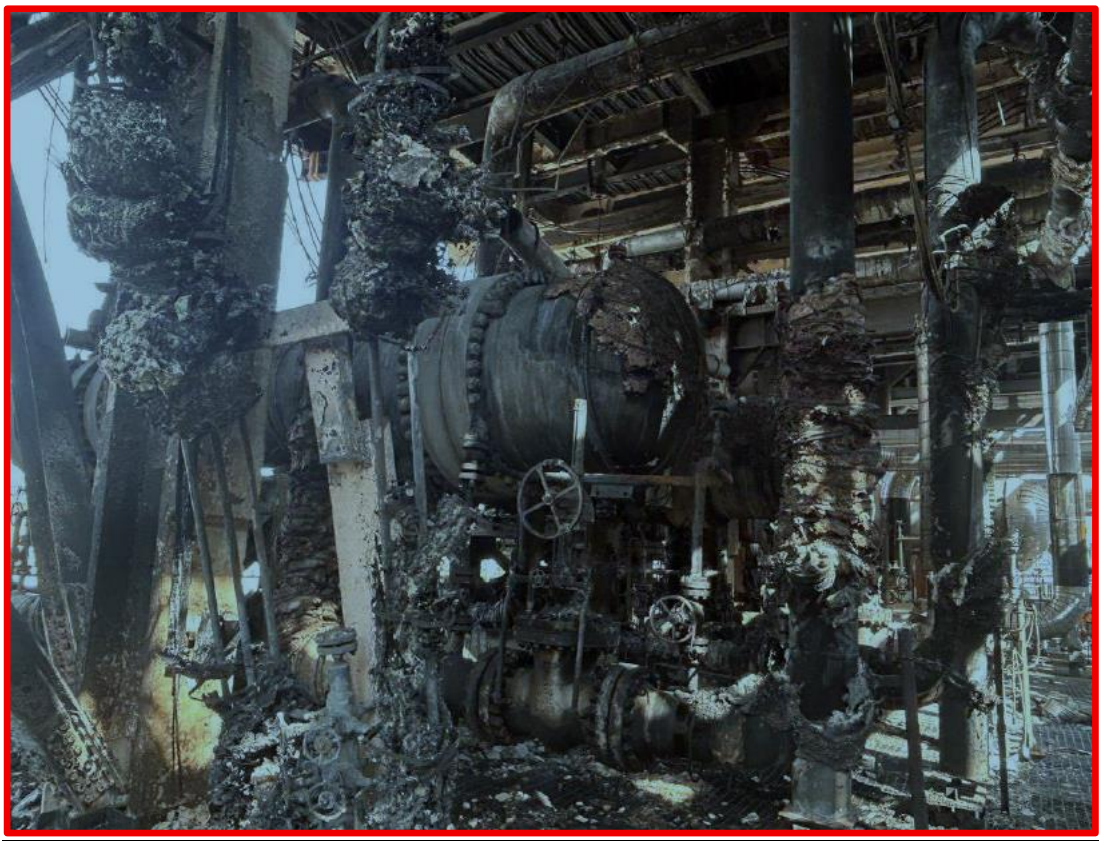

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