Training Package

TP N° 63/21

Yima City Gasification Plant Incident

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Information source

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CGA Consultant

Safety And Reliability Of Industrial Gases, Equipment, And Facilities Seminar

October 20, 2020

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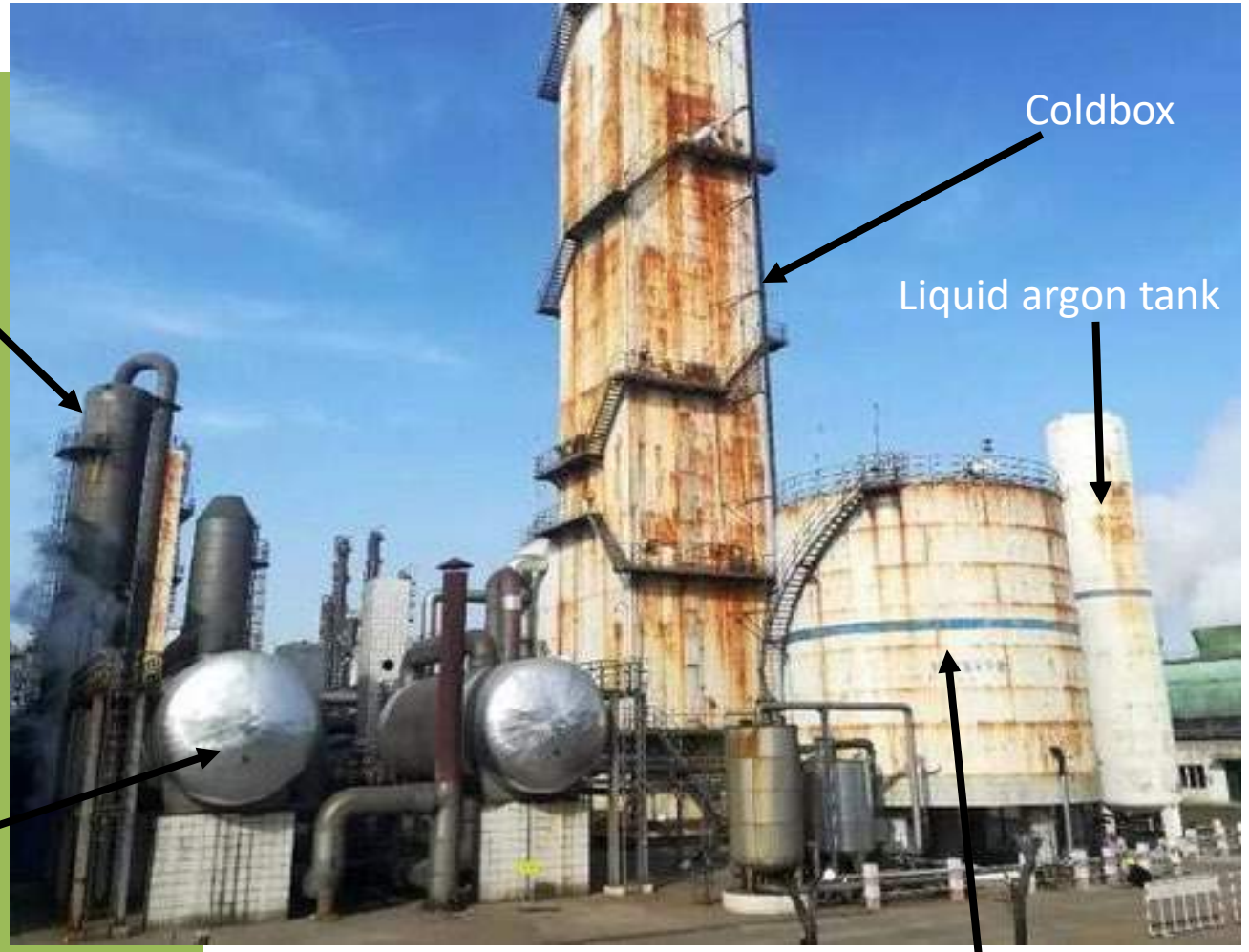
Yima City Gasification Plant

Henan, China

Air Separation "C" Explosion

July 19, 2019, 17:43



Before

Before (2)

Before (3) Plant Model

事故前厂区装置模型

Aftermath

Aftermath (2)

- 15 deaths
- 16 seriously injured
- 236 hospitalized
- Direct economic loss of 81.7 Million RMB ($12,000,000)

- Six (6) executives arrested and charged as criminally responsible
- Over thirty (30) public officials and related company officers punished and censured for party discipline

The Henan Gas Group Yima Gasification Plant produces:

240,000 tons/year Methanol

200,000 tons/year Dimethyl Ether

11,068 tons/year Liquid Oxygen

3,000 tons/year Liquid Nitrogen

3,910 tons/year Sulfur

4,634 tons/year Crude Phenol

11,068 tons/year Coal Tar

36,000 tons/year Aqueous Ammonia (10 to 35%)

4,288 tons/year Crude Benzene

200,000 tons/year Acetic Acid

2,350 tons/year Propanoic Acid

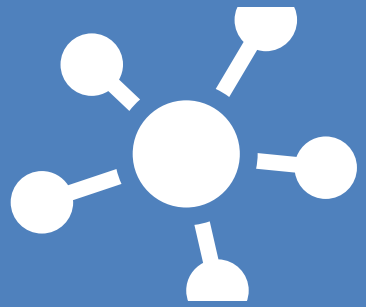
233,000,000 m^3/year Natural Gas

120,000 tons/year Ammonia

Yima City Gas Factory
Three (3) Air Separation Units (A, B, and C)

A and B
KDON-7500/8000
In service since 2000

C
KDON Ar –
20800/11000/720
In service since 2007



500 m^3
Liquid Oxygen Tank
Flat Bottom Field
Erected

Liquid Nitrogen and
Liquid Argon
Vacuum Insulated
Tanks

“C” operates 23 days with oxygen leaking into the coldbox insulation space

- Insulation space 25% to 30% Oxygen at 580 Pa (normal 5% or less at 400 Pa)
- Eleven days later Insulation space at 58% Oxygen and the pressure increases to 800/900 Pa
- Five days later a 25 cm crack is found on the coldbox shell leaking cold purge gas
- Seven days later, incident happens at 17:43:35

Video observations

0 to 14 seconds
- Perlite releases from right side of coldbox
- Perlite releases from the bottom left of the coldbox
- Perlite releases from the top of the coldbox

15 seconds
- Bright flash exiting the right side of the coldbox near an initial release

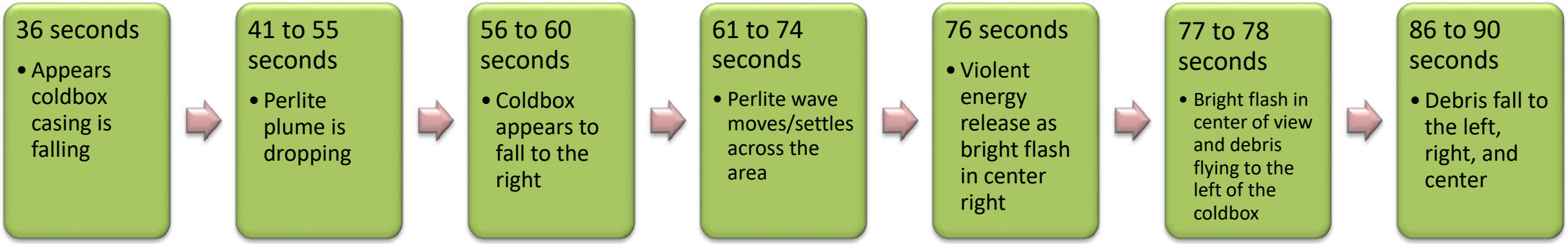
18 seconds
- Perlite release increases at the bright flash area

20 to 27 seconds
- Many perlite releases, all sides and top

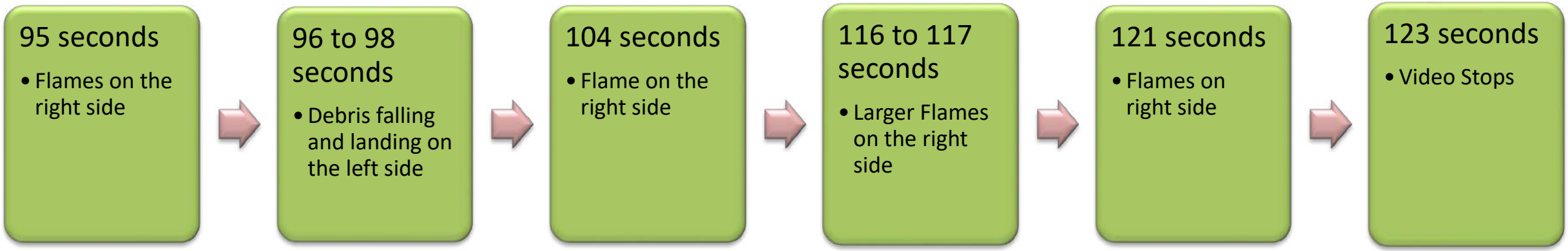
28 to 29 seconds
- Dark perlite release near the top left of the coldbox

33 to 35 seconds
- Large perlite release and coldbox is engulfed

Video observations (cont'd)



Video observations (cont'd)



CGA Review timeline

CGA forms a Task Force (TF) to review available incident information

- 17 Participants from 8 companies covering Asia, Europe, and US

November 2019

TF summarized the review and ranked lessons learned

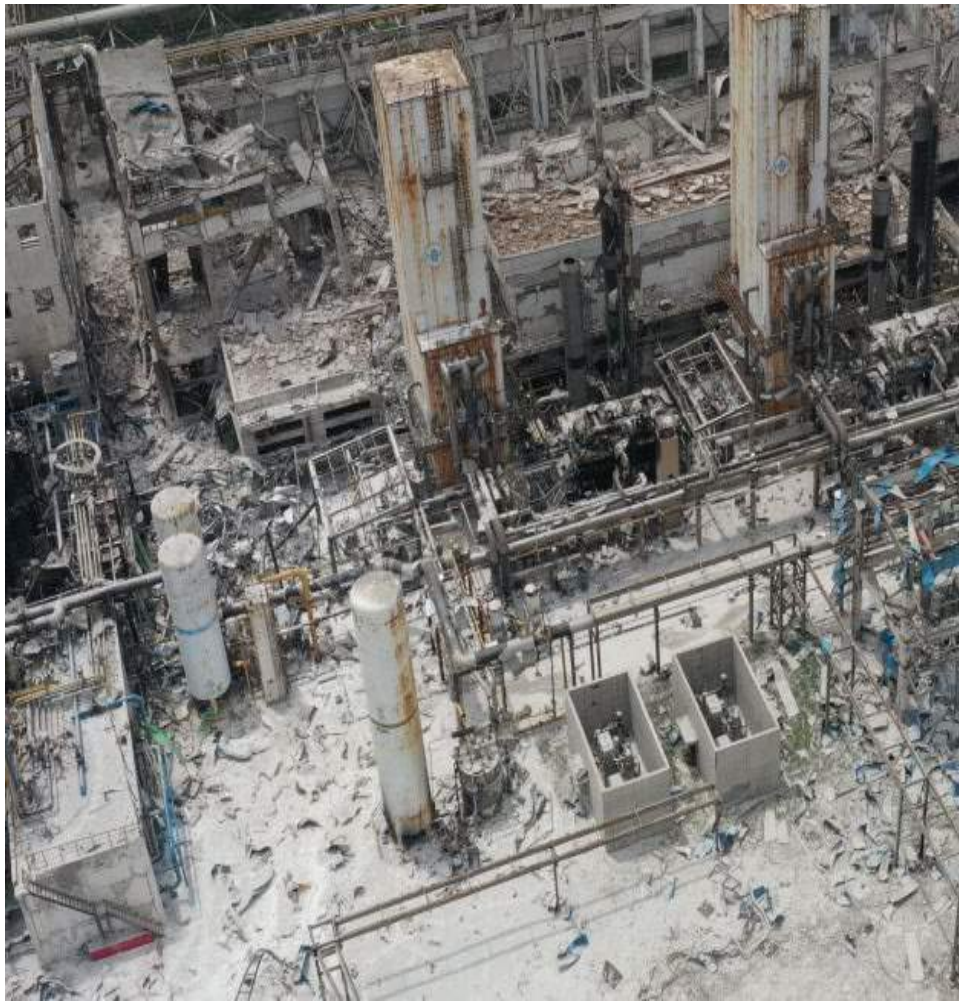
March 2020

Proposed changes drafted and reviewed by members of the TF

April to August 2020

Conclusions (1)

- **Liquid leaked into the coldbox annular space as evidenced by the elevated oxygen levels**
  - Leak was reported over an extended time period as pressure and purity increased over several days
  - Source of the leak is unknown, but it is expected in the process at or above the reported coldbox casing crack elevation
- **Perlite is released from the coldbox due to a rapid increase in the annular space pressure**
  - Could have been caused by perlite movement as a result of loss of containment due to a crack low in the coldbox casing from embrittlement
  - Could have been caused by the original process leak rapid expansion releasing liquid or vapor at a high rate into the annular space
  - Could have been caused by an ignition or energy release due to the high oxygen content in the annular space from contaminated perlite which was previously handled, or flammable material left behind in the insulation
  - Could be unrelated to the original leak such as a loss of process containment in another section, reboiler flash from a hydrocarbon/liquid oxygen reaction or an enriched oxygen line burns



Conclusions (2)

- **An "energy release flash" about 38 meters up the coldbox around on the northeast side near a platform soon after the perlite releases begin. The cause is unknown; however, it is in the same area as one of the very first perlite releases and not mentioned in any of the published documents**
  - Could be from a fire inside the coldbox
  - Could be from a fire outside the coldbox at an electrical junction box, etc.
- **Perlite releases then become more prevalent and violent from many other Cold Box casing locations**
  - Could be from additional embrittlement failures
  - Could be from over pressure failures

Conclusions (3)

- **Coldbox collapses and internal columns fall from unknown mechanisms**
  - Failure due to embrittlement
  - Failure due to over pressure
  - Combination of both embrittlement and over pressure
  - Structural design issues
- **Ignition sources for the initial and at least two (2) follow up explosions unknown**
- **Evidence of aluminum reboiler core explosion**
  - Sections of cores are found northeast, southeast, and southwest of the center of a referenced explosion point on the ground near the liquid oxygen bulk storage tank
- **Possible burning of aluminum packing**

Direct cause of the incident as reported by the Henan Provincial Emergency Management Department - June 12, 2020

- A leak in the interconnecting pipe of the coldbox valve in Air Separation Plant C
- Process leakage into the perlite insulation
- Over pressurization of the coldbox results in a violent blast
- Support frame and coldbox plates are cold and brittle
- Coldbox collapses smashing into the bulk liquid storage tank and the adjacent Liquid distribution truck's oxygen and fuel oil tanks
- Liquid oxygen leaks together with available combustibles (aluminum, etc.) in the area resulting in a violent explosion

Topics to consider

- ASU operation with process leaks into the coldbox annular space – High Priority
- Detection, monitoring of leaks – High Priority
- Responding to leaks – High Priority
- Leak Prevention – High Priority
- Cryogenic enclosure (coldbox) structural and piping design – High Priority
- Competencies, qualification and training – High Priority
- Siting – Medium Priority
- Perlite management – Medium Priority
- Reboiler energy releases – Medium Priority
- Management of Change – Medium Priority
- Routing of flammable products in ASU process and LOX bulk storage areas – Low Priority
- Over pressure design requirements for cryogenic vessels within insulated spaces – Low Priority

Task Force Recommendations

- P-8 Safe Practices for Cryogenic ASU's, 6 proposed changes (PCs)
- P-8.3 Perlite Management, 7 PCs
- P-8.4 Safe Operation of Reboilers/Condensers in Air Separation Units, 2 PCs
- P-8.6 Unmanned Air Gas Plants – Design and Operation, 3 PCs
- P-8.8 Safe Design and Operation of Cryogenic Enclosures, 30 PCs

Work Safely!

Protect the environment!