UNCLASSIFIED

47
ORNL
Central File Number
56-7-157

REPORT OF EXPLOSION AND FIRE IN
HYDROGEN LIQUEFIER APPARATUS

July 31, 1956

DO NOT
PROTOSTAT

OAK RIDGE NATIONAL LABORATORY

OPERATED BY

UNION CARBIDE NUCLEAR COMPANY

A Division of Union Carbide and Carbon Corporation

POST OFFICE BOX P • OAK RIDGE, TENNESSEE

UNCLASSIFIED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

UNCLASSIFIED

ORNL
Central Files Number

CF-56-7-157

0

REPORT OF EXPLOSION AND FIRE IN HYDROGEN LIQUEFIER APPARATUS

July 31, 1956

T. W. Hungerford
J. E. Loin
B. M. Beeler

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

Photostat Price \$ 3.30

Microfilm Price \$ 2.40

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

DATE ISSUED

NOV 2 1958

OAK RIDGE NATIONAL LABORATORY
Operated by
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

UNCLASSIFIED

449 001

UNCLASSIFIED

ORNL
Control Files Number
56-7-157

DISTRIBUTION

1. C. E. Center (K-25)	21. F. L. Culler
2. T. E. Lane (K-25)	22. K. A. Fowler
3. A. P. Huber (K-25)	23. J. H. Frye, Jr.
4. J. P. Murray (Y-12)	24. A. Hollaender
5. R. G. Jordan (F-2)	25. A. S. Householder
6. A. M. Weinberg	26. M. T. Kelley
7. J. A. Swartout	27. E. C. Miller
8. R. A. Charpie	28. K. Z. Morgan
9. G. E. Boyd	29. M. L. Nelson
10. R. W. Johnson	30. J. A. Lane
11. M. E. Ramsey	31. T. A. Lincoln
12. E. D. Shipley	32-37. L. P. Riordan
13. C. E. Winters	38. A. F. Rupp
14. E. A. Bagley	39. H. E. Seagren
15. D. S. Billington	40. A. H. Snell
16. E. P. Blizzard	41. E. H. Taylor
17. C. J. Borkowski	42. P. M. Reyling
18. D. W. Cardwell	43-47. Laboratory Records Department
19. D. D. Cowen	48. Laboratory Records, ORNL R.C.
20. S. J. Cromer	

DO NOT
PHOTOSTAT

UNCLASSIFIED

REPORT OF EXPLOSION AND FIRE IN HYDROGEN LIQUEFIER APPARATUS

SUMMARY

Nature of Incident: A hydrogen explosion occurred in the south cold trap of the hydrogen liquefier apparatus rupturing the high pressure hydrogen supply line. The escaping hydrogen ignited and continued to burn.

Injury to Personnel: W. H. Tabor, badge No. 8473, age 31, engineer in the Operations Division. Extent of injuries: Abrasions of both knees and right forearm. Second degree burns of right foot and ankle. He returned to regular work after treatment at the dispensary.

Property Damage: Damage to building: \$300.
Damage to building contents and liquefier apparatus: \$3600.
Total damage: \$3900.

Time of Incident: July 31, 1956 - 12:24 PM.

Location of Incident: Building 3081, Union Carbide Nuclear Company, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DESCRIPTION OF INCIDENT

On July 31, 1956, at approximately 12:24 PM, an explosion occurred in the south cold trap of the hydrogen liquefier apparatus located in Building 3081. The hydrogen supply line, fed by two 220-ft³ cylinders, ruptured and ignited. A fire-alarm box was actuated by C. B. Gaither, and the Fire Department responded promptly.

Upon arrival, the Fire Department was advised by the Operations Division Superintendent, A. F. Rupp, to exercise caution, as the possibility of a second explosion existed, involving either the hydrogen storage flask containing approximately 2 liters of liquid hydrogen or the hydrogen supply cylinders. A careful investigation of the fire revealed that hydrogen was burning in the vicinity of the cold traps. The plywood boxes housing the cold traps, wooden tool cabinets, and the asphalt tile floor covering had ignited, adding to the intensity of the fire, which was heating the walls and ceiling of the building. The fire was knocked down and controlled, with no attempt at extinguishment, by firefighters using a one inch booster line from the No. 1 pumper.

At approximately 12:45 PM, after consultation with W. R. Casto of the Operations Division, a decision was made to approach the supply cylinders and close the valves, shutting off the supply of hydrogen to the system. This operation was successfully completed with the assistance of W. R. Casto, and the firefighters completed extinguishment of the fire with the booster

line in a few minutes. A fog applicator was attached to the booster line and inserted above the door to cool the building, since the possibility of a second explosion still existed, involving hydrogen evaporating from the liquid hydrogen storage flask.

Prior to the water-fog operation the Y-12 Fire Department had been requested to send the Cardox fire truck, containing 3 tons of liquid CO_2 , to the scene. Upon arrival of the Cardox truck, the water-fog application was discontinued, and an intermittent purge of carbon dioxide was started. The intermittent purge was continued until the hydrogen collection flask was empty and explosimeter readings for hydrogen were negative.

Exhibits 1 through 6 are a pictorial description of the incident.

INCIDENTS INVOLVED

For a period of one week preceding the explosion, the system had been placed under vacuum and heated to regenerate the silica-gel in the cold traps. At 8:00 AM, on the day of the explosion, the system was pressurized with hydrogen and checked for leaks. The leak test was negative and the operating procedure was started. This consisted of filling the cold traps and the cryostat with liquid nitrogen, which was completed at 9:45 AM.

The cryostat, in which liquefying is done, had reached liquefying temperature at 10:00 AM, and the first liquid hydrogen transfer from the cryostat to the receiving flask was made at 11:45 AM. At 12:15 PM, two full cylinders of hydrogen at approximately 2000 psig were placed on the line, and the liquid nitrogen container, which supplied nitrogen to the cold traps, was removed in order to be replaced with a full container. The full container was in the process of being connected to the system when the explosion occurred.

PROBABLE CAUSE

The exact cause of the explosion was not determined. It was apparent from observation that the explosion occurred in the high-pressure hydrogen line of the south cold trap. There had been no indication of a hydrogen leak and obviously the explosion was internal; therefore it does not appear logical to suspect an air-hydrogen mixture. After consultation with Operations Division personnel and E. A. Long of Argonne National Laboratory, it was concluded that the most probable cause of the explosion was an interaction of hydrogen with an impurity, possibly oxygen, in the south cold trap. The physical constants of hydrogen, nitrogen, and oxygen are favorable for the deposition and concentration of oxygen in a liquid-nitrogen-cooled trap. The deposition and concentration of oxygen are enhanced if the purifier for oxygen removal does not perform its function.

PREVIOUS HISTORY

On January 23, 1953, a hydrogen explosion occurred in a small frame cubicle located in the northwest corner of Building 3001. The cubicle housed a hydrogen liquefier apparatus similar to the one discussed above. (See ORNL report No. CF-53-4-43, *Report of Hydrogen Explosion, January 23, 1953.*) This explosion was not directly caused by the liquefying process, but rather by a carpenter inadvertently driving a nail through the $\frac{1}{4}$ -in. hydrogen supply line.

As a result of that incident, Building 3081 was designed and constructed in order to locate the apparatus more remotely and remove the possibility of another explosion from a major building. Building 3081 was constructed of aluminum with hinged explosion panels and natural ventilation by roof and wall vents. Explosion-proof electrical fixtures were provided, and the hydrogen supply cylinders and manifold were separated from the building by a concrete block fire wall. A solenoid-operated valve was placed in the manifold so that the supply could be shut off quickly from a remote point. However, the operation of this valve was never satisfactory due to the high pressures involved, approximately 2000 psig, and efforts to locate a dependable valve were unsuccessful.

CONCLUSIONS

Explosions and fires must be anticipated in this type of operation, and the facilities should be designed to minimize the hazard. Serious personal injury and structural damage were probably avoided in this incident by adequate venting design of the structure, and isolation of the hydrogen supply cylinders. Had it been possible to close by remote means the valve in the high pressure line, the fire could have been extinguished in a few minutes. The building should also be free of combustibles. As the liquefaction equipment was damaged beyond repair, it is planned to replace the facility in the near future.

RECOMMENDATIONS

The following recommendations should be considered in the redesign of the facility:

1. an adequate remotely operated valve for the hydrogen supply system;
2. a water spray head to be installed in the ceiling—the water supply to be controlled by a remote-hand operated, quick-opening valve;
3. analyze each hydrogen cylinder for oxygen and establish acceptable limits;
4. evaluate the practicability of remote operation of equipment behind barricades;
5. construct all cabinets, equipment housing, boxes, etc., of aluminum and limit the use of combustible materials to an absolute minimum;
6. determine the adequacy of the oxygen removal unit, and if it is found to be unsatisfactory install a new unit and set up checks and procedures to ensure its proper operation.

4

4

669 005

EXHIBIT 1

5

UNCLASSIFIED
PHOTO 18159

← RUPTURE OCCURRED HERE

SILICA GEL TUBE →

EXHIBIT 1-A

900 675
006

663 007

9

6

EXHIBIT 2

EXHIBIT 3

EXHIBIT 4

9

UNCLASSIFIED
PHOTO 18150

EXHIBIT 5

449 010

UNCLASSIFIED
PHOTO 18148

HYDROGEN STORAGE FLASK

EXHIBIT 6

0-10