U. S. Chemical Safety and Hazard Investigation Board
RECOMMENDATION STATUS CHANGE SUMMARY

Report:	Enterprise Pascagoula Gas Plant Explosion and Fire
Recommendation Number:	2016-02-I-MS-R3
Date Issued:	February 13, 2019
Recipient:	GPA Midstream Association
New Status:	Closed – Reconsidered/Superseded
Date of Status Change:	April 26, 2022

Recommendation Text:

Develop a database for operators to submit BAHX operational data for collaborative industry learning and analysis. Encourage your members to submit pressure and temperature data associated with the entire service life of brazed aluminum heat exchangers as well as the date(s) of leak(s) or failure(s) for each exchanger on which data is being submitted. At a minimum this system should:

a. provide a way to anonymously input data into the database;
b. specify the time interval between measurements such that data can be normalized across different exchangers; and
c. capture the type of service in which the exchanger was operating.

Board Status Change Decision:

A. Rationale for Recommendation

On June 27, 2016, a major loss of containment (LOC) resulted in the release of methane, ethane, propane, and several other hydrocarbons at the Enterprise Products Pascagoula Gas Plant (PGP) in Pascagoula, Mississippi. The hydrocarbons ignited, initiating a series of fires and explosions, which ultimately shut down the site for almost six months. Two workers were on the night shift when the incident occurred and were uninjured.

The U.S. Chemical Safety and Hazard Investigation Board (CSB) determined that the probable cause of this incident was the failure of a brazed aluminum heat exchanger (BAHX) due to thermal fatigue. The absence of a reliable process to ensure the mechanical integrity of the heat exchanger contributed to the catastrophic failure of the equipment. Given this information, the CSB made three recommendations to GPA Midstream Association, a natural gas energy trade association that conducts research and develops technical reports and publications. This status change summary addresses CSB Recommendation No. 2016-02-I-MS-R3.

B. Response to the Recommendation

The GPA Midstream Association informed the CSB that they disagreed with the recommendation and provided engineering-based information to support their rationale. As a part of their rationale, the GPA Midstream Association stated that each BAHX core stands as an

individually engineered solution designed specifically to meet the operating conditions desired by the purchaser. While meeting industrial standards for BAHX core design and fabrication (i.e., API and ALPEMA), each vendor maintains its own proprietary design variations for the same unit in the same process. These inherent variations make developing an industry-wide database to compare operating BAHX units on an 'apple-to-apples' basis across services and across industries impractical and ineffective. They provided several different illustrations of how differently BAHXs can be configured.

Additionally, the GPA Midstream Association contracted with the University of Houston, noted for aluminum fatigue analysis, to study this issue. The University Team was provided several sets of BAHX core operation data. The findings, documented in GPA RR-241: *A Physics-of-Failure Approach to Life-Prediction, Fatigue Study and Failure Prevention in Brazed-Aluminum Based Heat Exchangers*, released in December of 2019, concluded a correlation could not be found. As no correlations can be drawn regarding service life or the prediction of leaks and other material failures can be drawn via industry information collaboration using operational, temperature, and/or pressure data, the need for sharing data points across the industry in a database would have no purpose.

Also of note, GPA RR-241 produced pertinent conclusions and recommendations, which are:

Conclusions:

- Analysis of operating data did not provide any meaningful insight into causes of failures. Normal mathematical modeling as well as cutting edge machine learning via big data techniques failed to find correlations between the submitted data and failures.
- Metallurgical analysis did find definitive answers as to why the specific failures occurred. The results show that cracks propagated from either defects in the aluminum material or points of high stress concentration in the exchanger. In addition, computational modeling indicated that a perfect piece of aluminum with no material defects and uniform stresses would last many orders of magnitude longer than the subject pieces where defects were present.

Recommendations:

- Share this work with the Brazed Aluminum Plate-Fin Heat Exchanger Manufacturer's Association (ALPEMA) to help them improve material quality and design standards.
- Incorporate learnings from this work into the GPA Midstream Technical Bulletin GPATB-M-001 Brazed Aluminum Heat Exchangers and revisions to other relevant standards and publications.
- Share this work with the American Petroleum Institute (API) to be considered in upcoming revisions to relevant standards.

C. Board Analysis and Decision

While the GPA Midstream Association elected not to implement the CSB recommendation to develop a database for the purposes of collaborative industry learning and analysis, the fatigue

analysis that the GPA Midstream Association contracted separately provides industry learning and analysis. The conclusions and the recommendations gleaned from their report will no doubt improve safety specific to BAHXs. The Board applauds and encourages these kinds of innovative efforts even when those efforts may appear to be at cross-purposes with the implementation of a CSB recommendation, however, still advances safety.

Based upon the information above, the Board concurred with the GPA Midstream Association's rationale not to implement the recommendation and voted to change CSB Recommendation No. 2016-02-I-MS-R3 to: **"Closed – Reconsidered/Superseded."**