World War II Remnant: Nuclear Waste Transfer Lines Pressure Evaluation using AFT Fathom™ and AFT Impulse™

CASE STUDY

Waste Transfer Lines

Nuclear

ARES Corporation
Richland, Washington, USA
Platinum Pipe Award Honorable Mention - Most Interesting Model

A one-mile (1.6 km) long piping system needed to be designed to transfer low-level radioactive waste generated during plutonium production for nuclear bombs used in World War II. The weapons production process left 56 million gallons (212 million liters) of solid and liquid radioactive wastes stored underground at Tank Farms facilities. It will be pumped to a Waste Treatment Plant (WTP) and transformed into a stable, glass product.

The goal of ARES Corporation's evaluation was to determine the sustained and occasional internal pressures in the conceptual Waste Feed Delivery (WFD) system piping from the Tank Farm to the WTP Low Activity Waste (LAW) facility, as well as determine if the pressures were within the allowables of ASME B31.3.

> "The Scenario Manager was used extensively to evaluate and compare the effects different system parameters had on the maximum transient pressure of the system. Conclusions were determined quickly and efficiently."

Senior Mechanical Engineer, Kodi Dixon, said the most difficult challenge was due to the difference between the WTP facilities being classified as general service with a 150 psig (10 bar-g) design pressure; and the Tank Farms facility being classified as safety significant with a 400 psig (28 bar-g) design pressure. In addition, the WTP facilities were under construction whereas the Tank Farms were in design.

As the valve(s) in the WTP facility were considered part of a general service system, the closure times were based on manufacturer data. However, the Tank Farms valve closure rates could not be based on manufacturer data because they had not undergone nuclear safety and licensing evaluations. Therefore, there was not enough confidence in the valve operation to ensure no failure methods exist, which could result in a faster closure time. Ultimately, this meant the transient evaluations had to consider instantaneous valve closures in a system already susceptible to significant transient pressures with a low design pressure. Assuming instant valve closure is a conservative, worst-case assumption.

To further complicate the evaluation, the potential for column separation and siphoning required the use of an air relief feature to mitigate such conditions - while preventing the release of the nuclear waste, or control and contain if it is released. However, similar to the valve closures, one cannot ensure they will not fail open unless they are analyzed for nuclear safety.

It was determined to implement passive air relief devices called anti-siphon, or weep holes, into the side of the pump columns within the head space of the waste tanks. Then using the siphoning flow rates determined in the AFT Fathom model (Figure 1), Dixon was able to hand calculate that the anti-siphon holes could sufficiently "break" the flow of siphon and any column separation conditions that would occur do to elevation differences.

AFT Fathom was also used to help determine the best system control method to size the WFD system pump. The selection of the control method also needed to consider the impact it would have on the transient pressures that would be created in the system during valve closures (Figure 2). Using AFT Fathom, Dixon's team was able to eliminate the control methods which did not fall within the allowable operating range and focus on the ones that could, while also minimizing pressure transients.

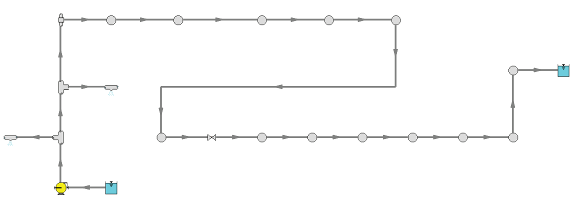
ARES Corporation's top-notch team of engineers, scientists, and other professionals, focuses on solving industry's most complex technical challenges in the key areas of nuclear, clean technology, space, and defense.

Once the system control method was defined and a pump selected, the actual transient calculations were performed using AFT Impulse. The Scenario Manager feature was used extensively to evaluate and compare the effects that different system parameters had on the maximum transient pressure of the system. Conclusions about dead legs, fluid properties such as bulk modulus and viscosity, valve characteristics, and many more were determined quickly and efficiently using the program. Extensive valve sensitivity studies were also performed along with pressure profiles to help better understand the pressure transients that were occurring on both the upstream and downstream side of the valve.

Without the use of AFT Impulse, the same calculations would have likely never been performed.

The final conclusions and recommendations of the evaluation looked at various closure times of the worst-case valve (Figure 3). Although it was shown that an increase in valve closure times would eventually meet the requirements of ASME B31.3, the implementation of an increased closure control would be very difficult due to the nuclear safety and licensing requirements. Regardless, ARES was still able to use the data to provide several possible abatement methods to move forward with the project.

Figure 1: AFT Fathom Workspace View.



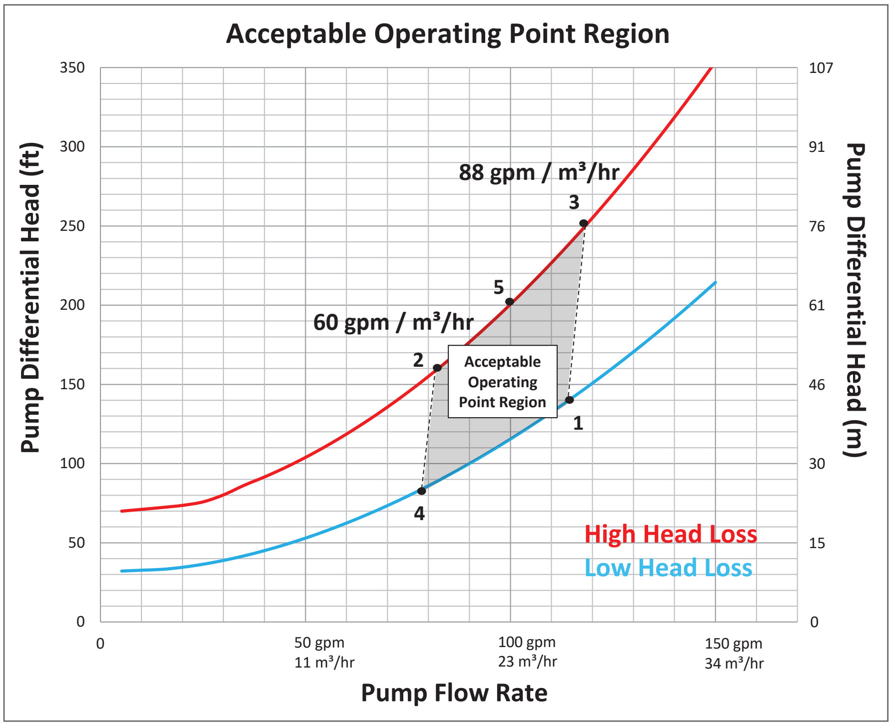


Figure 2: Graph of the acceptable operating point region as determined by the AFT Fathom model.

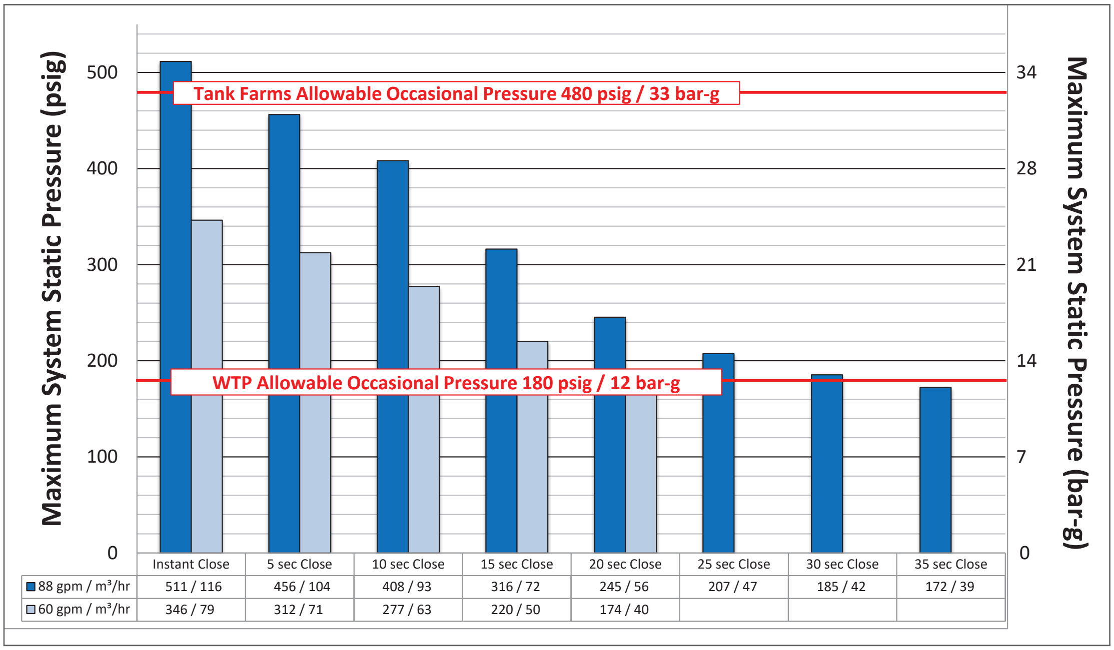


Figure 3: Maximum occasional pressure in Waste Feed Transfer (WFT) system due to varying total valve closure times and flow rates to Waste Treatment Plant (WTP), as determined by AFT Impulse.