December 6th, 2016

Client Plant
1313 Mockingbird Lane
Mid-America, USA

Re: Hotwork Quotation No. 17775400
Glass Drain & Heatup with Expansion Control Supervision (ECS)
Of your Electric Glass Furnace
Drain Starting December 2nd, 2016
Heatup Starting February 2017

Dear Mr. Client A & Mr. Client B

As you are aware, the glass furnace drain referenced in the above quotation was aborted on December 4th due to extraordinary conditions encountered during the attempted drain. This report is intended to document the conditions experienced and to further explain the decisions made on site.

As background, when Hotwork drains glass furnaces, certain standard conditions are required in order to insure a successful drain. These conditions are described in the attached client responsibility list which is supplied with every quotation. Of particular importance in this case are the requirements for the glass to be within a specified temperature to allow it to flow and that the refractory has to be in an adequate condition to insure molten glass containment.

Client Plant has been experiencing some furnace operating challenges and it appears that extraordinary efforts had been expended to keep the furnace operating. The furnace condition and the procedures attempting to preserve it are part of the reason that the drain had to be aborted.

Below is a timeline of events that occurred.

- **Monday November 28th, 2016**: Client A contacted Donna Esson at the Hotwork office in Lexington, KY. Mr. Client A informed Mrs. Esson that Client Plant needed Hotwork to drain their furnace again. Mr. Client A asked Mrs. Esson "*when could Hotwork, arrive without incurring the additional emergency prices?*" Mrs. Esson was able to submit a price quote, and informed that Hotwork could arrive on Thursday, December 1st for a two-day setup and be ready to drain on Saturday, December 3 without incurring the emergency prices. Mr. Client A informed Mrs. Esson that he would have to contact headquarters for approval, this would take a day, (Mrs. Esson advised this would automatically push the arrival date to Friday in order to avoid emergency pricing).

- **Tuesday November 29th, 2016:** Mr. Client A contacted Mrs. Esson via phone with the approval from Client Plant HQ. The official Hotwork quote was generated, and PO was sent by Client Plant. Schedule was for Hotwork to arrive on Friday December 2nd, 2016 to begin 2 day setup and be ready to drain Sunday, December 4.

- **Friday December 2nd, 2016:** Hotwork crew on site (Kevin Kelton, Allen Lehman, and Baron Loots). Per Mr. Lehman, production was still running, but was limited. Crew Leader Kevin Kelton described the furnace bottom as being in bad shape. The first day of setup for the drain proceeded.

- **Saturday December 3rd, 2016:** Client Plant Employees informed Mr. Kelton that they would like to get the furnace drained as soon as possible due to concerns about the furnace condition. Mr. Kelton informed Client Plant Employees on site that Hotwork would drill through and if the glass hot enough to run, Hotwork will gladly get the furnaced drained, a day early. The drilling process uses water to cool the drill bit and this process has a tendency to locally cool the drill site. For this reason, Hotwork prefers to drill thru to molten glass, pack the hole with fiber balls, and allow the glass to return to thermal equilibrium at the drill site. On some occasions, with some glasses, it is possible to immediately start the drain after drilling if the glass is hot and fluid enough. After drilling into the furnace sidewall, Mr. Kelton and Mr. Loots, never felt the shift in drill pressure that is to be expected when the drill breaks thru refractory and hits molten glass. The drill was extended for the entire length of the core drill bit and then they removed the drill. Most of the core came out with the bit but there was some core still inside the hole. They removed the remaining core and saw the glass behind, but it appeared to be dark orange. There was very little visual color difference between refractory material and the cold glass. This is a clear sign that the glass was not hot enough in the throat to flow. As per the client responsibility list, the client is to keep the glass between 2500°F and 2600°F.

  Mr. Kelton was asked about using a burner bar to heat up drain hole. The use of a burner bar is an extreme measure used only as a last resort in an attempt to get thru cold glass in order to find a pocket of hot glass. Since the local area had been cooled to some degree by the drilling process, it was recommended to pack the hole and let it heat over night. In addition, it was recommended to increase furnace general glass temperatures but Client Plant had concerns about the furnace condition and ability to withstand more temperature. Client Plant agreed to try the overnight temperature recovery with a packed hole.

- **Sunday December 4th, 2016:** Crew arrived at 5am. Upon removing the fiber balls the glass appeared to be dark still (cold). A torch was added to the hole at this point to try to heat the area locally from the outside. Some glass did dribble out from around the edges of the tile after heating it up with a torch, but just as quickly stopped. Hotwork crew members replaced the torch with a Hotwork burner, this action resulted in little to no results. Although some glass slumped in the hole.

  Over time, roughly 12- 14 inches of hard glass slumped out into the hole was then clipped away by a crew member. Client Plant requested the use of an oxy lance burning bar. This is a last ditch effort to get past locally cold glass in order to find a pocket of warmer glass that will flow. When using an oxy lance, it is very hard to see due to the bright light and smoke that is emitted when burning. The lance is equally capable of boring thru glass and refractory. Therefore, using a lance is a nonstandard Hotwork practice that is the last resort for Hotwork.

  Mr. Kelton was the one to attempt the lancing. Upon the attempt to use a lance, molten metal from the lance pipe was observed to have run thru the furnace sidewall and ran out under the Hotwork taphole and trough. The presence of this metal indicated that the sidewall refractory was deteriorated/compromised. If a flow of hot molten glass could be established, it had a path to an uncontrolled leak versus being controlled in the taphole and trough. This void created a safety concern with the potential for an uncontrolled glass leak if hot glass flow could be established. Lancing was discontinued for fear of creating a catastrophic situation by further compromising the sidewall refractory.

Mr. Kelton was asked if the drain site could be relocated to which he replied, “it would just cool the entire throat due to the drill water and killing all the power while we drill. It wouldn't gain us anything. It was hot on the outside due to us using our burner but cold behind the hole. We did everything we could.” Mr. Kelton was trying to convey that the general glass temperature in the furnace was too low. At this tapsite, with the advantage of an overnight soak and external burners, the glass was still too cold. Starting over at a new position would require interrupting the electric heating further lowering general glass temperatures. The drill site would be locally cooled from the drill water. Client Plant’s ability to heat the entire furnace up to a higher temperature was limited due to the poor condition of the furnace.

Moving the drain site was also not an option due to the limited clearance in the area. Compared to past drains this one had more cooling water running on the bottom, resulting in a cooler bottom and cooler overall glass temps.

At this point a conference call between Demetrius Rankin, Hotwork Crew members and Mr. Client B took place. Mr. Rankin agreed with the Hotwork Crew that attempting to keep lancing the hole will just result in the compromised sidewall deteriorating further as the metal from the lance will eat at the chrome. During the call Mr. Rankin listed the possible scenarios:

- Lance the hole again, but that more than likely would create a bigger sidewall void and there would be a potential uncontrolled leak below the taphole.
- Put a burner on it, heat it from the inside and outside but three possibilities could happen from this
    - Glass remains too cold to run
    - Glass is cold but eventually warm enough to run and hope that the compromised sidewall doesn’t get worse
    - Glass gets hot, runs, but an uncontrolled leak could occur
- Get the overall furnace hot and drain what we could until our hours were maxed out, then they freeze the remaining and mine it. This involved the risk of a bottom failure or sidewall leak.
- Stop the drain attempt and freeze it, with mining out the glass.

Mr. Rankin informed Mr. Client B that he stood behind the crew members on their assessment. Mr. Rankin later received a text from Mr. Kelton informing him that Mr. Client B was talking to his boss about the next step. Shortly afterwards another text was received from Mr. Kelton to Mr. Rankin stating, “will attempt to heat it from both sides at least until 2pm and if nothing happens tear down.” Per Mr. Lehman this was the moment when members from Client Plant called off the attempt to drain the unit.

- Other concerns in this drain was that there were smalls leaks that occurred at the charging station during setup, as well as the bottom being in bad shape. There were concerns about heating the unit since all four corners and the center had water spraying on it. This limited how hot Client Plant was willing to heat the unit.

Unfortunately, the furnace condition and low glass temperature prevented a successful drain from occurring. Hotwork pursued nonstandard, extraordinary procedures in an attempt to compensate for the

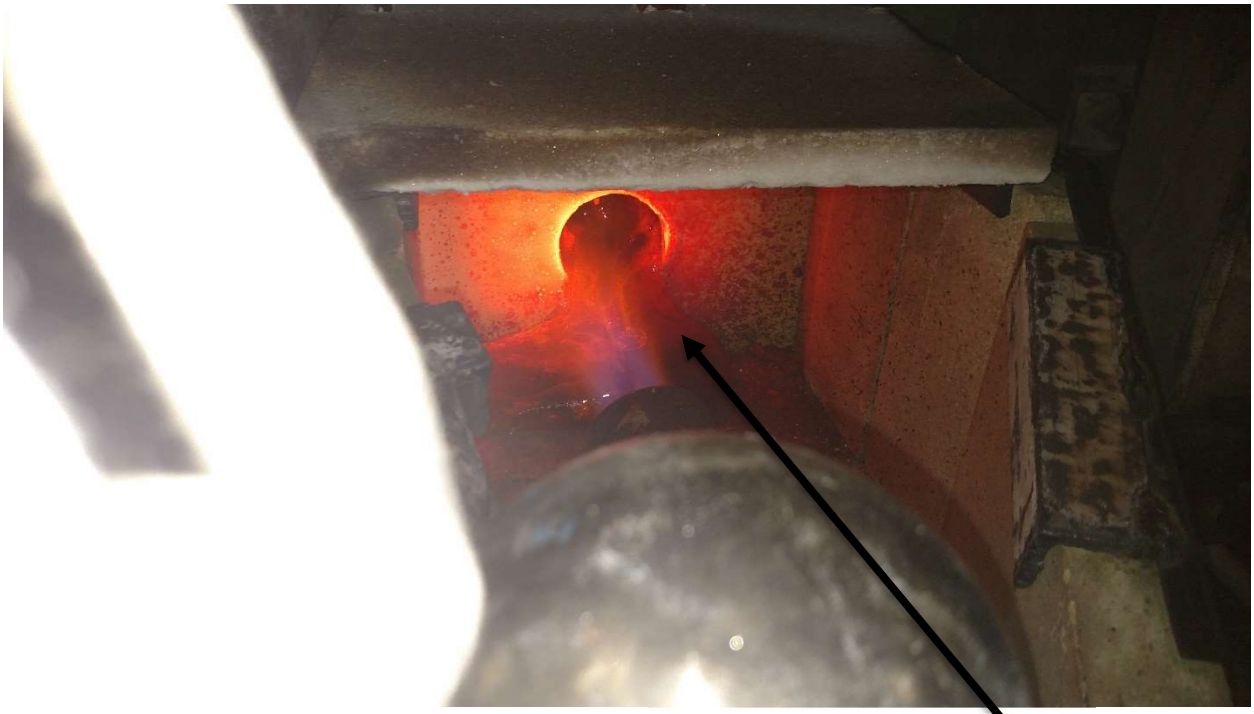
furnace conditions. Previous drains onsite were able to burn more burning bars searching for hot glass. Those attempts were also nonstandard Hotwork practices but were successful. In this case, the furnace condition did not permit continued attempts to compensate for the cold glass temperature.

JON PRENETA
Project Engineer

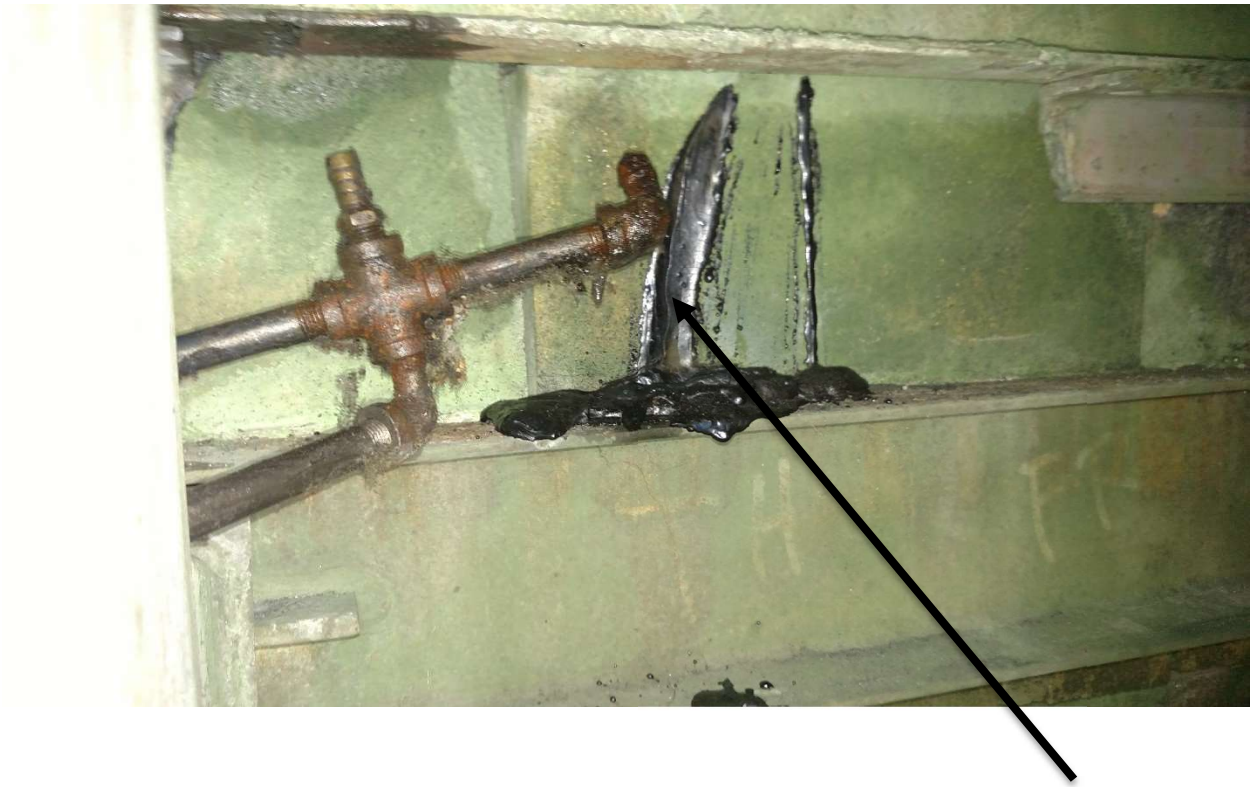
Enc.

Cc: Demetrius Rankin, Industry Manager
Tom Graham, President
Irish Cobane, Vice President
Larry Drake, Operational Manager
Dan Devera, Hydrogen Carbon Industry Manager
Donna Esson, Customer Service Manager

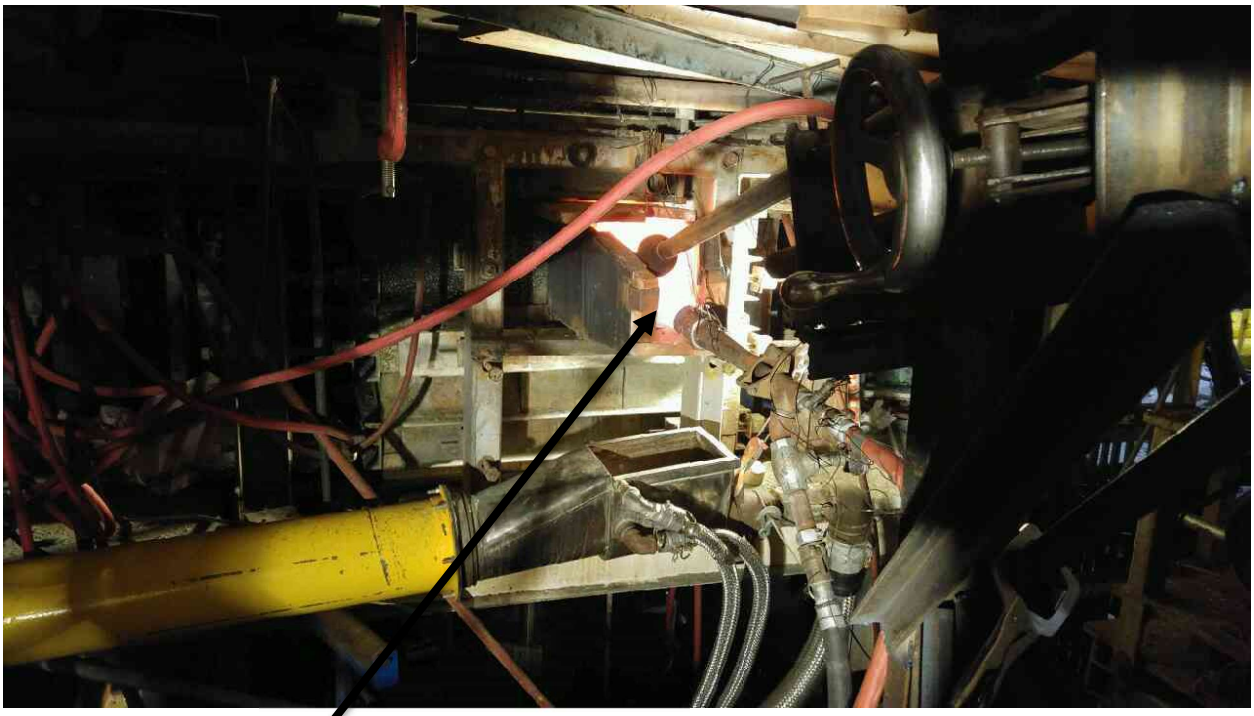
Remains of the fiber balls, used to heat up the drain hole overnight. Cold glass still in the hole, being heated by a burner.



Glass oozing out was before the drain was called off. No lancing was done after this picture, due to the void that was created in the refractory material. Shortly after this picture, the drain was called off.



Metal that had leaked out and under the Hotwork trough, through a void that was created in the refractory due to OXY lancing. All lancing was aborted after this point. Due to the concern of the void. If glass entered the void, there would be no way of controlling the leak. This is a major safety concern for the Hotwork crew on site as well as the safety of the plant.



Redrilling in another location was not an option, due to the constraints. At the same time redrilling in the same location was not an option as well. This would only further cool the furnace, due to shutting off the power to drill. As well as introducing water into the throat area from the drill