Evaluation of the Safety of the Situation (ESS):
Melter Feed Rate Temperature Correlation Basis (PISA PI-2014-0009)

APPROVALS

J.B. McCord, Author
Date: 12/16/16

E.M. Riddick, Technical Reviewer
Date: 12/16/16

J.M. Bricker, LW Safety Basis Regulatory Authority
Date: 12/16/16

E.J. Freed, Manager, DWPF Engineering
Date: 12-16-16

J.R. Cantrell, Facility Manager, DWPF
Date: 12/16/16
1.0 PISA Description/Summary

Potential Inadequacy in the Safety Analysis (PISA) PI-2014-0009 pertains to the Defense Waste Processing Facility (DWPF) Final Safety Analysis Report (FSAR), WSRC-SA-6, and is described in the PISA Database as follows:

“The feed rate to the melter is one of the inputs into the melter flammability analysis. The overfeed condition is protected by a melter vapor space low temperature interlock (LCO 3.3.1). The basis for this interlock setpoint is a heat model that was performed using assumptions that were valid before the installation of melter bubblers but have not been updated. The interlock setpoint may be non-conservative for operations with the melter bubblers.”

Additional information pertaining to PISA PI-2014-0009 includes:

- Date of Discovery: 11/19/2014

References pertaining to PISA PI-2014-009 include:

3. Integration of the Uncertainties of Anion and TOC Measurements into the Flammability Control Strategy for Sludge Batch 8 at the DWPF, SRNL-STI-2013-00139, Rev. 0.
5. Choi, A.S., Maximum Vapor Space Temperature During DWPF Melter Operation With Glass Pump at 1.5 GPM Feed Rate, X-CLC-S-00139, Rev. 0.
6. Choi, A.S., Steady State Indicated Temperature of DWPF Melter Vapor Space at 1.5 GPM Feed Rate, X-CLC-S-00096, Rev. 0.
2.0 Compensatory Measures / Operational Restrictions

2.1 PISA Compensatory Measures / Operational Restrictions

The following Compensatory Measure is currently in place as documented in PISA PI-2014-0009:

2.1.1 Prohibit operations of the DWPF melter in bubbler mode, thereby avoiding operations in the condition where the low temperature interlock setpoint may be non-conservative.

2.2 ESS Compensatory Measures / Operational Restrictions

Based on the evaluation provided in Section 3.1, PISA Compensatory Measure 2.1.1 will remain in place as clarified below:

2.2.1 When the DWPF melter is in Operation Mode, use of the agitation bubblers is prohibited, thereby avoiding operations in the condition where the low temperature interlock setpoint may be non-conservative.

When the DWPF melter is in Standby Mode, feeding the melter is prohibited by the existing TSRs; therefore, the agitation bubblers may be used.

3.0 Safety Assessment Results

3.1 Immediate Safety Assessment

Section 11.5.5.2 of Reference 1 states that the parameters that directly affect the flammable fuel concentration include the controls on melter feed contents, melter vapor space temperature, the melter feed rate (limited by the melter vapor space low temperature interlock), the combustion air (by measuring the backup off-gas film cooler air flow), and the dilution air (by measuring the total melter air flow). By controlling these parameters the flammable fuels are oxidized in the melter in a controlled fashion.

The safety analysis limits for the melter feed contents are a maximum TOC concentration on a slurry basis and a maximum carbon concentration from antifoam on a slurry basis (Ref. 4). Implementing these limits with uncertainties applied per the methodologies identified in Reference 3 ensures the flammable constituents produced in the melter are within the bounds of the melter off-gas flammability calculation (Ref. 4).

These limits on melter feed contents are protected by LCO 3.1.8 and as long as they are maintained, any distribution of the identified carbon contributors is bounded by the existing analysis and will result in a lower melter off-gas flammability concentration. These limits are based on a maximum feed rate of 1.5 gpm to the melter. Section 11.5.5.2 of Reference 1 as well as Reference 4 state that the maximum feed rate of 1.5 gpm is protected by the melter vapor space temperature indicators and associated interlock protected by LCO 3.3.1.
It has been determined that the statements and conclusions above are valid for melter operation without the agitation bubblers in operation (i.e., non-bubbled) which has been validated in the past (Ref. 6 and 7). Present operation with the agitation bubblers may cause the relationship between the max feed rate and minimum temperature to change in a non-conservative direction as it relates to the present FSAR/TSR limits. This is supported by data obtained during melter operation with the agitation bubblers in May 2014. The melter feed rate setpoint was 1.5 gpm for approximately 8 hours beginning on May 14, 2014. During this time the lowest vapor space temperature indicated was 645 °C. This temperature is significantly greater than the TSR limit of 493 °C, which is credited to interlock off the melter feed pumps if melter feed rate exceeds 1.5 gpm.

The following scenarios in the FSAR are potentially affected if the melter is in Operation Mode with the agitation bubblers operating while slurry feed is being transferred to the melter, thereby potentially causing the melter vapor space minimum temperature interlock setpoint to be non-conservative:

- FSAR Section 9.4.2.3 - Explosions in the Melter Off-Gas
- FSAR Section 9.4.2.13 - Earthquake
- FSAR Section 9.4.2.14 - High Winds

For each of these FSAR scenarios, further discussion is provided below to assess potential impacts to the reported consequences and evaluation of related controls/Compensatory Measures. When control sets are described below, the controls supporting integrity/functionality of credited Structures, Systems, and Components are not listed.

**FSAR Section 9.4.2.3 - Explosions in the Melter Off-Gas**

The FSAR reported consequences for this scenario are:

- Unmitigated and mitigated Offsite: < 9.5 rem
- Unmitigated Onsite: >100 rem
- Mitigated Onsite: 0 rem

The unmitigated offsite consequence does not challenge the Offsite Evaluation Guideline (EG) and requires no Safety Class (SC) controls. Thus, for protection of the public, no new SC controls would be required and no Compensatory Measures are required.

The radiological consequence to the onsite receptor exceeds the Interim Guidance Evaluation Guidelines (IGEG) and requires Safety Significant (SS) controls. The SS controls credited for this scenario are listed below:
1st LOC – Melter Off-Gas System Instrumentation and Associated Interlocks (LCO 3.3.1) - Provide indication of dilution and combustion air flow to the primary and backup off-gas film coolers and steam pressure to ensure a flammable mixture is not formed in the off-gas system. The interlocks shut off both melter feed pumps if the combustion or dilution air flow for the off-gas or steam pressure is low.

1st LOC – Melter Vapor Space Temperature Instrumentation and Associated Interlocks (LCO 3.3.1) - Provide indication of the melter vapor space temperature and interlock off the melter feed pumps on low temperature.

The 1st LOCs above are supported by a TSR control on Melter Feed Contents (LCO 3.1.8) which prevents excessive combustible off-gas compounds. Additionally, in order for the interlock limits to be valid, when the melter is in the operating mode, it must be aligned to the primary off-gas system (LCO 3.3.1).

1st LOC – Load Lift Program - Prevents crane load drops which may impact the safety related equipment for melter off-gas explosion events.

2nd LOC – Zone 1 Ventilation System – Mitigates effects of internal radiological process events with a minimum DF of 200.

The Vitrification Building, including the RPC Walls, supports the Zone 1 Ventilation System airflow configuration.

3rd LOC – The RPC Walls have the safety significant function of providing shielding for the workers within the Vitrification Building.

The 1st SS LOC above prevents the off-gas explosion and therefore the consequence of the SS mitigated scenario is zero rem for the onsite receptor. However, the existing setpoint for the melter vapor space temperature instrumentation and associated interlocks may be non-conservative for operations with the melter agitation bubblers. Therefore, the PISA Compensatory Measure 2.1.1 was put in place to prohibit operations of the DWPF melter agitation bubblers while in Operation Mode, thereby avoiding operations in the condition where the low temperature interlock setpoint may be non-conservative.

The PISA Compensatory Measure 2.1.1 and ESS clarification 2.2.1 have been implemented via the Immediate Procedure Change (IPC) process and includes proceduralized steps to ensure that the argon supply to each agitation bubbler is locked CLOSED in melter Operation Mode.
FSAR Section 9.4.2.13 - Earthquake

The FSAR reported mitigated Offsite and Onsite consequences for the Explosions in the Melter Off-Gas scenarios stated above for a Seismic Event are 0 rem (i.e., prevented).

A Seismic Event is a credible initiator of an explosion in the melter off-gas. The first level of control to prevent the explosion in the melter off-gas is the melter vapor space temperature instrumentation and associated interlocks, the total melter air flowmeter/switch, the backup off-gas film cooler air flow meter/switch, the OGFC and BUOGFC steam line pressure switches, and the associated interlocks (discussed in FSAR section 9.4.2.3). This equipment is required to remain operable during and following a Seismic Event to prevent the melter explosion. Because the roll-up of the unmitigated consequences of a Seismic Event would challenge the EG, these controls are required to be SC and seismically qualified to PC-3.

However, as in the discussion for FSAR Section 9.4.2.3 (Explosions in the Melter Off-Gas), the existing setpoint for the melter vapor space temperature instrumentation and associated interlocks may be non-conservative for operations with the melter agitation bubblers. Therefore, the PISA Compensatory Measure 2.1.1 was put in place to prohibit operations of the DWPF melter agitation bubblers while in Operation Mode, thereby avoiding operations in the condition where the low temperature interlock setpoint may be non-conservative. This compensatory measure is effective for the Seismic Event scenario since there is no credible mechanism for a Seismic Event to “start” a locked out bubbler.

FSAR Section 9.4.2.14 - High Winds

The FSAR reported mitigated Offsite and Onsite consequences for the Explosions in the Melter Off-Gas scenarios stated above for a Tornado and High Winds Event are 0 rem (i.e., prevented).

A Tornado and High Winds Event is a credible initiator of an explosion in the melter off-gas. The controls identified to prevent the melter off-gas explosion identified in FSAR section 9.4.2.3 are required to perform their safety function. These are not required to be high winds qualified as they are protected by the vitrification building with the exception of the interlock on melter feed pump #2. A TSR administrative control is required to stop this melter feed pump upon receipt of a tornado warning to prevent a melter off-gas explosion.

However, as in the discussion for FSAR Section 9.4.2.3 (Explosions in the Melter Off-Gas), the existing setpoint for the melter vapor space temperature instrumentation and associated interlocks may be non-conservative for operations with the melter agitation bubblers. Therefore, the PISA Compensatory Measure 2.1.1 was put in place to prohibit operations of the DWPF melter agitation bubblers while in Operation Mode, thereby avoiding operations in the condition where the low temperature interlock setpoint may be non-conservative. This compensatory measure is effective for the
Tornado and High Winds Event scenarios since there is no credible mechanism for a Tornado/High Wind Event to “start” a locked out bubbler.

3.2 Final Safety Assessment

An Unreviewed Safety Question Evaluation (USQE), USQ-WD-2014-00697, was performed for PISA PI-2014-0009 and resulted in a “positive” evaluation. The facility continues operation with the Compensatory Measure identified in the PISA in place (See section 2).

The USQE was “positive” based on a “Yes” answer to the following Question:

“Does the PISA increase the probability of occurrence of an accident previously evaluated in the Safety Bases?”

FSAR section 11.5.5 states that the feed rate is a bounding flow at which the melter can be controlled without forcing the low temperature interlock to shut off the melter feed pumps. It has been determined that the controls and setpoints credited to prevent the “Explosions in the Melter Off-Gas” scenarios are valid only for melter operation without the agitation bubblers in operation which has been validated in the past. Present operation with the agitation bubblers may cause the relationship between the max feed rate and minimum temperature to change in a non-conservative direction as it relates to the present FSAR/TSR limits. The maximum melter feed rate may be exceeded prior to actuation of the melter vapor space low temperature interlock. Therefore, the probability of occurrence of an accident previously evaluated in the Safety Basis may increase.

As discussed in Section 3.1, FSAR scenarios associated with this PISA are prevented such that the Offsite and Onsite EGs are not challenged/exceeded. However, the existing setpoint for the melter vapor space temperature instrumentation and associated interlocks may be non-conservative for operations with the melter agitation bubblers. Therefore, the PISA Compensatory Measure 2.1.1 and ESS clarification 2.2.1 were put in place to ensure that when the DWPF Melter is in Operation Mode, use of the agitation bubblers is prohibited, thereby avoiding operations in the condition where the low temperature interlock setpoint may be non-conservative.

The current operational status of the facility is impacted by the Compensatory Measure of this PISA and ESS. Melter system operation may continue using procedures as amended by this Compensatory Measure. However, Compensatory Measure 2.2.1, prohibits agitation bubblers from operating when the melter is in Operation Mode which results in reducing the melter slurry feed rate. This nearly doubles the time required to fill a canister and reduces the number of canisters that can be filled each month.

3.3 Path Forward

1. Continue to implement the Compensatory Measure discussed in section 2.2.
2. Pursue the following options to establish Safety Basis controls for operation of the agitation bubblers:
   a. Revise the heat model for agitation bubblers operation.
   b. Develop a creditable feed rate control using feed flow instrumentation.
   c. Develop a system to monitor the melter off-gas directly.
   d. Develop an alternate feed system design that has physical limitations to prevent melter overfeeding.
   e. Redefine the control strategy for Melter Off-Gas to include mitigation as the primary control while changing the preventive strategy to a significant contributor to defense in depth.

3. Revise the associated accident analysis and Safety Basis related to Item 2a, 2b, 2c, 2d, and/or 2e above.

   Items 2a through 2e will be worked in parallel until the best path for resolution is determined.

3.4 Summary of Recommendations and Conclusions

   Based on the results of USQ-WD-2014-00697 and evaluation of PISA PI-2014-0009, the PISA and ESS Compensatory Measure will remain in place until a permanent change is made to the Safety Basis and associated support documents. In order to support the milestones for the Alternate Reductant Project, the Safety Basis changes for this PISA will be incorporated into the DWPF FY2016 Annual Update, which will be implemented by March 31, 2017.