RPP WTP

Memorandum

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Subject: **PRETREATMENT NON-NEWTONIAN FLUID MIXING DESIGN REQUIREMENTS**

The following provides input to the Hanford Tank Waste Treatment and Immobilization Plant (WTP), Pretreatment Project Engineering regarding pulse jet mixer (PJM) and sparger design requirements for vessels containing non-Newtonian fluids. This input supports continuation of detailed physical design activities associated with piping, equipment, and structural interfaces.

Background

Mixing requirements for pretreatment (PT) vessels containing non-Newtonian fluids have been developed in a testing program conducted by WTP Research and Technology (R&T) department, with the close involvement of WTP Engineering. The PT vessels are as follows:

- Ultrafilter process (UFP) vessels (two vessels) [UFP-VSL-00002A, UFP-VSL-00002B]
- Lag storage (LS) vessels (two vessels) [HLP-VSL-00027A, HLP-VSL-00027B]
- PT blend vessel (one vessel) [HLP-VSL-00028]

Mixing system design requirements for both normal plant operation and for Important To Safety (ITS) operation have been determined. In each case, these requirements have been established based on a joint, Engineering and R&T, interpretation of the results of several months of 1/8-scale, 1/4-scale, and full-scale testing. These results have been presented in a series of project-wide meetings, with broad functional representation. These meetings are documented in correspondence control number (CCN) 077889.

R&T is in the process of developing a comprehensive series of reports to describe and document the testing results. A top-level summary report from R&T is planned for the end of March 2004, with a series of more detailed test reports being planned for issuance over the third quarter of 2004. In advance of this necessary documentation, these design requirements contained herein have been developed, to support continuation of detailed design and to support determination of related project cost and schedule impacts. For completeness, these design requirements will be supplanted by a system description.

Summary Specifications

For each group of PT non-Newtonian vessels, a mixing system has been selected. It should be noted that a combination of PJM's, spargers, and pumps are required to be deployed. The adopted specifications for each vessel group are summarized in Table 1.

Table 1: Summary Mixing System Specification

	SPECIFICATION	UFP	LS/BLEND
1	Recirculation Pump Required?	Yes	Yes
2	Recirculation Pump Flow (gallons per minute)	2200	2200
3	Pump discharge nozzle configuration within vessel	Single discharge nozzle (nozzle velocity - 30 feet per second)	2 discharge nozzles (nozzle velocity - 40 feet per second)
4	Spargers (quantity, size)	16, 1" (nominal diameter tubing)	36, 1" (nominal diameter tubing)
5	Sparger flow	(See Tables 3 and 4)	(See Tables 3 and 4)
6	Sparger minimum design pressure for cleaning	100 pounds per square inch gage (capability for water and compressed air cleaning shall be provided)	100 pounds per square inch gage (capability for water and compressed air cleaning shall be provided)
7	Antifoam	Required (supply from existing antifoam addition system)	Required (supply from existing antifoam addition system)
8	Waste Rheology	Non-Newtonian [Bingham Plastic yield stress of 30 Pascal, and a consistency viscosity of 30 centipoise (Reference: CCN 065607)]	Non-Newtonian [Bingham Plastic yield stress of 30 Pascal, and a consistency viscosity of 30 centipoise (Reference: CCN 065607)]
9	PJM (quantity)	6	8
10	PJM Configuration	Cluster (with inner shroud)	Cluster (with inner shroud)
11	PJM Nozzle diameter (inches)	4	4
12	PJM Nozzle velocity (meters per second)	12.0 minimum/14.2 maximum	12 minimum/13.4 maximum
13	PJM Air line diameter (inches) from jet pump pair (JPP) to vessel	2 (bounding line length of 200 feet)	2 (bounding line length of 200 feet)
14	PJM air demand (peak, average)	(See Tables 3 and 4)	(See Tables 3 and 4)
15	JPP Outline Dimensions	Same as AEA Technology (AEA) Model L50M (original JPP for this application)	Same as AEA Model L50M (original JPP for this application)

Vessel Mixing Mode Specifications

Table 2 provides a top-level summary of the required mixing modes of operation, for each vessel.

Table 2: Summary Operating Modes

	SPECIFICATION	UFP	LS/BLEND
1	Normal Mixing Mode	• Pump - ON • PJM's - ON • Spargers - IDLE [up to 1.4 aspect ratio for 30 Pascal fluid; up to 1.8 aspect ratio with leached (lower yield strength) fluid]	• Pump - ON • PJM's - ON • Spargers - IDLE [up to 0.74 aspect ratio for 30 Pascal fluid; spargers to be activated at higher fluid level]
2	Leach Mixing Mode	• Pump - OFF (high temperature leach mode) • PJM's - ON • Spargers - ON [> 1.4 aspect ratio, temperature up to ~194 degrees F]	N/A
3	Pump Failure Mixing Mode [normal power available]	• Pump - Not available • PJM's - ON • Spargers - ON	• Pump - Not available • PJM's - ON • Spargers - ON
4	ITS Mixing Mode (loss of normal power) [Note: ON/OFF frequency and duration of this mode to be determined]	• Pump - Not Available • PJM's - ON • Spargers - ON	• Pump - Not Available • PJM's - ON • Spargers - ON

Important to Safety (ITS) Requirements

ITS compressed air to the sparger system and the PJM system for each vessel shall be provided. Compressed air shall be provided to all PJM's and all spargers, assuming a single active failure. [See PT Preliminary Safety Analysis Report, Section 4.3.4 for project application of single failure criterion.]. The ITS compressor size, number, and operational sequences will be documented separately from this memorandum.

During ITS operation of the PJMs and the spargers, exhaust air may be directed towards the Zone 5 heating, ventilation and air conditioning system.

Additional safety criteria, generically applicable to the design of all WTP ITS systems, structures, and components (SSCs), are addressed within the *Safety Requirements Document* and are not repeated herein.

It should be noted that HLP-VSL-00022, although containing Newtonian fluids, generates sufficient hydrogen that its PJM system is ITS. Therefore, these same ITS requirements as noted above shall apply to this Newtonian vessel.

Spargers

Each sparger shall be capable of individual controlled flow. Two operating modes of sparger operation are necessary. In the IDLE mode, at least a minimum flow of air shall be provided (on the order of 1 standard cubic feet per minute) to maintain sparger nozzle clear of obstructions. In the ON mode, each sparger shall operate at its specified flowrate. Each sparger shall have the capability of being flushed, using either full pressure compressed air or water.

Compressed Air Consumption

Air consumption for PJM and sparger operation, for normal mixing operation, and for ITS mixing operation, is shown in Tables 3 and 4, respectively. It should be noted that sparger air flow is based on maximum operating volume, corresponding to an overflow condition, and is therefore considered to be bounding. With respect to PJM air flow, the noted figures in Tables 3 and 4 are the direct result of AEA's calculations, and do not contain any contingency allowance. A margin of 10% should be applied to these PJM flows, to account for uncertainty regarding JPP air consumption.

Table 3: Compressed Air Consumption - Routine System Operation

Vessel	# of Spargers	Sparger Mode	Total Sparge Air (SCFM)	# of PJMs	Peak PJM Air (SCFM)	Cycle Ave PJM Air (SCFM)	Total Air Required (SCFM)
UFP-VSL-00002A	16	idle	32	6	5016	1140	1172
UFP-VSL-00002B	16	idle	32	6	5016	1140	1172
UFP-VSL-00002A*	16	ON	394	6	5016	1140	1534
UFP-VSL-00002B*	16	ON	394	6	5016	1140	1534
HLP-VSL-00027A	36	idle	63	8	5936	1288	1351
HLP-VSL-00027B	36	idle	63	8	5936	1288	1351
HLP-VSL-00028	36	idle	63	8	5936	1288	1351

*The recirculation pump is not running during the (high temperature) leaching process. If a batch requires leaching, the spargers will be used for mixing during this process.

Table 4: Compressed Air Consumption - ITS System Operation

Vessel	# of Spargers	Sparger Mode	Total Sparge Air (SCFM)	# of PJMs	Peak PJM Air (SCFM)	Cycle Ave PJM Air (SCFM)	Total Air Required (SCFM)
UFP-VSL-00002A	16	ON	394	6	5016	1140	1534
UFP-VSL-00002B	16	ON	394	6	5016	1140	1534
HLP-VSL-00027A	36	ON	1449	8	5936	1288	2737
HLP-VSL-00027B	36	ON	1449	8	5936	1288	2737
HLP-VSL-00028	36	ON	1745	8	5936	1288	3033

Open Items

There are several additional actions that are being taken to complete closeout of this technical issue. These key items are summarized below:

- Post-Design Basis Event (DBE) Operating Requirements - Intermittent mixing requirements, ITS air demand, and required emergency diesel generator capacity will be defined separately, and will be included in the system description.
- Operation and Controls - Detailed operating and control modes for spargers and PJMs, and associated vessel level controls will be defined separately, and will be included in the system description.
- R&T Test Reports - These key project documents are in preparation by R&T, supported by Battelle and Savannah River Technology Center. A separate schedule has been developed to track and status these deliverables.
- Additional R&T Testing - There is some additional testing to be performed, primarily to support Engineering in developing a complete operating sequence for ITS mixing which minimizes compressed air demand.
- Vessel drawings - Several drawings are in preparation by Central Engineering, to support PT Plant Design layout of the sparge and PJM air supply piping. The LS and Blend vessel drawings should be available March 24, 2004 by close of business, with the Ultrafiltration Process System (UFP) vessel drawings available by March 26, 2004 close of business.
- Heat Transfer - Vessel heat transfer capacity is under evaluation and will be the subject of separate correspondence.

SUMMARY

The foregoing provides interim definitive design direction regarding Non-Newtonian vessel mixing. This has been determined to be sufficient to support near-term physical design activities for the PT facility.

Please contact Walt Tamosaitis or myself, should you have any questions.

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