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POSITION PAPER
PROJECT W-236A
MULTI-FUNCTION WASTE TANK FACILITY
WASTE STORAGE TANK HEAT REMOVAL SYSTEMS

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POSITION PAPER
PROJECT W-236A
MULTI-FUNCTION WASTE TANK FACILITY
WASTE STORAGE TANK HEAT REMOVAL SYSTEMS

Purpose

The purpose of this paper is to develop and document a position on the heat removal system to be used on the waste storage tanks currently being designed for the Multi-Function Waste Tank Facility (MWTF), project W-236A.

Background

The current preliminary design for the waste storage primary tank heat removal system consists of the following subsystems: 1) a once-through dome space ventilation system, 2) a recirculation dome space ventilation system, and 3) an annulus ventilation system. These subsystems are shown schematically in Figure 1. Recently completed and ongoing studies have evaluated alternative heat removal systems in an attempt to reduce system costs and to optimize heat removal capabilities. In addition, a thermal/heat transfer analysis is being performed that will provide assurance that the heat removal systems selected will be capable of removing the total primary tank design heat load of 1.25 MBtu/hr (ref 1) at an allowable operating temperature of 190 F. Although 200 F is the design temperature limit, 190 F has been selected as the maximum allowable operating temperature limit based on instrumentation sensitivity, instrumentation location sensitivity, and other factors as noted in sections 4 and 5 of ref 2.

Ventilation Cooling Systems

During the Advanced Conceptual Design (ACD) phase of the MWTF project, the design heat load for the waste storage tanks was 2.6 MBtu/hr (ref 3), and the vapor pressure suppression in the dome space was assumed at 30%. At these values, each subsystem of the proposed ventilation system would remove the following approximate portions of the total heat load:

Annulus	7%	0.17 MBtu/hr
Once-Through	23%	0.60 MBtu/hr
Recirculation	68%	1.77 MBtu/hr
Other	2%	0.06 MBtu/hr
Totals	100%	2.60 MBtu/hr

The ACD primary tank once-through ventilation system provides 300 scfm of ventilation air flow. The intake side of each system consists of a high-efficiency particulate air (HEPA) filter and electric heating coils. The exhaust side has a condenser, high-efficiency mist eliminator (HEME) and high-efficiency metal fiber (HEMF) filter trains with electric heating coils, high-efficiency gas adsorber (HEGA) and HEPA filter trains, and exhaust fans discharging all flow to an exhaust stack. This system maintains a negative pressure in the tank dome space, sweeps explosive gasses from this space. As shown above, this system is sized to remove approximately 23% of the total heat load.

The ACD primary tank recirculation ventilation system provides 1200 scfm of ventilation air flow. This system consists of a pressure-relief device, a condenser, an air/liquid separator, and a fan which recirculates all of the flow back into the tank. This system is sized to remove approximately 68% of the total heat load.

The ACD primary tank annulus ventilation system provides 1100 scfm of ventilation air flow. The intake side of the annulus system consists of prefilters and HEPA filters with electric heating coils. The exhaust side consists of exhaust ducting to a common bank of HEPA filters with electric heating coils, and common exhaust fans serving all tanks. As with the once-through system, the annulus system also discharges to an exhaust stack. This system removes approximately 7% of the total heat load.

Revised Heat Load

Subsequent to completion of advanced conceptual design, the heat load was reduced to the present value of 1.25 MBtu/hr (ref 1) with a conservative vapor pressure suppression in the dome space of 45% based on test results (ref 4). Using these new values, the ventilation subsystems remove the following (based on empirical equations used in the Water's report [ref 5], an inlet temperature of 55 F, a design temperature limit of 200 F, and a recirculation rate of 350 scfm):

Annulus	14%	0.17 MBtu/hr
Once-Through	38%	0.47 MBtu/hr
Recirculation	44%	0.55 MBtu/hr
Other	5%	0.06 MBtu/hr
Totals	100%	1.25 MBtu/hr

Alternative Cooling Subsystems

Recent studies and evaluations have investigated the feasibility of several alternative means of heat removal from the primary tank (ref 6). Alternative heat removal subsystems include: a combined mixer pump/heat exchanger system (Figure 2); a stand-alone loop cooler/heat exchanger system (Figure 3); and an increased annulus ventilation system. A variable capacity once-through system has also been considered and is described under the proposed ventilation system options section of this paper.

Mixer Pump/Heat Exchanger

The mixer pump/heat exchanger subsystem consists of a heat exchanger located in a curbed area adjacent to the waste tanks. A heat exchanger chamber is located at the bottom of the mixer pump and is fabricated integrally with the mixer pump itself. Alternatively, independent external cooling coils could be attached to the mixer pump housing. Normal and redundant chillers are located outside the Weather Enclosure (200 East site only) and provide chilled water to the heat exchanger. This system allows for elimination of the proposed primary tank recirculation system and subsequent reduction in the size of the Support Facility. Consequently, this would provide an estimated rough-order-of-magnitude (ROM) cost savings of ***$13.6 Million*** (ref 6).

Advantages of the mixer pump/heat exchanger subsystem include the following:

- Reduced in-tank items from combined equipment compared to stand-alone in-tank cooling coils
- Heat removal at the source of the highest heat load, which is the most effective means of heat removal
- Reduced number of tank dome penetrations when compared to systems utilizing separate cooling coils
- No interference with mixing flow patterns
- More effective means of cooling compared to proposed ventilation systems
- More effective at low waste temperatures when compared to evaporative cooling systems

Disadvantages of the mixer pump/heat exchanger subsystem include the following:

- Failure of one part results in removal of another for combined system
- Significantly higher cost/complexity for mixer pump for the combined system
- Unproven reliability and effectiveness of combined system
- Unproven operational experience
- Extreme difficulty in cleaning and removing debris from coils if they become fouled
- Significant design development effort required

Loop Cooler/Heat Exchanger

The stand-alone loop cooler/heat exchanger subsystem consists of a heat exchanger located in a curbed area adjacent to the waste tanks. Loop cooler cooling "coils" extend into the waste through penetration risers located in the dome of the primary tank. Normal and redundant chillers are located outside the Weather Enclosure (200 East site only) and provide chilled water to the loop cooler heat exchanger subsystem. Retractable or "bayonet" cooling coils are being evaluated by the Savannah River site and are desirable due to their capability of being left in a retracted position until needed. There is limited operating experience with the bayonet coolers, but there is extensive experience with permanently installed cooling coils. The loop cooler/heat exchanger subsystem allows for elimination of the proposed primary tank recirculation system and subsequent reduction in the size of the Support Facility. Consequently, this would provide an estimated ROM cost savings of ***$15 Million*** (ref 6).

Advantages of the loop cooler/heat exchanger subsystem include the following:

- Separate systems provide independent reliability/failure rates when compared with the combined mixer pump/heat exchanger system
- Lower cost and less complexity than combined mixer pump/heat exchanger
- Operating experience and reliability data is available from other sites
- If not needed for cooling, coils could be removed
- More effective means of cooling than evaporative or convective methods provided by the proposed conceptual ventilation system design
- More effective at low waste temperatures when compared to evaporative cooling systems

Disadvantages of the loop cooler/heat exchanger subsystem include the following:

- More in-tank items and more penetrations
- Heat removal not located at the primary source of heat (mixer pumps)

- Increased decontamination/disposal costs
- In-tank coils interfere with mixing flow patterns
- Cooling coils difficult to seismically qualify and support
- Fouling of in-tank cooling coils resulting in reduced effectiveness has been experienced at other sites
- Significant design development effort required
- Increased O & M efforts
- Ineffective at low waste levels

Increased Annulus Ventilation System
The 1.25 MBtu/hr heat load can also be handled by increasing the annulus flow rate from 1100 scfm to 13,000 scfm (or greater). This requires enlarging the supply ducting, increasing the capacities of the intake filtration systems, enlarging the in-tank supply ducts, enlarging the air distribution chamber, enlarging the ventilation slots in the top of the supporting pad, increasing the capacities of the common exhaust filtration trains, increasing the capacities of the exhaust fans, increasing the capacity of the flow distribution system, and enlarging the exhaust stack. For this subsystem, complexities and uncertainties are involved in the heat removal capacity calculations and design of the annulus ventilation subsystem at flow rates of 13,000 scfm or higher. Estimated cost savings for this option were not developed.

In lieu of designing a 13,000 scfm annulus subsystem to completely replace the recirculation subsystem, improved heat removal can be achieved with a 3000 to 5000 scfm annulus ventilation subsystem. The advantage of these lower flow rates is that the complexities and uncertainties of analysis and design no longer apply, and the flow rates remain in the range of natural convection heat removal. In addition, at these lower flow rates, the annulus subsystem can be designed without impacting the design of the supporting pad and ventilation slots by maintaining the underslab ventilation system flow rates at 1100 scfm. The remaining flow will be exhausted directly into the annulus through a header system.

Advantages of the enlarged annulus subsystem include the following:

- Ventilation air is clean as it normally does not come in contact with the waste
- Similar to existing systems already in use at other tank farms
- Changing a proposed system, not adding a new system (salvage some design development efforts)
- No added high-level decontamination/disposal costs
- Low operating and maintenance efforts
- Low capital costs
- Achieves ALARA
- Effective at low temperatures

Disadvantages of the enlarged annulus subsystem include the following:

- Cost savings for elimination of the recirculation subsystem would be reduced due to enlarged size of annulus subsystem equipment cells in the Support Facility for the 13,000 scfm flow rate
- Larger ducts from Support Facility to tanks
- Larger and possibly more dome penetrations (4" to 6" diameter)
- Potential design changes to the supporting pad at 13,000 scfm flow rate

- Potential adverse affect on annulus space (i.e. access for in-service inspection)
- Uncertainties in analysis methodology and definition of flow patterns at 13,000 scfm flow rate
- Potential adverse impact on the operation of the radiation monitoring systems

Combined Once-Through/Recirculation System

A high-capacity, 1500 scfm combined once-through and recirculation system has also been considered. This system is a larger flow rate recirculation system with a bypass or bleed-off into a low-flow (300 scfm) once-through stack exhaust system. The once-through system maintains the tank dome space negative pressure. Since equipment and building space savings for this alternative are minimal, it is not considered an improvement on the current design.

Recirculation Ventilation Subsystem

Although a recirculation ventilation subsystem is technically feasible and is capable of removing a significant (44%) portion of the total design heat load of 1.25 Mbtu/hr, it is believed that the other alternative heat removal subsystems (increased annulus flow, cooling coils, etc.) are technically preferred and more cost effective. As previously noted, elimination of the recirculation subsystem could result in an estimated ROM cost savings of ***$15 Million*** if cooling coils are used. Even higher cost savings may be realized for other recirculation subsystem replacement options.

Advantages of retaining the proposed primary tank recirculation ventilation subsystem include the following:

- Title I design well underway (salvage design effort)
- Minimized releases to the environment
- No impact to design schedule
- More effective as temperatures increase

Disadvantages of retaining the proposed primary tank recirculation ventilation subsystem include the following:

- Higher capital costs and large amounts of floor space in the Support Facility
- Higher decontamination/disposal costs when compared to the annulus system
- Less effective at lower temperatures

Discussion

Dome Space Heat Transfer Analysis

At present, for the heat transfer analysis of the dome space, inconsistencies exist between the results from the computational fluid dynamics code, FIDAP, and from the more traditional closed form solutions developed from using the classical empirically derived heat transfer equations contained in ref 5. The preliminary FIDAP analyses indicated that the heat removal capability of the dome space ventilation systems is roughly one-half of that predicted by use of the empirical equations. Currently, after several model refinements, the latest FIDAP analysis results are within approximately 20% of the empirical correlations. Efforts are currently underway to resolve the disagreements and to select the appropriate method for use in the final design. The selection of the heat removal system must be made now and should be capable of satisfying the tank cooling requirements regardless of the analysis method selected.

Once-Through Subsystem Flow Rates

Once-through flow rates in excess of 300 scfm (up to 960 scfm) could be used to remove that portion of the heat loads previously removed by the eliminated recirculation system. Although the higher flow rates are undesirable from an environmental release perspective, they are needed infrequently or not at all during the expected normal tank operating conditions.

Cooling Coils

Both the FIDAP and empirical analyses indicate that, to satisfy design conditions, additional heat removal capacity would be needed as shown in Option G below. This additional heat removal could be provided by cooling coils. The need for cooling coils is based on the assumption that the recirculation subsystem is eliminated and the once-through and annulus subsystems remain as currently designed. However, under expected nominal operating conditions of only installing and operating one mixer pump, the cooling coils could remain in an uninstalled, standby status.

Proposed Ventilation System Options

Following are descriptions of the options considered for the primary tank heat removal system. For ease of reference, these options are presented in tabular form in Table 1.

Option A:

This option is the proposed ACD scheme for the tank ventilation system. It consists of a 300 scfm once-through subsystem, an 1100 scfm annulus ventilation subsystem, and a 1200 scfm (only 670 scfm required using the empirical equations) recirculation subsystem. The subsystems of this ventilation system would remove the following portions of the total design heat load (using an inlet temperature of 77 F and an operating temperature limit of 190 F):

Subsystem	Empirical Results		FIDAP Results	
Annulus	11%	0.14 MBtu/hr	11%	0.14 MBtu/hr
Once-Through	26	0.33	18	0.23
Recirculation	59	0.74	67	0.84
Cooling Coils	0	0.00	0	0.00
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

Option B:

This option maintains annulus flow at 1100 scfm and provides a once-through subsystem with normal operation at 300 scfm. It provides additional capacity for periodic flow rates up to 960 scfm when additional cooling capacity may be required to remove the worst-case design heat load of 1.25 MBtu/hr. Cooling coils may be required, depending on the method selected for the analysis of the dome space heat transfer. The recirculation subsystem is eliminated in this option. The subsystems of this ventilation system would remove the following portions of the total design heat load:

Subsystem	Empirical Results		FIDAP Results	
Annulus	11%	0.14 MBtu/hr	11%	0.14 MBtu/hr
Once-Through	85	1.07	60	0.75
Recirculation	0	0.00	0	0.00
Cooling Coils	0	0.00	25	0.32
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

Option C:

This option increases annulus flow to 4400 scfm and provides a once-through subsystem with normal operation at 300 scfm. It provides additional capacity for periodic flow rates up to 650 scfm when additional cooling capacity may be required to remove the worst-case design heat load of 1.25 MBtu/hr. Cooling coils may be required, depending on the method selected for the analysis of the dome space heat transfer. The recirculation subsystem is eliminated. The subsystems of this ventilation system would remove the following portions of the total design heat load:

Subsystem	Empirical Results		FIDAP Results	
Annulus	37%	0.47 MBtu/hr	37%	0.47 MBtu/hr
Once-Through	59	0.74	37	0.46
Recirculation	0	0.00	0	0.00
Cooling Coils	0	0.00	22	0.28
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

Option D:

This option increases annulus flow to 3300 scfm and maintains the once-through subsystem at 300 scfm. Cooling coils are required to remove the worst-case design heat load of 1.25 MBtu/hr. The recirculation subsystem is eliminated. The subsystems of this ventilation system would remove the following portions of the total design heat load:

Subsystem	Empirical Results		FIDAP Results	
Annulus	30%	0.38 MBtu/hr	30%	0.38 MBtu/hr
Once-Through	29	0.36	18	0.23
Recirculation	0	0.00	0	0.00
Cooling Coils	37	0.46	48	0.60
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

Option E:

This option increases annulus flow to 13,000 scfm (46,000 scfm required using the FIDAP results) and maintains the once-through subsystem at 300 scfm. No cooling coils are required. The recirculation subsystem is also eliminated. The subsystems of this ventilation system would remove the following portions of the total design heat load:

Subsystem	Empirical Results		FIDAP Results	
Annulus	62%	0.78 MBtu/hr	78%	0.98 MBtu/hr
Once-Through	34	0.43	18	0.23
Recirculation	0	0.00	0	0.00
Cooling Coils	0	0.00	0	0.00
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

Option F:

This option increases annulus flow to 4400 scfm and provides a once-through subsystem with normal operation at 300 scfm. It provides additional capacity for periodic flow rates up to 650 scfm (960 scfm required using the FIDAP results) when additional cooling capacity may be required to remove the worst-case design heat load of 1.25 MBtu/hr. Cooling coils are not required. The recirculation subsystem is eliminated. The subsystems of this ventilation system would remove the following portions of the total design heat load:

Subsystem	Empirical Results		FIDAP Results	
Annulus	37%	0.47 MBtu/hr	37%	0.47 MBtu/hr
Once-Through	59	0.74	59	0.74
Recirculation	0	0.00	0	0.00
Cooling Coils	0	0.00	0	0.00
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

Option G:
This option maintains annulus flow at 1100 scfm and maintains the once-through subsystem at 300 scfm. Cooling coils are required to remove the worst-case design heat load of 1.25 MBtu/hr. The recirculation subsystem is eliminated. The subsystems of this ventilation system would remove the following portions of the total design heat load:

Subsystem	Empirical Results		FIDAP Results	
Annulus	11%	0.14 MBtu/hr	11%	0.14 MBtu/hr
Once-Through	26	0.33	18	0.23
Recirculation	0	0.00	0	0.00
Cooling Coils	59	0.74	67	0.84
Other	4	0.04	4	0.04
Totals	100%	1.25 MBtu/hr	100%	1.25 MBtu/hr

TABLE 1: HEAT REMOVAL SYSTEM OPTIONS

Design Conditions =			1.25 MBtu/hr @ 190° F		
Option	**Cool Coil Operational Probability**	**Once-Thru (scfm)**	**Annulus (scfm)**	**Recirc. (scfm)**	**Cool Coil Required?**
A.	N/A	300	1100	1200(±)	N
B.	50%	300/960	1100	0	Y (FIDAP) N (EMP)
C.	25%	300/650	4400(±)	0	Y (FIDAP) N (EMP)
D.	100%	300	3300	0	Y
E.	N/A	300	13000(+)	0	N
F.	N/A	300/960	4400(±)	0	N
G.	100%	300	1100	0	Y

Comparison of Options

For purpose of comparison, each option was evaluated and rated qualitatively based on the rating criteria categories of cost, schedule, environmental/ALARA, and operational considerations. The evaluations were performed by a cross-section of project personnel representing design, thermal analysis, stress analysis, environmental, estimating, and management functions. Detailed costs and schedules were not developed. The ratings are qualitative, based on engineering judgement, and relative to the other options within each rating criteria category. A description of the rating criteria categories is as follows:

COST	This rating criteria category includes design costs, capital and operating costs, D & D costs, and life cycle considerations.
SCHEDULE	This rating criteria category includes a consideration of impact to both design and construction schedules.
ENV/ALARA	This rating criteria category includes a consideration of releases to the environment, the amount of contaminated waste produced, the contamination of the system components, contamination levels, ALARA concerns, and postoperational decontamination and disposal.
OPERATIONS	This rating criteria category includes a consideration of ease of operations; extent and complexity of operating and maintenance activities; exposure of operating personnel; and accessibility for replacement, repair, and inspection.

Rating results are shown in Table 2. Two weighting factor schemes were used to achieve summary rating scores for comparison of options. This was done to evaluate the sensitivity of the summary ratings to variations in the weighting factors. However, if technical choices are equal, cost and/or schedule could be given greater weight in the final selection. Option D was not included in the rating evaluation because it is a more complex variation of Option G and would obviously achieve a lower rating score.

TABLE 2: EVALUATION OF HEAT REMOVAL SYSTEM OPTIONS

						HEAT REMOVAL SYSTEM OPTIONS[1]					
DECISION FACTORS						A	B	C	E	F	G
COST						1	3	3	3	5	4
SCHEDULE						5	2	2	2	2	3
ENVIRONMENTAL/ALARA						4	3	3	5	4	2
OPERATIONS						4	2	2	5	5	1
ITEM	COST	SCHEDULE	ENV/ALARA	OPER							
WEIGHT FACTORS:	10%	30%	30%	30%	SUMMARY/ SCORE RATING[1]	4.0	2.4	2.4	3.9	3.8	2.2
WEIGHT FACTORS:	10%	10%	40%	40%	SUMMARY/ SCORE RATING[1]	3.8	2.5	2.5	4.5	4.3	1.9

[1] Underlined summary score ratings are considered equal within the range of accuracy of the evaluation process.

The summary rating scores indicate that for both weighting factor schemes, the options without cooling coils achieved the highest scores. Although the scores for Options A, E, and F were not equal, they were higher than the options eliminated, and were so close within the range of accuracy of the qualitative ratings that they were considered equal at this point. Further discussions concerning these three options were held in an attempt to determine the best choice. Option E was eliminated because of the complexities and uncertainties involved in the design and analysis of an annulus ventilation subsystem with a 13,000 scfm or greater flow rate. Schedule considerations favored Option A because it is the only option that does not impact the design schedule. However, Option F was selected over Option A due to the simplicity of having a heat removal system comprised of only two subsystems versus three subsystems as required by Option A. In addition, even if both options were equal based on technical merit, Option F offers the potential for significant cost savings (even greater than the ***$15 Million*** estimated for the cooling coil alternative of ref 6) due to the elimination of the recirculation system without the addition of a replacement cooling subsystem. Finally, using Option F under nominal operating conditions (0.50 MBtu/hr heat load and 30% vapor pressure suppression) results in an operating temperature in the waste of approximately 150 F.

Conclusions & Recommendations

Based on the preceding discussion and evaluations, the following heat removal system conclusions and recommendations are presented:

- Eliminate the primary tank recirculation heat removal subsystem and associated support facilities.
- Design the primary tank annulus heat removal subsystem for a variable flow rate of up to 5000 scfm. (Due to potential solids precipitation at lower temperatures, the heat removal system selected should be evaluated to determine cooling capacities, flow rates, and waste temperatures over the full range of anticipated operating conditions.)
- Design the primary tank once-through heat removal subsystem for a nominal operating flow rate of 300 scfm with capability for providing infrequent flow rates up to approximately 960 scfm during periods of high-heat generation.
- Reevaluate the number of spare 42 inch diameter risers in the dome to ensure that a sufficient number of risers will be available in the event a portable cooling lance is added for operational flexibility. If this is the case, spare chiller piping could be installed adjacent to a designated spare riser at each tank for possible future connection to the portable cooling lance heat exchanger.
- If needed to eliminate significant uncertainties in the thermal hydraulic performance of the heat removal system, it is recommended that laboratory testing be performed to simulate the dome space heat removal conditions. This would improve the reliability of the vapor phase heat removal estimates to determine the evaporative heat loss rates, and to correlate these rates to the analysis method selected for use in the final design.

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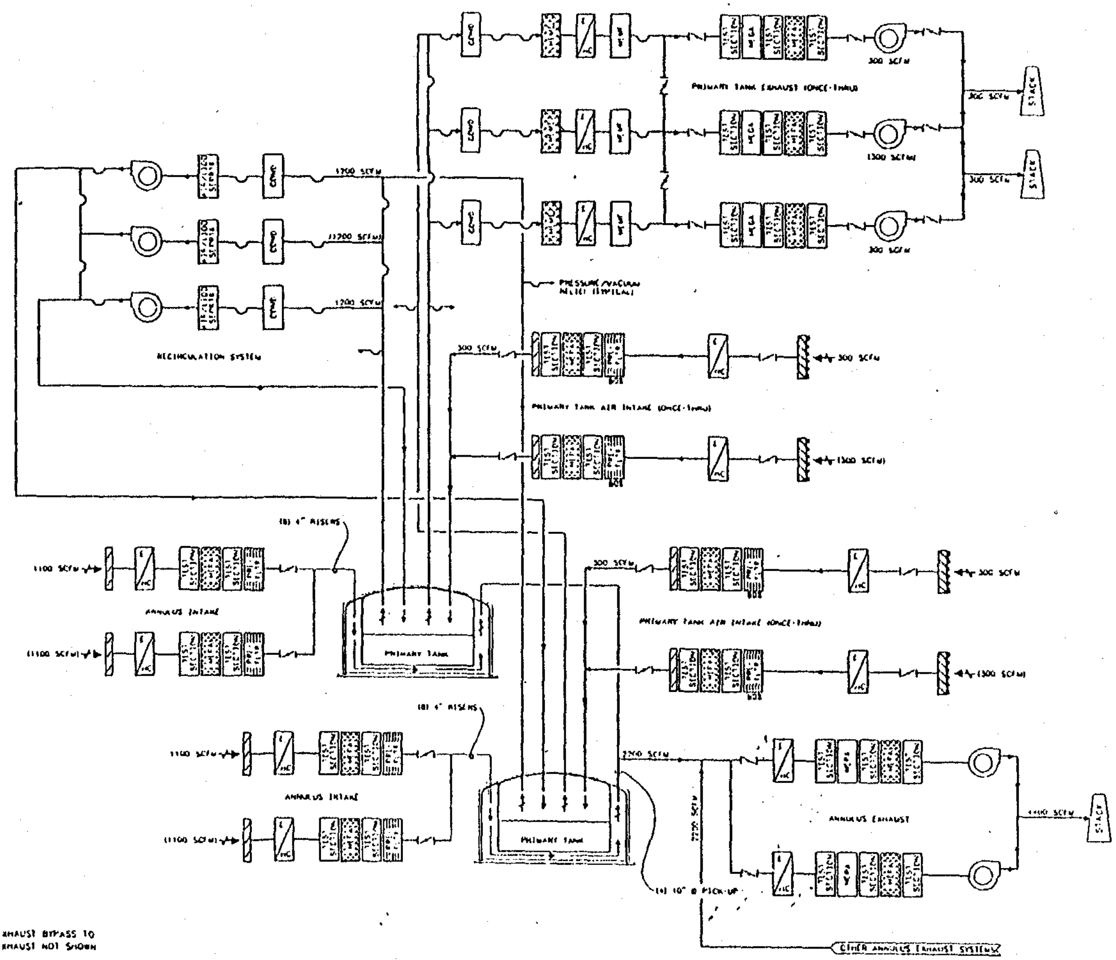
6. Letter Report, "Mixer Pump/Heat Exchanger, Multi-Function Waste Tank Facility," Document # W236A-T1-TR3, prepared by Kaiser Engineers Hanford, September 1993.

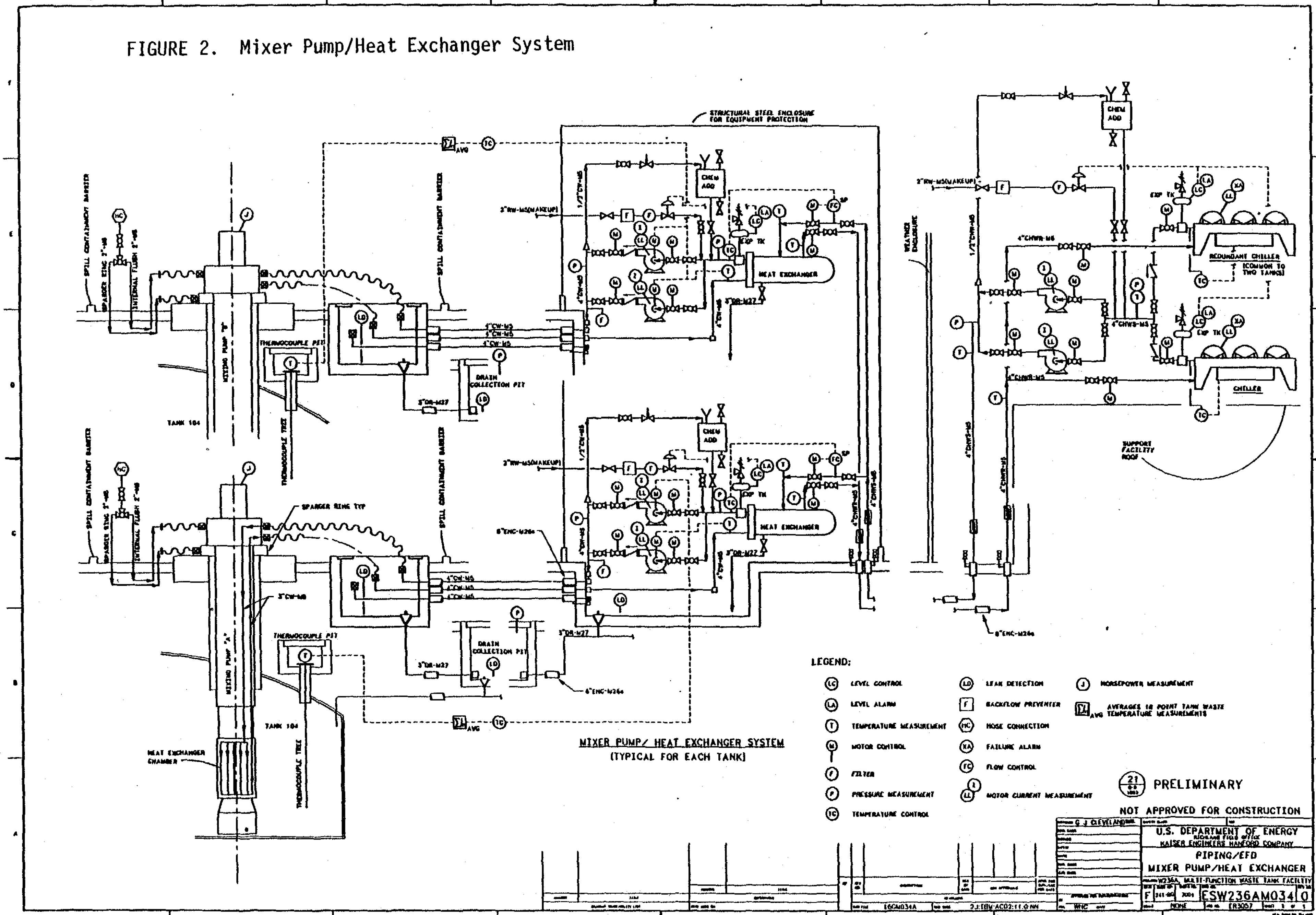


NOTE: ANNULUS EXHAUST BYPASS TO PRIMARY EXHAUST NOT SHOWN

FIGURE 1. PRIMARY TANK VENTILATION SYSTEMS

/users/projects/w236a/c/nph15a

FIGURE 2. Mixer Pump/Heat Exchanger System



LEGEND:

LC	LEVEL CONTROL	LD	LEAK DETECTION	J	HORSEPOWER MEASUREMENT
LA	LEVEL ALARM	F	BACKFLOW PREVENTER	Σt AVG	AVERAGES 18 POINT TANK WASTE TEMPERATURE MEASUREMENTS
T	TEMPERATURE MEASUREMENT	HC	HOSE CONNECTION		
M	MOTOR CONTROL	XA	FAILURE ALARM		
F	FILTER	FC	FLOW CONTROL		
P	PRESSURE MEASUREMENT	I LL	MOTOR CURRENT MEASUREMENT		
TC	TEMPERATURE CONTROL				

21 PRELIMINARY

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U.S. DEPARTMENT OF ENERGY
RICHLAND FIELD OFFICE
KAISER ENGINEERS HANFORD COMPANY

PIPING/EFD
MIXER PUMP/HEAT EXCHANGER

W236A, MULTI-FUNCTION WASTE TANK FACILITY

F 241-90 7004 ESW236AM034 0

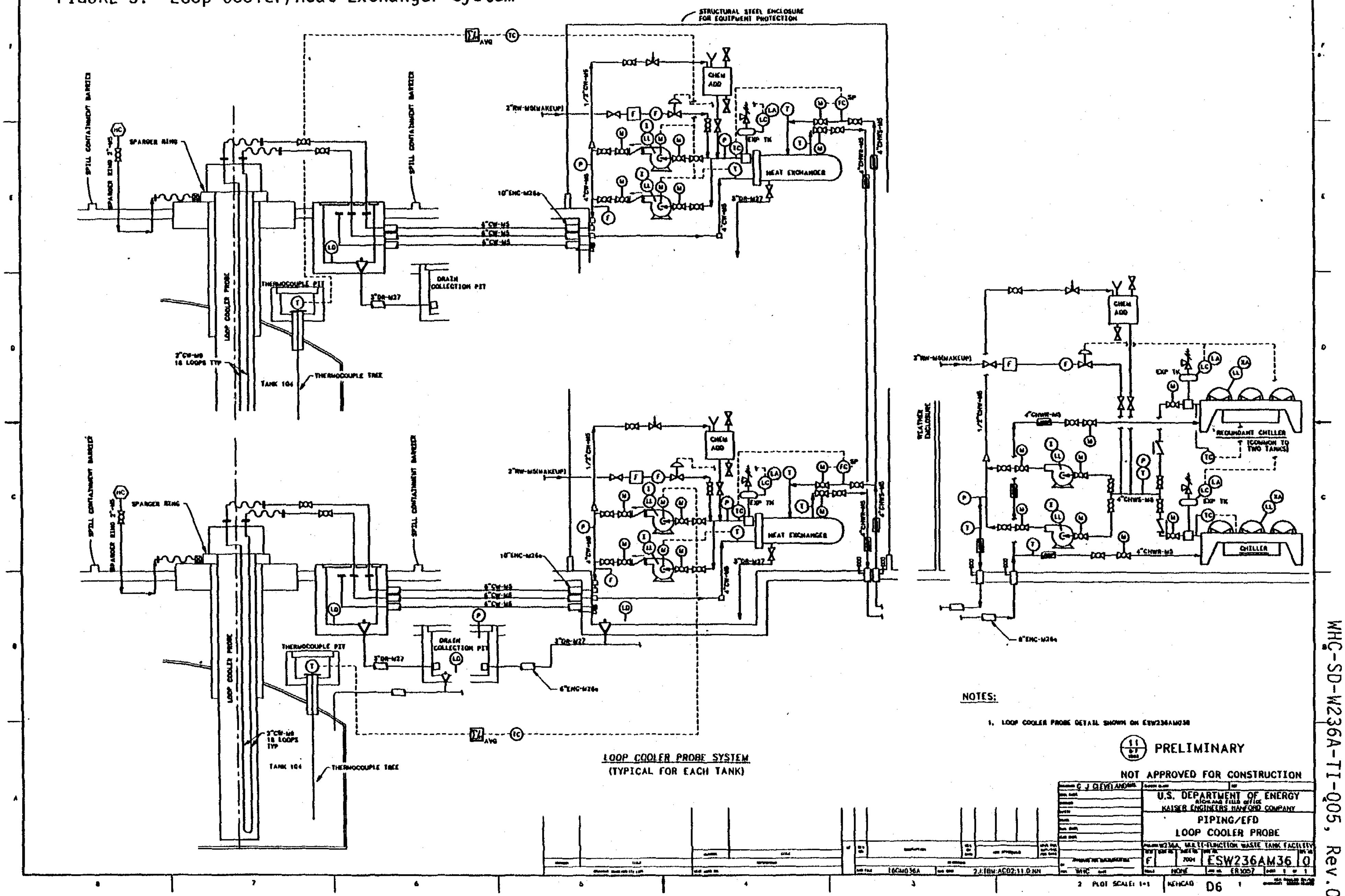
NONE ER3057 1 of 1

16GM034A 2J:IBM-AC02:11.0 NN

WHC

PLOT SCALE: 1=1 KEHCAD D3

FIGURE 3. Loop Cooler/Heat Exchanger System



NOTES:

1. LOOP COOLER PROBE DETAIL SHOWN ON ESW236AM038

PRELIMINARY

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KAISER ENGINEERS HANFORD COMPANY

PIPING/EFD
LOOP COOLER PROBE

W236A, MULTI-FUNCTION WASTE TANK FACILITY

F 7004 ESW236AM36 0

NONE ER3057 1 OF 1

16GM036A 2J:IBM:ACD2:11.0:NN WHC

PLOT SCALE: 1=1 KEHCAD D6