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KAISER ENGINEERS HANFORD

W-105-124

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

REG. NO. KAISEEH134GM

September 11, 1991

RECEIVED
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EDMC

L. R. Tollbom, Project Manager
Effluent Treatment Projects
Westinghouse Hanford Company
P. O. Box 1970
Richland, Washington 99352

Dear Mr. Tollbom:

W-105, RESPONSE TO LOI 73

Reference:

1.) Westinghouse Hanford Company (WHC) letter #9156336, "Letter of Instruction Number 73" dated 8/28/91.

2.) Kaiser Engineers Hanford (KEH) dike certification by Edgar A. Goakey dated May 5, 1991.

LOI 73 requested that Kaiser Engineers Hanford (KEH) prepare a formal response to three separate technical issues that the Washington Department of Ecology (WDOE) has expressed concerning the W-105 LERF project. The following will describe the issues and provide KEH's response.

Item #1

Issue 1a.) Because the dikes were reworked, Ecology has requested that a new certification be provided. The calculations and certification should not consider use of the soil/bentonite to prevent piping and scouring. The new certification must be the same as that provided by Reference 2 in that it must say "I (name) certify ..." In this context, Ecology considers the certification provided by Reference 2 null and void. Ecology requests that a new certification be provided in accordance with WAC 173-303-650(4) (c) (i) and (ii).

If the certification can not be accomplished on the basis of no soil/bentonite, the KEH is also requested to complete the calculations or analysis to determine if the extra six inches of soil/bentonite that is presently installed in Basins 42, 43, and 44 can be included in the analysis for piping and scouring. This extra thickness of soil/bentonite goes beyond the thirty six inches required by the environmental Protection Agency guidance

S-2-8

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(EPA/530-SW-85-014) for the basin slopes, which presently have a minimum of forty two inches of soil/bentonite installed.

<u>Response</u>: Attachment #1 establishes the technical basis to certify the structural integrity of the dikes. As requested, the analysis does not consider the soil/bentonite liner system as part of the dike structure. Attachment #2 certifies that the dikes are structurally sound and will not fail due to piping and scouring.

<u>Issue 1b.)</u> In addition to the above, Ecology requested in Reference 1 that a detailed explanation be provided as to why "the certifying engineer during his process of certification did not identify the grading problem that delayed the project by nearly two months."

<u>Response</u>: The re-grading activities that took place in May and June of 1991 did not result from any known nonconformances. Survey data available in the March/April time frame indicated that the subgrades were constructed as designed. To provide additional assurance that the proper depths of soil/bentonite would be installed in the basins, it was decided (in April) to change our survey strategy. A far more detailed survey was performed that allowed for a higher frequency of survey points be obtained in the basins. Results of the detailed survey revealed areas that required minor rework. A number of cycles of reworking and resurveying were necessary until all three basins were deemed acceptable. The basis and net effect of this action was to provide additional Quality Assurance and Environmental Compliance.

Note: The attached and referenced certifications do not certify an as-built condition. Regardless of semantical interpretation, these engineering certifications are intended to address only approved drawings and specifications. Construction Quality Assurance documents can be provided to assure that the dikes were constructed as designed.

<u>Item #2</u>

<u>Issue 2.)</u> Ecology believes that the grading problem discussed in item one resulted in excessive drying of the stockpiled soil/bentonite, which has resulted in the introduction of unacceptable clods in the liner system. The KEH is

(EPA/530-SW-85-014) for the basin slopes, which presently have a minimum of forty two inches of soil/bentonite installed.

<u>Response</u>: Attachment #1 establishes the technical basis to certify the structural integrity of the dikes. As requested, the analysis does not consider the soil/bentonite liner system as part of the dike structure. Attachment #2 certifies that the dikes are structurally sound and will not fail due to piping and scouring.

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Response: Attachment #1 establishes the technical basis to certify the structural integrity of the dikes. As requested, the analysis does not consider the soil/bentonite liner system as part of the dike structure. Attachment #2 certifies that the dikes are structurally sound and will not fail due to piping and scouring.

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Issue 2.) Ecology believes that the grading problem discussed in item one resulted in excessive drying of the stockpiled soil/bentonite, which has resulted in the introduction of unacceptable clods in the liner system. The KEH is

requested to provide the quality assurance rationale explaining how the introduction of clods into the soil/bentonite liner system was controlled, and how clods were broken up and mixed to ensure the correct density of installed soil/bentonite.

Response: Attachment #3 addresses the methods and controls employed to prevent excessive drying of stockpiled soil/bentonite and eliminate installation of clods into the basins.

Item #3

Issue 3a.) The KEH is requested to provide the rationale for the following:

Will the soil/bentonite freeze during the winter without water in the basins? Will it be necessary to heat empty basins? Assume that approximately 1 foot of water will remain in the basins to hold the liner and cover in place. This rationale should also include the freeboard area (top 5 feet) of the basins. The rationale should show that it will be acceptable to leave the basins empty (1 foot or less) through the winter months.

Response: Left empty and without an alternative heat source the soil/bentonite will freeze during the winter. Although the local design frost penetration depth is known to be approximately 18", a number of thermal variables (including the solar effects on the covers and the heat sink properties of the liner systems) make the known depth of frost penetration indeterminant at this point. Attachment #1 addresses what little is known regarding the affects of freezing to sand-bentonite liners.

Based on the input we have received from our consultants, it is KEH's position that further research is required to adequately respond to this concern.

Issue 3b.) The present construction schedule could result in the installation of liner materials during cold weather, rain or snow, or freezing conditions. The rationale for conditions for working in these environments should be provided. Be sure to address problems related to moisture, and how this problem will be handled when welding the basin liner and cover material.

Response: See attachment #3

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Response: Attachment #3 addresses the methods and controls employed to prevent excessive drying of stockpiled soil/bentonite and eliminate installation of clods into the basins.

Item #3

Issue 3a.) The KEH is requested to provide the rationale for the following:

Will the soil/bentonite freeze during the winter without water in the basins? Will it be necessary to heat empty basins? Assume that approximately 1 foot of water will remain in the basins to hold the liner and cover in place. This rationale should also include the freeboard area (top 5 feet) of the basins. The rationale should show that it will be acceptable to leave the basins empty (1 foot or less) through the winter months.

Response: Left empty and without an alternative heat source the soil/bentonite will freeze during the winter. Although the local design frost penetration depth is known to be approximately 18", a number of thermal variables (including the solar effects on the covers and the heat sink properties of the liner systems) make the known depth of frost penetration indeterminant at this point. Attachment #1 addresses what little is known regarding the affects of freezing to sand-bentonite liners.

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Will the soil/bentonite freeze during the winter without water in the basins? Will it be necessary to heat empty basins? Assume that approximately 1 foot of water will remain in the basins to hold the liner and cover in place. This rationale should also include the freeboard area (top 5 feet) of the basins. The rationale should show that it will be acceptable to leave the basins empty (1 foot or less) through the winter months.

Response: Left empty and without an alternative heat source the soil/bentonite will freeze during the winter. Although the local design frost penetration depth is known to be approximately 18", a number of thermal variables (including the solar effects on the covers and the heat sink properties of the liner systems) make the known depth of frost penetration indeterminant at this point. Attachment #1 addresses what little is known regarding the affects of freezing to sand-bentonite liners.

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Response: See attachment #3

Please feel free to contact me at 6-7216 if you have any further questions or concerns.

Sincerely,

S. L. Petersen

SLP:kaw

cc: R. T. French
A. G. Lassila - DOE
G. P. Burchell - WHC

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Chen-Northern, Inc.

Attachment #1

Consulting Engineers and Scientists

2214 North 4th Avenue
PO Box 2601
Tri-Cities, Washington 99302

509 547-1671
509 547-1673 Facsimile

September 10, 1991

Kaiser Engineers Hanford Company
P.O. Box 888
Richland, Washington 99352

ATTENTION: Mr. Stephen Petersen

SUBJECT: Technical Response to Westinghouse Letter August 28, 1991; Regarding W-105 Project and WDOE Inquiries Regarding Same

Gentlemen:

In accordance with your request of September 3, 1991, we are providing technical responses to inquiries placed by personnel from Westinghouse Hanford Company (WHC) and the Washington State Department of Ecology (WDOE). The specific items Chen-Northern was asked to address include the "certification" of the regraded dikes, and the effects of freezing and thawing on the soil-bentonite liner.

DIKE REGRADING

During May and June of 1991, ponds AL42, AL43, and AL44 were surveyed and were found to be out of specification with regard to constructed surface grade tolerances of the gravel dikes. The grade variations were all less than 1 foot from specification. In June, 1991, the grade variations were repaired to project tolerances. Surplus dike gravel and on-site sand were used to achieve the required grades. The repairs consisted of less than 1 foot of material cut or filled from the previous as-built dike grade.

We analyzed the stability of the original gravel dikes, as designed prior to June of 1991. We analyzed slope stability, settlement, subsidence, and susceptibility to piping and scour. Our original conclusions (delivered to KEH in our letters of March 26, 1991, April 10, 1991, and April 11, 1991, and April 18, 1991) indicated that the dike slopes were expected to be stable under static and design earthquake conditions. Our analyses also indicated that the anticipated total settlement was minimal, and that the environmental conditions for subsidence were not present, and that therefore subsidence was not expected to occur.

The last of our analyses concerned the potential for piping and scour through the gravel dikes, both with and without the soil-bentonite liner. The results of our analyses indicate that, because of the high permeability of the native soils, the low impounded

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The last of our analyses concerned the potential for piping and scour through the gravel dikes, both with and without the soil-bentonite liner. The results of our analyses indicate that, because of the high permeability of the native soils, the low impounded

fluid height (relative to adjacent exterior ground level), and the relatively finite amount of impounded fluid, neither piping nor scour are expected to develop or be possible to develop through the gravel dikes.

Considering the very minor amount of grading which occurred during June of 1991, it is our opinion that our original calculations of conditions regarding dike stability, settlement, and susceptibility to piping and scour have not materially changed. Therefore, the geotechnical design of the W-105 project, including the factors listed above, still complies with the requirements set forth in WAC 173-303-650.

SOIL-BENTONITE LINER FREEZING

To date, our research has consisted of a very limited literature search and phone conversations with Dr. David Daniel, University of Texas, Austin. The present results of our research are summarized below:

1. Freeze-thaw may adversely affect a compacted soil liner designed to a specific low permeability requirement.

2. Research performed on compacted pure clay liners has indicated that an increase in permeability of 2 to 3 orders of magnitude may occur after as few as two or three freeze-thaw cycles.

3. It was Dr. Daniel's opinion that a sandy (soil-bentonite) liner would be affected less than a pure clay liner. It was also his opinion (and is ours) that the only way to obtain any indication of freeze-thaw effect would be to perform laboratory triaxial permeability tests on liner samples which have undergone a minimum of two freeze-thaw cycles.

During our conversations with Dr. Daniel and others from the U.S. Army Corps of Engineers, it was the general concurrence that little, if any, research has been performed on the effects of freeze-thaw on a sand-bentonite liner system (or soil liners in general). At this time, we are however continuing to research the subject and the possibility of perforimng laboratory testing on samples of Test Fill #6, which was constructed using the design mix for the W-105 project.

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If you have any questions regarding this letter, or if we can be of further service, please contact us.

Respectfully Submitted,
CHEN-NORTHERN, INC.

Brian J. Williams, P.G.
Geotechnical Engineer

Dee J. Burrie, P.E.
Division Manager

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Dee J. Burrie, P.E.
Division Manager

Attachment #2

KAISER ENGINEERS HANFORD

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

REG. NO KAISEEH134BM

CERTIFICATION OF QUALIFIED ENGINEER

In accordance with WAC 173-303-650(4)(c)(i) and (ii), I, Edgar A. Goakey, P.E. certify that the dike portion of the W-105 Project Design has structural integrity. Specifically:

(i) The dike will withstand the stress of the pressure exerted by the types and amounts of wastes to be placed in the impoundment; and

(ii) The dike will not fail due to scouring or piping, without dependence on any liner[1] system included in the surface impoundment.

This certification is based upon the independent analysis of the structural integrity of the dike as set forth in attachment #1 of Kaiser Engineers Hanford letter W-105-124 dated September 11, 1991.

DATED THIS 12 day of September, 1991.

Kaiser Engineers Hanford, Co.

Edgar A. Goakey
Edgar A. Goakey,
Professional Engineer

EDGAR A. GOAKEY
STATE OF WASHINGTON
9813
REGISTERED
PROFESSIONAL ENGINEER
Edgar A. Goakey
9/12/91

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1. The soil /bentonite liner has not been considered as contributing to the integrity of the dike structure.

Attachment #2

KAISER ENGINEERS HANFORD

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Edgar A. Goakey

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Professional Engineer

EDGAR A. GOAKEY
STATE OF WASHINGTON
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PROFESSIONAL ENGINEER
Edgar A. Goakey
9/12/91

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1. The soil /bentonite liner has not been considered as contributing to the integrity of the dike structure.

Attachment #2

KAISER ENGINEERS HANFORD

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

REG. NO KAISEEH1348M

CERTIFICATION OF QUALIFIED ENGINEER

In accordance with WAC 173-303-650(4)(c)(i) and (ii), I, Edgar A. Goakey, P.E. certify that the dike portion of the W-105 Project Design has structural integrity. Specifically:

(i) The dike will withstand the stress of the pressure exerted by the types and amounts of wastes to be placed in the impoundment; and

(ii) The dike will not fail due to scouring or piping, without dependence on any liner[1] system included in the surface impoundment.

This certification is based upon the independent analysis of the structural integrity of the dike as set forth in attachment #1 of Kaiser Engineers Hanford letter W-105-124 dated September 11, 1991.

DATED THIS 12 day of September, 1991.

Kaiser Engineers Hanford, Co.

Edgar A. Goakey

Edgar A. Goakey,
Professional Engineer

1. The soil /bentonite liner has not been considered as contributing to the integrity of the dike structure.

AttACHMENT #3

KAISER ENGINEERS HANFORD

INTEROFFICE MEMORANDUM

91-LAG-019

TO S. Petersen E6-50

DATE September 11, 1991

FROM D McShane/ L Gaddis
CQA Officers W-105

COPIES TO

JOB NO. ER0241

SUBJECT RESPONSE TO LOI NO. 73 ITEMS 1 AND 2

Item 1, Reworked Dikes:

The rework of the dikes became necessary when additional survey information indicated that the subgrade was out of tolerance. The rework was minor and for the most part material was merely shuffled around. In basin 42 approximately .5 ft. was added to the slopes on the north end and the south east corner. In basin 43 and 44 some material was removed, approximately 60 cubic yards total from both basins. In all three basins the pipe trench and sump were redone. This trench rework was anticipated as the sump was lowered .5' by ECN W105-88 (4-15-91) after the contractor demobilized from basin grading and the construction of the test fills in December 1990.

Daily inspection records indicate that there were 28 working days between the time when regrading began and the start of soil/bentonite placement in basin 42. Seven of these days the contractor did not work on regrading.

Item 2, Clods in Stockpiled Soil/ Bentonite:

The soil/bentonite material was stockpiled longer than anticipated and some surface drying did occur. However, during this period KEH successfully took action to remoisten and maintain the moisture in the soil/bentonite stockpile using a water truck and fire hoses. In addition, the following activities controlled the introduction of unacceptable material and clods into the soil/bentonite liner:

1. The contractors' operator, loading the soil/bentonite into the dump trucks, would segregate and discard unacceptable material during the loading activities.

2. The contractor had labor personnel removing clods from the material as it was being dumped into the basins.

3. The soil/bentonite was spread into 6 in. lifts with a bulldozer which reduced the size of any clods and mixed the material together.

4. The 40 ton pad foot compacting roller would further break up and remix any remains and completely mix and compact the soil/bentonite.

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INTEROFFICE MEMORANDUM

5. The contractor and KEH inspection personnel were all aware of the requirements for the soil/bentonite and everyone on the project would remove unacceptable material from the basins when found.

6. All compaction test taken on the placed and compacted material met or exceeded the moisture and density requirement.

LAG:tam

ATTACHMENT #3

INTEROFFICE MEMORANDUM

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LAG:tam

KAISER ENGINEERS HANFORD

W-105-126

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

REG. NO. KAISEEH1348M

September 30, 1991

L. R. Tollbom, Project Manager
Effluent Treatment Projects
Westinghouse Hanford Company
P. O. Box 1970
Richland, Washington 99352

Dear Mr. Tollbom:

ADDENDUM TO LETTER OF INSTRUCTION NUMBER 73 RESPONSE

My letter of September 13, 1991 "Westinghouse Hanford Company Letter of Instruction Number 73 Response" failed to address the following:

Issue 3b.) The present construction schedule could result in the installation of liner materials during cold weather, rain or snow, or freezing conditions. The rationale for conditions for working in these environments should be provided. Be sure to address problems related to moisture, and how this problem will be handled when welding the basin liner and cover material.

Response: Installation (handling, placing, cutting and welding) of HDPE or VLDPE liners in cold or wet weather conditions may result in an unsatisfactory product. Therefore, the specification for the C-2 liner contract (section 2755 paragraph 1.5) and the C-8 cover contract (section 2757 paragraph 1.6) require a minimum temperature of 40 degrees F., with wind less than 15 mph and no precipitation when handling (installing and welding) the liners and covers for the basins.

KAISER ENGINEERS HANFORD

W-105-126

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

REG. NO. KAISEEH134BM

September 30, 1991

L. R. Tollbom, Project Manager
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Westinghouse Hanford Company
P. O. Box 1970
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KAISER
ENGINEERS
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W-105-126

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This was an oversight on my part, I hope it did not cause you any inconvenience.

Sincerely,

S. Petersen

S. L. Petersen, Project Manager
Effluent Treatment Projects

SLP:kaw

cc: R. T. French
A. G. Lassila - DOE
G. P. Burchell - WHC

bcc: C. J. Denson
M. E. Witherspoon

FACT SHEET - FIBERCAST PIPING TEST

Fiberglass piping samples were fabricated and tested in the simulated solutions used to perform the 9090 Tests on the LERF liner materials. The results of the tests are reported in WHC-SD-W105-TD-001, and it was concluded that the piping successfully passed the tests. Some degradation was noted in the piping tensile strength and elongation at break, but this was not sufficient to cause any concern about the material's performance for transferring process condensate water from the 242-A Evaporator to the LERF.

The following data and observations are presented to substantiate the above conclusion:

1. The tests were conservatively conducted at 50 C, a temperature much higher than actual planned service conditions in order to accelerate any chemical reactions that might occur. The Evaporator process condensate service temperature average is 27.9 C, and the maximum temperature is 39 C. The rate of the chemical reactions governing the degradation would be controlled by Arrhenius kinetics, although the activation energy associated with these reactions is not currently known. A rule of thumb is that chemical reaction kinetics are doubled for each 10 C increase in temperature.

2. The configuration of the specimen used in the tests allowed the solution to contact both the interior and exterior surfaces of the piping. In addition, the specimens were machined prior to exposure which exposes the fiberglass strands. Normally, the thick epoxy coating on the interior pipe surface protects the fiberglass from the solutions being transported. The fiberglass by itself does not possess the extreme resistance to liquids in contact with it as well as does the epoxy; this is the reason an epoxy coating is provided. This was a recognized factor prior to the tests; therefore the exposed machined surfaces were hand painted with an epoxy coating to protect them from the test solution. The hand coated epoxy may not have been the quality of factory coatings, and it certainly wasn't nearly as thick. We don't have any way of determining whether the hand-coated surfaces provided sufficient protection from the solution. If the solution contacted the machined edges of the specimens, it could travel along the exposed fibers relatively easily. In service, the fiberglass would be protected by the thick epoxy layer on the interior of the pipe. The fact that the tensile strength of the test specimens only slowly decreased, and appeared to be leveling out at about 40,000 psi at the test conclusion, indicates that the degradation was not severe, even though the uncoated outer pipe surface was exposed to the test solution.

3. A key point in concluding that the piping provides sufficient resistance to the test solution is that absolutely no damage was observed to the protective epoxy coating. The interior epoxy layer

is intended to prevent the solution inside the pipe from affecting the fiberglass structure. For this reason, the observed decreases for tensile strength and ductility (elongation at break) were most likely due to artifacts of the specimen design. In order to further substantiate this conclusion, additional tests are planned in which the test solutions will be in contact only with the piping interior epoxy surfaces. Specimens for tensile tests will not be machined from the piping until after the testing in order to make sure that exposed fiberglass is not in contact with the test solution.

4. The actual test duration was a substantial portion of the duration that the piping would be exposed to the Evaporator process condensate during service conditions. The Evaporator will produce condensate at an average flow rate of 49 gpm, and at a maximum flow rate of 60 gpm. The time to fill the 13 million gallon capacity of the LERF basins, as shown on the attached graph, is 184 days and 150 days for these two flow rates, respectively. Thus, the tests were conducted for a time period representing 65% of the actual projected time to fill the LERF at the average flow and 80% at the maximum flow. This long test time in proportion to the actual service time provides good confidence that the piping will provide adequate strength during service for the period that the LERF will be filling. These calculations are based on exposure times at service conditions. Total exposure will be longer since the piping will remain full during shutdown periods, but since the piping will cool to ambient temperature during shutdown, negligible deterioration would be expected during these periods.

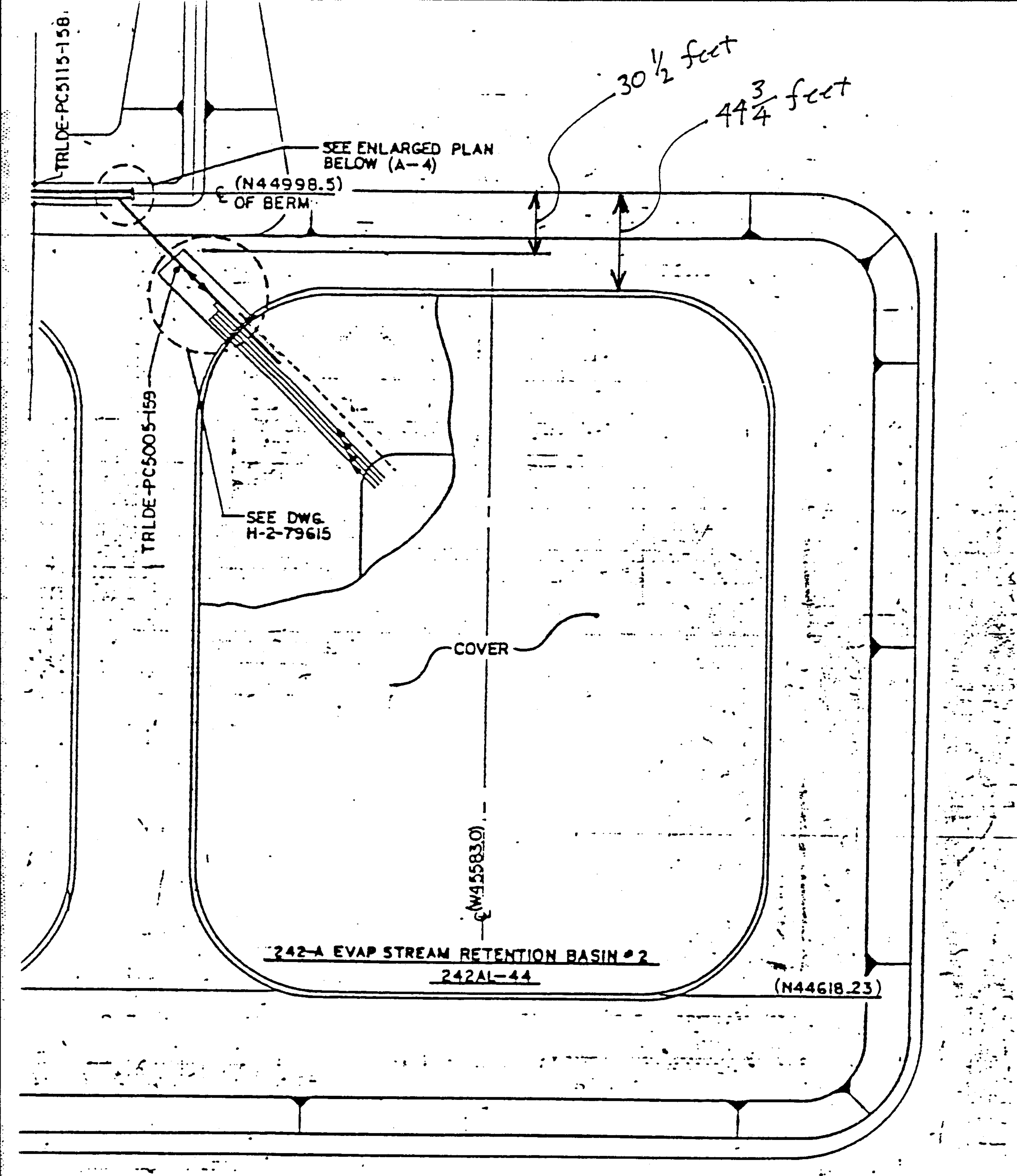
However, on a related but completely different aspect, the test time was short compared to the time the piping would be used for subsequent programs; i.e., when the Evaporator process condensate would be routed to the Effluent Treatment Facility over a subsequent 30-year period. Assuming a 50% TOE, this is equivalent of 15 full years of service. For this reason, WHC has elected to obtain additional data on the piping by conducting the next set of tests. In addition to these laboratory tests, WHC plans on removing actual piping from the Evaporator-to-LERF pipeline during the tie-in for the ETF to obtain data from actual service conditions.

5. The Manufacturer's data show that the 3-inch carrier piping used for transporting the process condensate from the Evaporator to the LERF is rated at 200 psi at a temperature of 225 F (107 C). In comparison the pump discharge head is only 13.6 psi, a factor of 15 less than the rated pressure. Thus the 30% decrease in strength noted during the test is only a small fraction of the available rating and a large excess of strength exists for the service intended.

6. Finally, the carrier piping is installed inside a containment piping. Should an unlikely failure occur, the process condensate would be safely contained. The failure would then be diagnosed as to cause, and a repair or replacement of the carrier piping be made

based upon the diagnosis.

7. In summary, the tensile testing of pipe material was successful in that it provide a conservative measure of susceptibility to environmental degradation. However, the test results may not be directly applicable to the LERF Project because of the higher temperatures employed in the laboratory tests, the specimen configuration which allowed solution to contact the outside and possibly the machined sides of the pipe specimens, and the fact that no discernible degradation of the epoxy layer occurred.



STA 6+42.70
N44999.50
W45757.75

12 X 8 RDCR, ECC SOCKET (FOB)
M17-TYP 2 PLACES

H-2-79610

KAISER
ENGINEERS
HANFORD

W-105-125

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

REG. NO. KAISEEH1348M

September 16, 1991

L. R. Tollbom, Project Manager
Effluent Treatment Projects
Westinghouse Hanford Company
P. O. Box 1970
Richland, Washington 99352

Dear Mr. Tollbom:

KAISER ENGINEERS HANFORD CONCURRENCE PERTAINING TO THE WESTINGHOUSE HANFORD COMPANY INVESTIGATION OF THE STRUCTURAL FAILURE IN THE 8" CARRIER AT 200E LERF BASINS (PROJECT W-105)

References: Westinghouse Hanford Company (WHC) letter #9156556, LOI number 74 dated September 5, 1991.

As requested in the above referenced letter, Kaiser Engineers Hanford Company (KEH) has completed a review and analysis of the WHC investigation of the W-105 8 inch pipe failures.

Kaiser Engineers Hanford Company concurs with the following:

1.) The pipe failures which occurred in the 8 inch carrier pipe, likely resulted from the overpressurization of the containment pipe.

2.) The failures occurred sometime during the hydrotesting of the 8 inch assemblies.

3.) The 8 inch pipe sections in question have been properly repaired and tested.

4.) All 8N12 and 3N6 fiberglass piping currently installed is fit for service.

Please take notice that KEH is scheduled to begin backfilling the two 8N12 pipe sections on September 25, 1991 and that said activities will not negatively impact the basins.

Please contact me at 376-7216 if you have any questions or concerns.

Sincerely,

Stephen Petersen

S. L. Petersen, Project Manager
Effluent Treatment Projects

SLP:kaw

cc: R. T. French
S. J. Bensussen
R. T. Hallum
A. G. Lassila - DOE
G. P. Burchell - WHC
J. J. Sisk - WHC

From: Materials and Welding Engineering
Phone: 3-4156 S2-03
Date: September 4, 1991
Subject: INVESTIGATION OF STRUCTURAL FAILURES IN 8 INCH CARRIER PIPES AT 200E LERF BASINS (PROJECT W-105)

To: L. R. Tollbom (10) R3-30

cc:

L. D. Blackburn LDB	H5-67	W. J. Karwoski (2)	H5-53
G. P. Burchell	R3-30	D. E. Kelley	R1-48
W. C. Carlos	H5-52	D. E. McKenney	R1-48
D. J. Green	H5-53	K. V. Scott	H5-52
L. R. Hall	S1-54	T. S. Vail	R1-43
M. N. Islam	R3-08	R. B. Wurz	S5-14
R. J. Julian (7)	R1-48	JJS File/LB	

INTRODUCTION

On June 20, 1991, the Materials and Welding Engineering group was requested by Project W-105 to investigate two failures that occurred in the Liquid Effluent Retention Facility (LERF) interbasin piping during hydrostatic testing operations. This report documents the results of that investigation.

SUMMARY

Two failures occurred in double containment fiberglass reinforced thermosetting resin pipe that is to be used for transfer of effluent between the LERF basins. The failures occurred in the 8-inch carrier pipes during hydrostatic testing operations for the 12-inch containment pipe, following successful hydrostatic testing of the 8-inch carrier pipe.

The information obtained in this investigation indicates that the external overpressurization of the carrier pipe during some portion of the hydrostatic testing operations is the likely cause of failure. The failure mode is buckling from the excessive external pressure. The pipefitters devised the test equipment and carried out the hydrostatic testing operations with limited field engineering support. The process control package (PCP), by reference to the construction specification, set forth the hydrostatic test requirements which called for equalizing the pressure between the containment pipe and carrier pipe during the test operation. The precise events that led to the deviation from this requirement have not been identified.

The piping assemblies have been repaired and successfully retested using a new hydrostatic test procedure. Fibercast has examined and tested the failed pipe sections and reported that the pipe exceeds the required wall thickness and that the pipe material meets all manufacturing standards. Therefore, the piping assemblies are considered fit for service.

BACKGROUND

The LERF is designed to receive effluent from the 242-A evaporator at the 200 East area. The effluent is to be stored in up to three 6.5M gallon covered retention basins. Double containment fiberglass reinforced thermosetting resin pipe (RTRP) is used to bring the effluent to the basins and to transfer effluent from one basin to another. The pipe is manufactured by Fibercast Company, Sand Springs, Oklahoma, under the product name Centricast III EP.

The double containment pipe consists of a small diameter carrier pipe centered in a larger diameter containment pipe and supported by guides spaced uniformly. The guides are rigidly attached to the carrier but free to slide inside the containment pipe. The containment pipe has risers for the leak detection system that are spaced uniformly along its length. Three-inch carrier pipe in 6-inch containment pipe (3N6) is used to transfer effluent to the basins. Eight-inch carrier pipe in 12-inch containment pipe (8N12) is used to transfer effluent from one basin to another. Each of the two 8N12 piping assemblies are approximately 250 feet long and have 45° elbows at each end. Short sections extend from the elbows toward the basins (see Figure 1).

The carrier pipe and the containment pipe are required to pass separate hydrostatic tests. The carrier pipe is tested at 150 lbf/in^2 (gauge) and the containment pipe at 90 lbf/in^2 (gauge) (see Figure 2). The subject failures occurred in the 8-inch carrier pipes at some point during the hydrostatic testing operations (filling, venting, pressurizing and depressurizing) for the 12-inch containment pipe, following successful hydrostatic testing of the 8-inch carrier pipe (see Figures 3 through 6).

Fibercast Company has been involved extensively since the failures occurred through site visits and examination and testing of the failed pipe sections at their facility. Fibercast's conclusion is that both failures resulted from external over-pressurization of the 8-inch carrier pipe. Consultation with design engineering indicated that their investigation thus far had implicated the hydrostatic testing methods as the cause. This investigation has therefore focused on the hydrostatic testing methods for the double containment pipe.

Major portions of the 3N6 piping were fabricated and tested prior to the 8N12 piping. Therefore, hydrostatic test methods for the containment pipe were initially developed and implemented on the 3N6. Essentially the same methods were then transferred to the 8N12. No carrier pipe failures from external pressure have occurred on the 3N6 piping.

METHOD OF INVESTIGATION

This investigation included the following activities:

- Interviews with key pipefitters and inspection personnel
- Field observations of hydrostatic tests and examination of the piping assemblies and the failed pipe sections
- Review of applicable construction specifications, construction force procedures, and quality assurance procedures
- Review of inspection and hydrostatic test records for the piping assemblies
- Consultation with Fibercast technical personnel, design engineers, and others
- Review of Fibercast design information, factory test data for Centricast III EP double containment pipe, and Fibercast's report on examination of failed pipe sections
- Review of a PNL Library literature search on the subject of failures in fiberglass reinforced thermosetting resin materials

RESULTS AND DISCUSSION

Hydrostatic Testing Operations

Independent interviews were conducted with key pipefitters involved with the set up and conducting of hydrostatic tests on the double containment fiberglass reinforced pipe. Two quality control inspectors involved with the installation of the piping were also interviewed. A compilation of the information obtained in the interviews is attached as Appendix A.

The pipefitter crews devised and set up the hydrostatic test rig (see Figure 2) to meet the general requirements of the applicable construction specification, W-105-C3, and Book 2 of the KEH Construction Force Manual, Procedure CFM 6.1 for hydrostatic tests. The crews also developed their own methods for filling, pressurizing, venting, and depressurizing the piping for the hydrostatic test operations. No engineering sketch or drawing of the specific test arrangement was available. Valve opening and closing sequences were carried out according to past experience and best judgement. This is apparently consistent with construction force practices at Hanford for hydrostatic testing of piping systems. However, most piping applications are of single wall design and prior to the use of fiberglass reinforced pipe, applications of double contained piping at Hanford involved carbon steel and stainless steel piping which are significantly less susceptible to failure from external pressure.

Fibercast Company provides minimal guidance regarding the hydrostatic testing of double containment pipe. The construction specification for the LERF also provided limited information. Section 15493, Paragraphs c, d, e, and f of W-105-C3 briefly address flow limits for filling and draining, verification that air has been vented, prevention of water hammer, and a requirement that the containment pipe (encasement) be 'jumpered' to the carrier pipe to assure that the pressure is equalized between the carrier pipe and the containment pipe during hydrostatic testing. The KEH Construction Forces - Book 2, Procedure CFM 6.1, General Requirements for Hydrostatic and Pneumatic Testing applies for the hydrostatic testing. This procedure references CFM 6.5 for American Society of Mechanical Engineers (ASME) B31.3 applications such as the LERF piping. Both procedures recognize the need for additional provisions to suit a particular job; however, neither procedure specifically addresses the hydrostatic testing of double containment piping. The process control package (PCP), which is intended to provide job control information, also provided limited instructions for hydrostatic testing of the double containment pipe.

Testing performed by the manufacturer demonstrated that an annulus pressure of approximately 34 lbf/in^2 (gauge) is sufficient to cause buckling failure of the 8-inch carrier when it is not internally pressurized. Based on information obtained in this investigation, opportunities existed during the hydrostatic testing operations for exposing the carrier pipe to excessive external pressure.

The filling and pressurizing of the containment pipe continued after noise was heard and pipe movement was observed in the case of both failures. The pipefitters later assumed that the failures occurred at the time of the noise and pipe movement during the filling. However, a subsequent test of the 8-inch carrier (by pressure decay or other method) was not performed in either case after the noise and pipe movement and prior to filling and pressurizing the 12-inch containment. Therefore, a question exists with regard to when the failures actually occurred.

The hydrostatic test rig (see Figure 2) relied on 1/4-inch tubing connected between the carrier and the containment pipes to maintain an equal pressure between the two at all times during filling, pressurizing and venting. Two gauges were used during hydrostatic tests. One gauge was installed at the fill end and one at the vent end on the containment pipe for pressure testing of the 12-inch containment pipe. The gauge at the fill end was assumed to indicate at all times the pressure in both the 12-inch containment pipe and the 8-inch carrier pipe.

Examination of Failed Pipe Sections

Both failed carrier pipe sections had been removed from their installed locations and moved to the pipefitter shop prior to this engineer's examination. Both pipe sections had axially oriented fractures that extended completely through the pipe wall (see Figures 3 through 6). The fracture in the pipe section in Basins 43-44 measured approximately 8 feet 5 inches long and was several inches longer on the inside than on the outside. The fracture extended between two carrier guides but had arrested short of passing through either guide. The fracture from the Basins 42-43 carrier pipe measured approximately 4 feet 5 inches, also being slightly longer on the inside. The fracture extended between a guide and bell type socket joint. The fracture extended to the end of the pipe but did not extend beyond the joint to the bell end section. The joint was separated when observed in the shop (see figure 6). The opposite end of the fracture arrested short of passing through the guide. The exterior fracture appearance was essentially unbranched and identical for both pipe sections. Both interior fractures exhibited branching and areas of delamination of the pure resin layer from the glass reinforced resin outer layer.

The fracture appearances of the LERF failures are similar to fractures obtained in buckling failures caused by external pressure failure tests conducted by Fibercast. Consultation with J. Tillson, Fibercast testing engineer, indicated that the branching of the interior surface of the fracture observed in the pipe sections that failed at Hanford is typical of external pressure failures. He indicated that delamination between the pure resin inner layer and outer reinforced layer is also to be expected. Delamination was observed in both failed pipe sections.

The pipe sections were subsequently shipped to Fibercast for further examination and testing. Fibercast's letter reporting their evaluation, dated July 24, 1991 (see Appendix C), is consistent with the above observations regarding the fractures and takes the position that the cause of failure was external over-pressurization. The letter indicates that the pipe sections exceed the minimum wall thickness requirement. The letter also provides test information that is consistent with the conclusion that the piping material was properly manufactured.

Information provided from a Fibercast engineer present for removal of the failed carrier pipe at Basins 42-43 indicated that the bell type coupling joint (see Figure 6) was still together (pipe end in bell) prior to removal of the failed section. However, the bonded joint had peeled completely around except at one small location near the top where the bond was still intact. The removal operation broke the remaining bond area and the joint separated. The fact that some bonded area remained intact suggests that the pipe end was forced radially inward by the pressure in the containment pipe.

CONCLUSIONS

The information obtained in this investigation indicates that the external overpressurization of the carrier pipe during some portion of the hydrostatic test operations is the likely cause of failure. The failure mode is buckling from the excessive external pressure. However, the precise events that led to the failures have not been identified.

The pipefitters devised the test equipment and carried out the hydrostatic testing operations with limited field engineering support. The hydrostatic test requirements set forth in the construction specifications section 15493 para 3.2.2.2 required that the containment pipe and carrier pipe pressure be equalized. The precise events that led to the deviation from this requirement have not been identified.

The cause of the noise and pipe movement noted by the pipefitters during the filling of the carrier pipe and thought to have been associated with the failures may have been caused by thermal contraction of the carrier pipe within the containment pipe. Movement occurs between the carrier pipe and containment pipe, and between the containment pipe and its temporary supports as a result of temperature change. Thermal contraction results from the temperature change of the carrier pipe as the 50 to 60 °F water enters and begins to fill the carrier pipe which is hot from solar heating. Temperature of the carrier pipe is believed to have been over 100 °F during filling prior to the failures.

The necessary repairs have been made to the 8N12 piping assemblies and both repaired assemblies have been successfully hydrotested using a new procedure. No new failures have occurred. Fibercast's letter reporting their evaluation of the failed pipe sections is consistent with the conclusion that the pipe exceeds the required wall thickness and that the material was properly manufactured. Therefore, the 8N12 piping is considered fit for service.

RECOMMENDATIONS

Improved field engineering support should be provided to the pipefitters, particularly when new technology is involved as in the case of double containment fiberglass pipe. Consideration should be given to development of a modified test rig for double containment fiberglass pipe that would preclude excessive external pressure on the carrier pipe during hydrostatic testing of the containment pipe.

An informal hydrostatic testing procedure for double containment pipe has recently been developed with technical guidance from Fibercast representatives. The new procedure has been used successfully on two occasions since the subject failures, for hydrostatic testing of the LERF 8N12 piping. The procedure is based on isolating the carrier pipe from the containment pipe and maintaining the carrier pipe at a higher pressure at all times during the hydrostatic testing operations. The test rig and valving procedures are somewhat complicated. Therefore, further review and refinement is encouraged as more experience is gained with double containment piping. It is further recommended that the procedure be formalized as a KEH Construction Force procedure. The informal procedure is included in Appendix B.

IMPLICATIONS OF 8-INCH CARRIER PIPE FAILURES ON 3-INCH CARRIER PIPE INTEGRITY

The 3-inch carrier pipe integrity is judged not affected by the failures in the 8-inch carrier pipe. The external pressure rating of the 3-inch carrier pipe is approximately 3 times the rating of the 8-inch carrier pipe because of its greater stiffness. Therefore, the 3-inch carrier pipe is less susceptible to failure by external over-pressurization. Major portions of the 3N6 piping, because of the assembly sequence used, have had both carrier and containment pressurized multiple times. It is estimated by construction forces management that major portions of the 3N6 piping have experienced 6 or more hydrostatic test cycles. No 3-inch carrier pipe failures from external pressure have occurred. The 3-inch carrier pipe will be hydrostatically tested in its completed length when the evaporator and basin final connections are bonded. This will provide additional assurance that the 3-inch carrier pipe is sound.

REFERENCES

W-105-C3, Construction Specification for Piping and Electrical for 242 A Evaporator and Purex Interim Retention Basin, Kaiser Engineers Hanford Company, Richland, Washington, released for construction, August 3, 1990.

Construction Forces - Mechanical (Book 2), CFM 6.1, "General Requirements for Hydrostatic and Pneumatic Testing," June 28, 1990 and CFM 6.5, "Hydrostatic Testing - ASME B31.3," May 1, 1991, Kaiser Engineers Hanford Company, Richland, Washington (see Appendix B).

Letter, W. J. Jones, Fibercast Company, to Ms. Penny Harvey, Kaiser Engineers Hanford, Subject: Kaiser Engineers Hanford (KEH) Purchase Order No. 51874, dated July 24, 1991 (see Appendix C).

"KEH W-105 Hydrostatic Test 8N12," not formalized (see Appendix B).

J. J. Sisk
Materials and Welding Engineering

kjs

Attachments
- Figures 1 through 6
- Appendix A
- Appendix B
- Appendix C

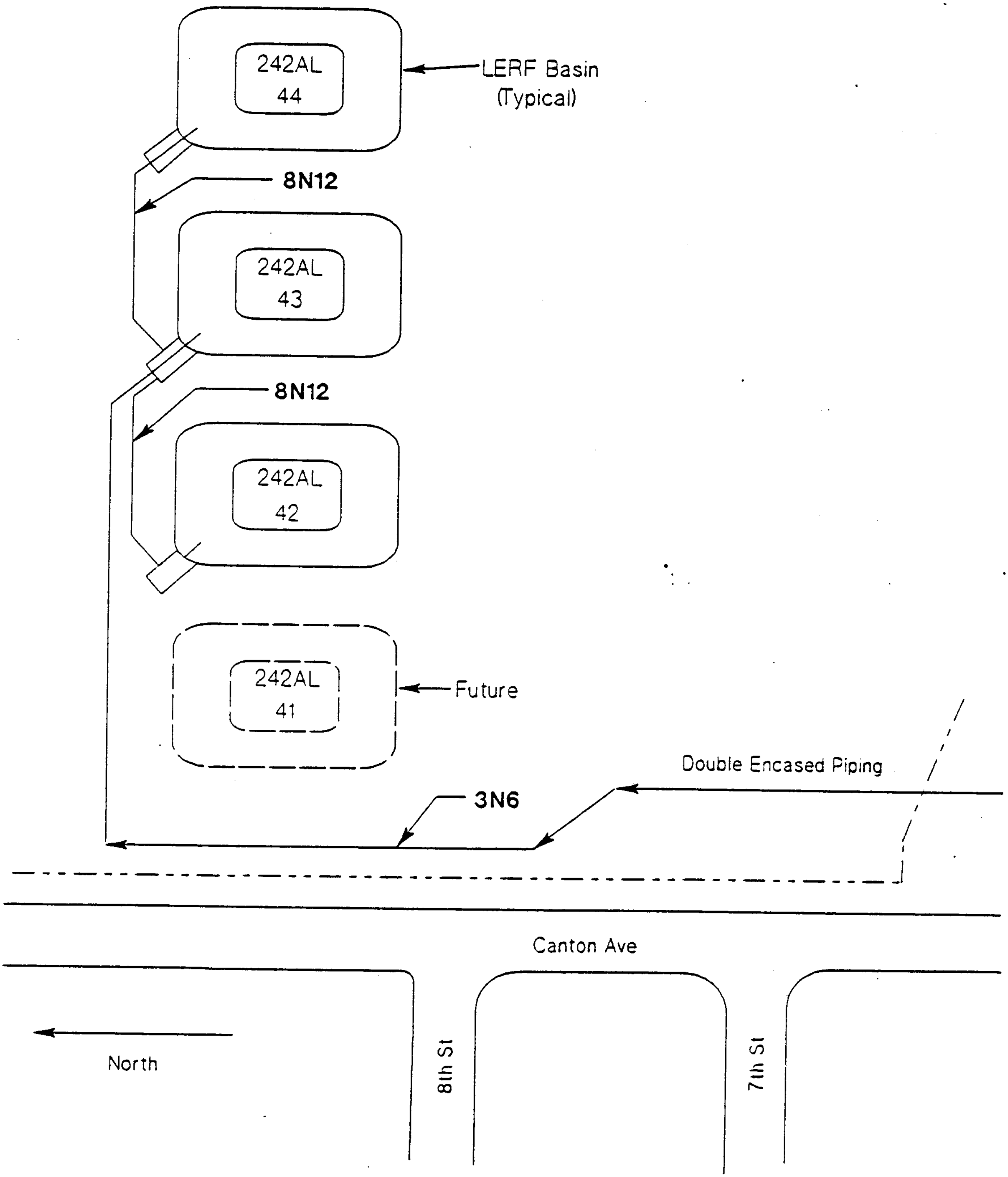


Figure 1. 242-A Evaporator Liquid Effluent Retention Facility (LERF)

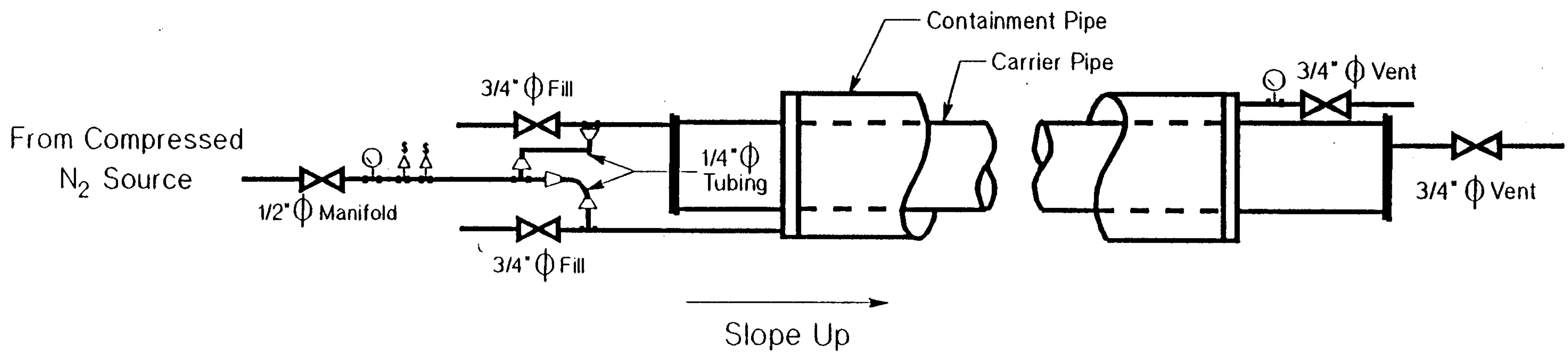


Figure 2
Liquid Effluent Retention Facility
KEH Containment Hydrostatic Test Rig
(Not to Scale)

Figure 3. Failed Section of 8-Inch Carrier Pipe at LERF Basins 42-43 Prior to Removal

Figure 4. Failed Section of 8-Inch Carrier Pipe from LERF Basin 42-43

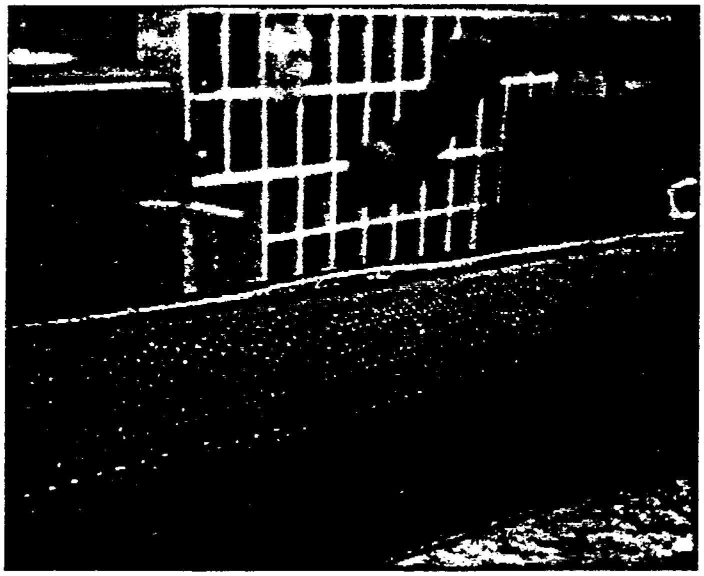


Figure 5. Failed Section of 8-Inch Carrier Pipe from LERF Basins 42-44 (Near Side)

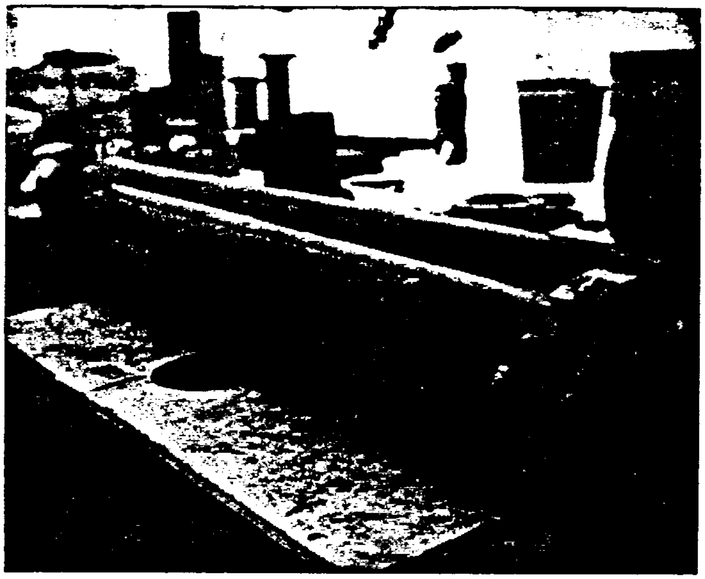
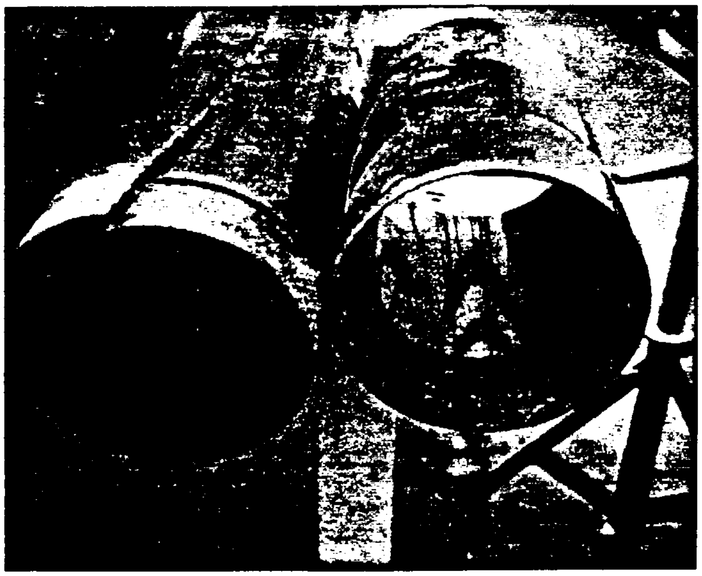


Figure 6. Failed Section of 8-Inch Carrier Pipe from LERF Basin 43-44, Bell Type Coupling



APPENDIX A

Interviews with Pipefitters and Inspection Personnel

Independent interviews were conducted with key pipefitters involved with the set up and conducting of the hydrostatic tests on the double containment fiberglass pipe. Two quality control inspectors involved with the piping were also interviewed. The following is a compilation of the information obtained.

Service Water Supply

Service water for all hydrostatic testing was brought by hose from a hydrant near the 242-A Evaporator. Final hose size to the basin piping was 3/4-inch diameter. Water pressure at the job site varied from approximately 65 lbf/in^2 (gauge) to 160 lbf/in^2 (gauge) depending on system demand from other users. The water supply was common for all hydrostatic tests.

3N6 Assembly and Hydrostatic Testing

The double containment piping is pre-assembled in 40 foot lengths from the factory. In the field, the 3-inch carrier pipe is bonded first and then the 6-inch containment pipe is bonded except that slip collars remain unbonded. Slip collars in the 6-inch containment pipe allow access to the field bonds in the 3-inch pipe for the observation of those joints during the hydrostatic test. Following the successful hydrostatic testing of the 3-inch carrier pipe, the 6-inch containment pipe is bonded together at the remaining joints.

The 3-inch carrier pipe was filled in preparation for the hydrostatic testing of the 6-inch containment pipe. The fill point was at the low end of the sloped pipe run to be tested and the vent was at the high end (see Figure 2). Runs are quite long so radio communication was used to coordinate opening and closing of valves at each end of the test section. The vent valve was closed off immediately after the fill valve was closed but while the vent valve still had a solid stream of water. Filling of the 6-inch containment pipe was then initiated. Test risers in the 6-inch containment pipe were open when filling. As water spilled from each riser beginning at the fill (low) end, the cap was clamped tight. The last riser was at about the same elevation as the vent. There was some doubt as to whether the 6-inch containment vent valve was closed first or the fill valve closed first. Best memory was that fill valve was closed after the vent valve was closed.

The standard practice was for the pipefitters to perform information leak tests prior to formal hydrostatic testing. Test pressure for the 6-inch containment pipe was achieved by pressurizing with the service water and then pressurizing with compressed N2 to obtain the required 90 lbf/in^2 (gauge) test pressure for the informational check by the pipefitters. In some cases, the service water pressure alone may have been used for the information test. The test rig was fully connected (see Figure 2) for all informational and final hydrostatic tests of the containment pipe. Pressurizing with N2 generally took about 5 to 10 minutes. The pipefitters would then examine the chalked joints (a chalk solution was painted on the joints to show water leakage). When assured the joints were leak free, the inspectors were contacted to witness the formal hydrostatic test, normally that same day.

At completion of the test, the vent valves were opened. It was not clear whether the 3-inch carrier pipe and 6-inch containment pipe vent valves were opened simultaneously or if one before the other or, if so, which would have been opened first. The fill lines were then allowed to drain.

8N12 Assembly and Hydrostatic Testing

Basins 43-44

The 8-inch carrier pipe between Basins 43-44 was assembled first in the same manner as the 3N6. The informational test on the 8-inch carrier pipe was performed with service water pressure only and no leaks were found. The formal hydrostatic test was performed and witnessed later that day. No leaks were found. The line was drained and a second crew began assembly of the 12-inch containment pipe at Basins 43-44. The first crew began fabrication of the 8-inch carrier pipe at Basins 42-43.

The piping at Basins 43-44 was completed by the second crew and filling of the 8-inch carrier pipe was commenced by one pipefitter. Approximately 1 hour into the 8-inch carrier pipe fill a loud noise (described as a "woompf") was heard coming from the piping assembly and a sudden up and down movement of the piping was felt by the pipefitter who had been sitting on the pipe. The fill was continued until a solid stream of water was observed coming from the 8-inch carrier pipe vent. Time estimates for filling the 8-inch carrier pipe ranged from 3/4 to 1-1/2 hours. The pipefitter walked over and throttled back the fill valve and then walked down and closed the vent valve and returned to the fill end and closed the fill valve.

The fill hose was moved to the 12-inch containment pipe and filling initiated. The fill valve was throttled back after water was observed spilling out the lowest riser. The fill valve was maintained in throttled position as each riser spilled water and was capped tight. The vent valve was closed and the pipefitter returned to close the fill valve when a leak was observed in the 45° elbow at the fill end. The leak was in a factory bond and was a slow, air and water leak. The pipefitter then closed the fill valve. No N2 gas pressure had been placed on the assembly. Other pipefitters were called over to observe the leak. The hydrostatic test was called off and later that day the assembly was drained. Vents were opened first but it is not clear whether the 8-inch carrier pipe or 12-inch containment pipe vent was opened first. It was indicated that probably the 12-inch containment pipe vent was opened first. Four or five days later, filling of the Basins 43-44 assembly was again commenced in order to allow the inspectors and others to observe the leak in the 45° ell. Water was observed in the 12-inch containment pipe through a riser approximately 1/2 hour after the start of 8-inch carrier pipe fill. At that point it was recognized that the 8-inch carrier pipe had been breached. The fill was continued to completion and the assembly was pressurized to approximately 90 lbf/in^2 (gauge) to observe the 45° elbow leak. The assembly was drained. The breach in the 8-inch carrier pipe at Basins 43-44 was located and the failed section was removed.

Basins 42-43

The 8-inch carrier pipe at Basins 42-43 was completed, hydrostatically tested, and no leaks were found. The 8-inch carrier pipe was drained and final assembly of the 12-inch containment pipe began. Filling of the 12-inch containment pipe was commenced in preparation for the containment leak test following its assembly. Approximately 1/2 to 1 hour into the filling of the 8-inch carrier pipe a noise and pipe movement was heard essentially the same as that heard on the 8-inch carrier pipe fill at Basins 43-44. The noise and movement was assumed at the time to be the 8-inch carrier pipe adjusting to changing thermal conditions. Filling of the 8-inch carrier pipe was completed. The vent valve was closed and then the fill valve was closed. No other unusual conditions were noticed. It was later assumed by the pipefitters that the noise and pipe movement on both occasions was caused by the failures.

The fill line was moved to the 12-inch containment pipe and filling was carried out as in the assembly at Basins 43-44, except that both pipes were rechecked for air in the following manner after filling was completed. The fill valve on the 8-inch carrier pipe was opened first then the vent valve was opened. The same action was taken on the 12-inch containment pipe. However, both vent valves may have been opened at the same time. There was some doubt as to exact sequence. The containment pipe was pressurized to the 90 lbf/in^2 (gauge) test pressure for an informational leak test. No leaks were found. The inspectors witnessed the formal hydrostatic test and the assembly was accepted the same shift. The piping was drained. Construction forces management determined that the 8-inch carrier pipe should be filled for a retest because of the failure found in the carrier pipe at Basins 43-44. Filling was commenced and a breach was discovered in the 8-inch carrier pipe at Basins 42-43 after observing water through a riser in the 12-inch containment pipe. The failed section was located and removed.

APPENDIX B. KEH PROCEDURES

CFM 6.1 General Requirements for Hydrostatic and Pneumatic Testing

CFM 6.5 Hydrostatic Testing - ASME B31.3

QA 11.0 Leak/Pressure Test Inspection

KEH W-105 Hydrostatic Test 8N12 (not formalized)