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Critical Analysis Team Report
on
Accelerated Waste Retrieval Final Design
and Fixed Price Contracting

CAT Report #19

30 January 2001

The CAT has conducted a brief review of the following Accelerated Waste Retrieval (AWR) documentation: Systems Design Descriptions; Reliability, Availability, and Maintainability Analysis; Final Design Report; and Failure Modes and Effects Analysis. The CAT understands that these documents represent the final design for AWR.

The CAT does not intend to issue a lengthy set of detailed comments at this time. In general, the design documentation provided by Foster Wheeler is adequate. Although the CAT has multiple comments on the documentation, we do not recommend Foster Wheeler spend a great deal of time and effort on reworking the documentation.

Failure Modes and Effects (FMEA) and Reliability, Availability and Maintainability (RAM) Analyses Comments.

In general, the FMEA and RAM analysis are useful in developing an understanding and resolving process issues. However, quantitative/mathematical analyses (e.g. 98% availability of a particular component) are not bounded by practical experience. As a result, these quantitative analyses are not particularly useful or meaningful. Following are more specific comments on this issue:

1. RAM, Page 5: Using "library component failure rates" probably will not be applicable to AWR because of operations in a humid, radioactive, corrosive, and erosive environment. In addition, quantitative RAM analysis are not particularly useful for the reasons indicated below.
2. RAM, Page 7: The CAT is unclear how the administrative and equipment replacement times were predicted. In general, the replacement times appear extremely optimistic. These time periods are generally many times higher for DOE than for commercial industry due to administrative oversight, approval procedures and personnel requirements—in short, replacement activities at a DOE site take place in a zero-risk environment.
3. RAM, Page 10: Two different methods are used to calculate failure rates and identify failure prone components. The two methods identify different failure-prone components. The CAT is unclear as to which results Foster Wheeler has chosen to use and why.
4. RAM, Page 10: Applying "engineering insight" to determine failure rates and identify failure prone components is subjective and probably not reliable or defensible. If this

method is used, personnel experienced in DOE projects (preferably, Fernald projects) should be consulted and such consultation should be documented.

5. If an EMMA failure occurs, how long will be required to extract EMMA from the silo and then reinsert EMMA into the silo?
6. RAM, Page 11,13: The availability factors for EMMA are unrealistically optimistic. Given the one-of-a-kind, relatively complex design and application of EMMA, it is unlikely that the assumed availability factors will be achieved. Analytical studies are generally optimistic. This is especially true in EMMA's case since all of EMMA's systems are not included in the analysis, limited operations experience exists for EMMA, and the assumption is made that repairs can be performed outside normal operating times.
7. RAM, Page 14: The assumption that the EMMA mast will not fail is risky given the stated importance of this item. With the size, weight, design, and movement of the mast, a failure of some sort is likely.
8. RAM, Page 14: The FMEA and RAM analyses appear to rely heavily upon preventive and predictive maintenance. The CAT is uncertain how preventive and predictive maintenance can be translated into failure rate calculations, as well as how such maintenance reduces failure rates.
9. RAM, Page 15: The RAM analysis refers to an EMMA support system as having "failure modes that are undetectable." The RAM analysis (or FMEA) should have an analysis of the consequences of an undetected failure for these components.
10. RAM, Page 15: Manufacturers' data is utilized to justify the assumption that components will not fail within the forecast life of the project. Manufacturers' data may not be accurate or applicable to AWR situations. Data based on actual experience with, or use of, the components would be more reliable. In addition, the RAM analysis should at least fully consider the consequences if components fail despite the estimated low probability of failure.
11. RAM, Page 15: The RAM analysis states that the, "Ultrafiltration system on-stream time may be enhanced with additional maintenance during normal facility shutdowns." How would such enhancement be accomplished and what are the additional maintenance requirements? This appears to be a case in which the text is glossing over potential problems.
12. RAM, Page 17: It appears that the mean time to failure and repair calculations are extremely optimistic. Actual experience will likely result in showing equipment failures much sooner than predicted. Repair activities will likely require much more time than the analysis estimates.
13. The CAT is uncertain how human error has been factored into the RAM and FMEA analyses. Human error may likely be the most frequent cause of remote equipment failures and should be more fully analyzed.

Other Design Comments

1. The CAT review identified multiple areas where the systems design descriptions are inconsistent with the design (P&IDs). This may reflect a lack of adequate squad checking prior to release of the documents.

2. The FMEA analysis refers to jet pumps needing specific attention to water quality in order to prevent erosion/corrosion. The CAT agrees with this concern. In addition, jet pump erosion/corrosion will be trivial in comparison with the erosion/corrosion potential in the high pressure piston pumps. There is no indication that Foster Wheeler has taken any action to study and, if necessary, resolve this issue.
3. It appears likely that lifting or lowering EMMA, the sluicing nozzle, or the slurry pump within the tower will be classified as critical lifts. Fernald site procedures indicate that critical lifts require three people (person in charge, rigging representative, and experienced operator). Because of this, Foster Wheeler should consider analyzing these lifts.
4. The CAT cautions Fluor Fernald to ensure that its final design review is comprehensive and organized to produce a timely, complete review to Foster Wheeler.

The use of the slurry line cleanout to unplug a slurry line is briefly described in the system descriptions. However, it is not sufficiently detailed and the design does not demonstrate adequate containment and protection of personnel and the environment. As is noted below, The CAT has previously recommended a mockup and demonstration of the equipment and procedures to unplug a slurry line. In addition, such mockup and testing will be useful for training.

In addition to the above comments, the CAT offers the following comments based on previous CAT input concerning bentonite and ultrafiltration issues:

> *...the CAT was hopeful that the (bentonite settling) tests would also include a piping loop to determine the pumping characteristics of the bentonite and understand the process control of the slurry system. Currently, the test plan does not include such a loop.*
>
> *The CAT has not seen a test plan for the ultrafiltration process. Because of the importance of ultrafiltration in providing clean flush water, the CAT recommends that testing to confirm filtration performance be completed.*
>
> *Recommendation 14-2: FDF should complete (or have FW complete) a pump test loop to determine the characteristics of bentonite in the slurry system as well as the ultrafiltration performance.* (CAT Report #14, 28 February 2000).

In the latest documentation, it does not appear that the bentonite issues have been resolved. The previously recommended testing is still needed.

Because EMMA is being used primarily for heel removal, wall washing and fixative application activities, the CAT made the following recommendation in 1999:

An approach that eliminates EMMA would have the potential to reduce risks, reduce costs, and increase reliability. The Foster Wheeler Value Engineering Study (Document 624-P622-43; recommendation SWRS-2-8) recommended considering other technologies for heel removal. The CAT recommends that, concurrent with definitive design work, a value engineering study be conducted to determine a more practical heel and discrete object removal approach that does not require EMMA and the EDT (CAT Report Number 13,17 November 1999).

The CAT has also been concerned about wastewater management. Below are past comments of the CAT which remain valid:

Cation concentrations should be included on the Process Flow Mass Balance to better understand potential water treatment needs. Because cations are not currently included in the mass balance, it cannot be determined whether the effluent will meet AWWT requirements.

It is not clear that Foster Wheeler had adequately considered secondary waste issues. The bentonite stream and the AWWT are examples.

The CAT remains concerned about assumptions in the silos project concerning AWWT. If AWWT and its requirements are not given full consideration, it could quickly become a constraining factor in AWR or Silos 1 and 2 treatment (CAT Report Number 13,17 November 1999).

The CAT has raised concerns in the past about the operational aspects of EMMA. It does not appear that the RAM analysis nor the Failure Modes and Effects Analysis sufficiently address CAT concerns. Following are the two important needs that the FMEA does not address sufficiently:

A comprehensive analysis of potential in-tank accidents and recovery needs to be completed. This is particularly important given the technical risks associated with EMMA. Consideration should include retrieval of a damaged and/or immobilized EMMA.

Time and motion studies need to be completed for worker activities in the EDT. The RAM analysis that is going to be complete must be 'hands-on' oriented, not analytical. This RAM should also be realistic about how much a worker can *accomplish in a given time period under these working conditions* (CAT Report Number 13,17 November 1999).

Lastly, the analyses do not adequately consider off-normal events. These are important as many projects have failed due to inadequate planning in this area.

Fixed Price Contracting Issues for both AWR and Silo 3

The CAT is concerned with the extent of Fluor's review and approval ("sign and stamp") process for the AWR contract. The CAT cautions Fluor Fernald to ensure that it does not take *de facto* ownership of the design through its review process.

The failure of the Silo 3 contract provides learning opportunities for the AWR project. Apparently, one of the prime concerns of the Silo 3 contractor was the requirement to use Fluor Fernald's workforce for project labor under the fixed-price contract. AWR is vulnerable to a similar contractor concern. To ensure that the labor requirement does not result in inordinate claims, Fluor Fernald and DOE should investigate alternative contracting mechanisms to establish and maintain an effective, efficient project.

The resolution of the Silo 3 contract dispute and Fluor's new Fernald site contract provide Fluor with new opportunities to better control, manage and perform work. However, Fluor and DOE should understand that the advantages of these recent changes are balanced by distinct disadvantages. Some of these disadvantages include:

1. The Site contract is fixed price, and any changes to the agreed upon scope baseline must be negotiated between Fluor and DOE. All future actions and activities will be bound by the agreed upon and documented scope, schedule and cost baselines.
2. Self performance of silos activities places more responsibility upon Fluor in the area of project management practices and principles. Tracking, managing and reporting activities that were previously the responsibility of a subcontractor become Fluor's responsibilities. As a result, different skills are required as well as added attention to baselines and performance.
3. Fluor Fernald and DOE must develop a more businesslike relationship. Out of scope work requests must be discussed, understood, negotiated, approved and implemented through a contract modification.

Recommendations

Recommendation 19-1: Fluor Fernald and DOE should investigate alternative contracting mechanisms to ensure the AWR project will move forward effectively and efficiently.

Recommendation 19-2: Fluor Fernald should aggressively pursue the planned meeting with Foster Wheeler to identify, discuss and resolve issues pertaining to EMMA's cost, operability, reliability, and maintainability.

Appendix 1, CAT Report #19

Additional EMMA Issues

Over the last two years, the CAT has developed a long list of concerns with the EMMA system (see CAT Reports #13 and #14). The following list adds to these concerns and questions based on the systems design description document. These questions and concerns should not be considered as formal comments on the AWR final design documentation. Rather, they represent areas of interest the CAT would like to pursue during the Grey Pilgrim tour and the EMMA Technical Transfer meeting in March.

1. Is EMMA capable of deploying sluicing/retrieval equipment: flexibility, degrees of freedom; required angles of operation; and particle, spray and mist environment?
2. The ability of EMMA to force waste and debris away from the sluicing pump is questionable (systems design description, page 1). Can the water jet be accurately aimed so that the arm, end effector, pump, discharge pipe, hoses, instruments, leads are fee of risk?
3. How many simultaneous tasks can EMMA perform?
4. Is there a procedure for clearing the wall-mounted sampling ports?
5. How does EMMA perform some of the indicated tasks without hand, fingers, clean water supply, air supply, wipe technique?
6. What is the relationship between the arm, end effector(s), movement, capacity, capability?
7. Will the fixative have any impact on any components of EMMA, e.g., sticky, gummy?
8. How is the GEES attached to the arm and remain attached?
9. Many of EMMA's operations are going to require excellent visibility. How will this be assured and/or achieved?
10. How much time does Foster Wheeler visualize for training remote operators?
11. How many EMMA's and associated support devices have been built and deployed in similar operating conditions? What were the results?
12. What is the distance from EMMA's entry port to the corners of the silo?
13. Two degrees of freedom provide limited capability to rotate, touch, and move in and out.
14. EMMA has very little dexterity.
15. How does the EMMA operator and the cannon operator communicate in real time?
16. Will there be separate operators for EMMA, water cannon, pump, utilities, HVAC, and product transfer system?
17. Is the 1,000 hours before failure based on experience, vendor information or mathematics?
18. Has a time and motion study been completed to evaluate time to repair failures? Including the number and types of personnel required, tools and materials required, and radiation exposures.
19. How were personnel fatigue factors included in EMMA operating projections? Have there been any communications with FF operations or maintenance personnel?

20. What is the anticipated retrieval non-operating period per day? Can EMMA function with a failure until a non-operating period occurs?
21. What training is going to be provided to FF operators and maintenance personnel? How realistic will the training be? Will TV be involved?
22. Between the local control station and the remote station, which has control and how is this determined/verified?
23. What type of sensors are being provided, and how do they work? Accuracy, lifetime, operating experience in the silo environment, replacement, repair?
24. How large is the designated safety space by the wall?
25. What are the additional safety systems and what do they do? Basis of operation, operator requirements, arm restrictions/limitations, lifetime of each additional safety system?
26. What is the effect on temperature of the in-tower lights? It will be an enclosed space with added restrictions. In an emergency situation, how will a person be evacuated from the tower? What if the person is hurt or disabled? What does PG 3 mean? Have the FF operations and maintenance personnel reviewed the tower design?
27. What would a lightning strike do to people, instrumentation, equipment, process systems (especially HVAC) that are located in the tower at the time of the strike?
28. What does PG 4 mean?
29. How do the elastomer couplings withstand grit, wear, radiation? Where are these couplings located and how are they repaired or replaced?
30. How are the EMMA cables protected from wear, especially that which may result from grit?
31. How is a cable replaced; how long does it take; how many and what type of personnel; tools; and equipment are required? What is the weight and length of the longest cable?
32. What is the weight and length (dimensions) of the largest components of EMMA? Has a time and motion study been performed to assure the largest items can be easily and quickly removed from the tower? Have removal paths been identified? Storage, transportaion, and removal areas must be defined.
33. How does an average, older, smoking worker get to the top of the tower without collapsing, not even considering doing some work and then getting down?
34. What will the ability of women to work on EMMA, especially inside the tower?
35. Is claustrophobia going to be a problem in the tower?
36. What is the process and possible hazards of folding floors that are raised and lowered with hand winches?
37. What is the process for changing control stations; how is the controlling station indicated; how is inadvertent transfer of control avoided?
38. Have any tests been done with the protective shield of its ability to withstand washing and spraying?
39. How is control system hardware and software access controlled? Is the remote software under change control? Who has the authority over the software and what is the process for altering software?
40. What does "remote sensing" mean?
41. How are the in-silo detectors accessed for maintenance, changeout?

42. The air flow is 250 cubic feet per minute for the tower, the sluicer module, and the slurry module. This will result in very low—basically stagnant—airflow through the tower. This air flow will not meet radioactive area air flow requirements.
43. Is the EMMA winch in the top of the tower a single failure point?
44. Do the various winches have inching capability?
45. In case of cable failure, is there a fail safe breaking system to prevent dropping a load?
46. Where are the controls for the Z-drive and the maintenance crane? If they are at the base of the tower, will the operator be able to see the crane from the control point?
47. Are all controls capable of being locked out?
48. Is the tower air flow sufficient to maintain working temperatures in winter and summer?
49. When EMMA is extracted will there need to be a person (monitor) at each floor in the tower?
50. What is a "ladder safety climb"?
51. How does a maintenance person pull a 90 foot long breathing air up the 90 foot tower?
52. Can maintenance or operations personnel be on the entry floor of the tower when others are working overhead?
53. How many individual cables are there associated with EMMA, the tower, winches?
54. What is the pressure of the hydraulic fluid when that system is in operation? Is this a safety issue?
55. If the actuation package is 8 ft in diameter and the tower 12 ft in diameter, the maximum clear space is a 2 ft annulus.
56. What is required to replace the support bearings?
57. What is the "other special tooling"?
58. What is the weight of the GEES and the ADSS?
59. Will there be any problem with material galling?
60. How are the hatches attached; captive nuts and bolts?
61. The elastomer couplings need to be tested under field conditions and under a 200 pound load.
62. Can all connects and disconnects be done remotely? If not, how are the end effectors changed?
63. If pinching occurs, doesn't that limit the ability to bend segments?