U.S. Department of Energy
Office of River Protection
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03-WEC-018

APR 21 2003

Mr. R. F. Naventi, Project Manager
Bechtel National, Inc.
2435 Stevens Center
Richland, Washington 99352

Dear Mr. Naventi:

CONTRACT NO. DE-AC27-01RV14136 – SUBMITTAL OF U. S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT FOR BECHTEL NATIONAL, INC. (BNI) MATERIAL SELECTION PROCESS

This letter forwards the report of the ORP Design Oversight of the BNI Material Selection Process. This Design Oversight was conducted as part of ORP's monitoring of design products and design overviews under Contract Deliverables 3.5 and 3.9. The objectives of this oversight were to (1) identify and understand the BNI requirements for selection of materials of construction for Waste Treatment and Immobilization Plant (WTP) Structures, Systems, and Components considering the corrosive, erosive, and radiation environments to which the materials will be exposed; (2) understand the technical bases for these requirements and confirm that the technical bases are definitive and supported by substantive analysis, testing or experience; and (3) identify and confirm the effectiveness of the process applied to control the implementation of these requirements.

The Oversight Team has determined that the BNI material selection process includes the necessary elements and structure, including external review, for effective selection of materials for the WTP. The Team also determined that the Corrosion Evaluations, which are the principal products of the material selection process, are very comprehensive, well documented, and include the elements necessary to document the bases for selection of materials for each WTP component.

The Team raised issues, however, with certain of the interfaces between the material selection group and the balance of the BNI engineering organization. The more significant of these issues concern whether bounding chemistry conditions are being provided for use in the corrosion evaluations, how BNI is ensuring that all actions that were identified in the main body of the corrosion evaluations are being documented, and how process requirements and limitations that are assumed in the corrosion evaluations are identified and tracked to implementation in the design of the plant and in developing maintenance and operating procedures.

The Oversight Team met with cognizant BNI personnel on April 7, 2003, to present the results of the review and submit a preliminary draft of this report for review and comment. The attached report includes resolution of general BNI comments on the preliminary draft.

It is not necessary for you to respond to this letter. The prior discussions between the oversight team and BNI engineering management and actions taken by BNI and ORP to track open issues are adequate to define the path forward to address the issues raised in this report.

If you have any questions, please contact me, or your staff may contact William F. Hamel, Director, WTP Engineering and Commissioning Division, (509) 373-1569.

Sincerely,

Roy J. Schepens
Manager

WEC:WFH

Attachment

cc w/attach:
S. Piccolo, BNI
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U.S. Department of Energy, Office of River Protection

Waste Treatment Plant
BNI Material Selection Process
ORP Design Oversight Report

D-03-DESIGN-001

April 2003

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Executive Summary

The Office of River Protection (ORP) staff and technical contractor support staff has conducted a Technical Design Oversight of the Bechtel National, Inc. (BNI) Material Selection Process for the Waste Treatment and Immobilization Plant (WTP). The objectives of this oversight were to:

(1) identify and understand the BNI requirements for selection of materials of construction for process vessels, piping, piping system components, and other facility structures considering the corrosive, erosive and radiation environments to which the materials will be exposed,
(2) understand the technical bases for these requirements and confirm that the technical bases are definitive and supported by substantive analysis, testing or experience, and
(3) identify and confirm the effectiveness of the process applied to control the implementation of these requirements.

The approach and bases for the BNI Materials Selection Process are defined in the BNI Material Selection Report (24590-WTP-RPT-M-01-001). Figures 1 and 2 in the main body of the report, prepared by the ORP Oversight Team and BNI personnel from the Materials Selection Group, depict the principal elements, interfaces and the flow of information and data of the process. The Material Selection Report also includes some guidance on the types of materials recommended for use in specific chemistry and operating environments. The principal bases for material selection, however, are contained in industry references on material selection and corrosion and erosion mechanisms contained in this document. These references are the fundamental bases used in the Corrosion Evaluations (CE) that document the recommendation of a material for a specific application. The Team has determined that this process includes the necessary elements and structure, including external review, for effective selection of materials of construction for the WTP.

CEs are the output documents of the Material Selection Process. These evaluate candidate materials for specific applications considering the chemical environments and relevant operating conditions and recommend a material for that application. These evaluations may also include operating and maintenance limitations that were assumed in the evaluation to assure long term corrosion and erosion resistance of the selected material. These CEs are transmitted to the Design and Operating organizations for consideration in completing the plant design, developing component specifications and developing plant operating and maintenance procedures. The Team has determined that the CEs include the necessary elements to document the rationale for selection of the material of construction for the WTP Systems, Structures, and Components (SSC).

The Team raised issues, however, with certain aspects of the interfaces between the Material Selection Process and the balance of the BNI Engineering Organization. The chemistry and applicable operating conditions that are the inputs to the CEs are provided by Process Engineering in the form of Material Selection Data Sheets (MSDS). The Team questions whether the steady state material balance runs that are used by Process Engineering to develop the MSDSes include the most corrosive environments to which the components may be exposed during the life of the plant. The Contract requires that the plant be designed for a 40-year design

life, that BNI ensure that the waste characteristics used in the plant design process are representative of the actual tank waste, and that the plant be designed to process all waste envelopes. The plant design process must also consider dynamic effects during plant operation. The concern is that the CEs may not be considering bounding chemistry and fluid conditions. Accordingly, inappropriate materials may be recommended and that could lead to material integrity problems over the long term. The Team recommends that BNI confirm that the information provided to the Materials Selection Group bounds the expected process conditions anticipated over the design life of the plant.

Several CEs were reviewed in the course of this evaluation. The CEs reviewed are very comprehensive and detailed in the evaluation of several potential corrosion and erosion mechanisms. However, inconsistencies were noted in the review of some of the CEs. These include failure to consider aspects of the component operation that may affect selection of the material and identification of concerns that are not reflected in the detailed discussion of the rationale for selection of the material. Also, open issues and process and operations limitations identified on the front sheet of the CEs were not always consistent with the detailed discussion in the body of the report. The concern is that key assumptions or conditions that were made in the material selection process may not be carried forward in the design or operating and maintenance procedures, if the cover sheet is not complete and accurate. [BNI indicates that some of these inconsistencies are due to the evolving understanding of the waste process chemistry as the design of the plant progresses.] The Team recommends that BNI determine what steps are necessary to ensure that these evaluations consider all factors that could affect the selection of materials and that all assumptions, requirements and limitations identified in the evaluations are clearly identified. In this regard, BNI should also confirm that, as the design progresses and more information becomes available on process chemistry conditions, the original bases for material selections will be re-evaluated along with the need to conduct testing to supplement available information on the corrosion/erosion behavior of the selected materials for those conditions.

As noted, the CEs make assumptions or establish limitations (e.g., assumption that certain piping systems will be flushed with water after each use) that affect plant design, operation and maintenance. The Team was not able to determine how these requirements and limitations are captured for incorporation in operating and maintenance procedures. The concern is that these requirements will not be implemented if there is no formal mechanism to track them to completion. Failure to implement these requirements may have an adverse impact on the integrity of the material over the long term. The Team recommends that BNI confirm that there is a formal process to track these requirements and limitations and that the process is functional.

Table 1 of the main report summarizes these and other open issues identified by ORP in this oversight and recommendations for their resolution. The ORP oversight Team met with cognizant BNI personnel on April 7, 2003 to present the results of the oversight and submit a preliminary draft of this report for BNI review and comment. This final report includes resolution of general BNI comments on the preliminary draft. ORP will track disposition of significant open issues from this oversight through the Consolidated Action Reporting System (CARS). ORP will confirm appropriate closure of these issues as part of the continuing technical oversight of WTP design development.

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1.0 INTRODUCTION

A Team comprised of personnel from the ORP WTP Engineering and Commissioning Division and support consultants performed an oversight of the process used by BNI to select materials of construction for the WTP over the period February 5, 2002, through April 4, 2003. The scope of this oversight included the methods and bases for selection of the materials of construction for process vessels, piping, piping system components, and other facility structures (e.g., ducting, wall liners and coatings). The purposes of this oversight were to:

- Confirm that the BNI design process effectively addresses all factors required by Contract requirements in selection of materials of construction to ensure long-term operability and optimal life cycle cost of the WTP, and

- Continue to monitor the BNI design process to facilitate ORP oversight and, where appropriate, influence of BNI design products and design overviews, in accordance with Deliverables 3.5 and 3.9 and related provisions of the Contract.

The oversight included review of applicable documentation and discussions with BNI Material Engineering Technology, Process Engineering and engineering managers as summarized in the Oversight Plan [1]1.

2.0 BACKGROUND

The selection of materials of construction for process vessels, process piping, shielded cell surfaces and ventilation ducting is driven by the expected service duty for these components and other applicable requirements specified in the WTP Contract. In addition, the materials must be selected to meet structure, system and component (SSC) functional requirements and design criteria considering the long term operation of the plant, optimization of life cycle costs and support of efficient deactivation and decommissioning of the facility upon completion of the WTP mission. The following include key Contract requirements applicable to material selection. (Note these are the key requirements but are not intended to be all inclusive.)

1. Safety Requirements Document Appendix H, Ad Hoc Implementing Standard for Erosion/Corrosion and Assessments includes provisions for corrosion evaluations and material selection, setting of corrosion and erosion allowances, vessel and piping assessments and in-service inspection for Important to Safety vessels and piping, and identification of features to be considered for vessels and piping systems in "black cells" to achieve a 40-year life without in-service inspection.

2. The Contract requires that the WTP shall be designed to:

   - Have a 40-year operating life. (Section C.7, (a), (1))

1 Numbers in brackets refer to references listed in Section 6.0, below.

- Receive and treat Low Activity Waste (LAW) and High Level Waste (HLW) feed and produce Immobilized Low Activity Waste (ILAW) and Immobilized High Level Waste (IHLW) in accordance with contract requirements (Section C.7)
- Include process and facility design features that safely and efficiently facilitate deactivation, decontamination, decommissioning, and RCRA closure of the facilities. (Section C.7, (a), (12))

3. The Preliminary Safety Analyses Report (PSAR) includes the following additional requirements:

- Corrosion evaluations will be conducted for the vessels and piping. Process chemistry conditions, temperature ranges, fluid velocities, and external conditions including radiation fields will be determined for each vessel and attached piping. Various materials will be evaluated for general corrosion, pitting corrosion, end grain corrosion, stress corrosion cracking, crevice corrosion, corrosion at welds, microbiologically induced corrosion, corrosion fatigue, vapor phase corrosion, erosion, galling, fretting, wear, galvanic corrosion, cavitation damage, and creep. The acceptable materials will be identified, and the least-cost acceptable material generally selected. General corrosion rates will be derived from the literature, laboratory investigations, and experience at other plants, and a corrosion allowance for a 40-year life will be specified.

  The process chemistry conditions will be provided by process engineering on material selection data sheets. Pertinent information for each component will be transferred to the corrosion evaluation. The corrosion evaluation will be performed by a mechanical systems corrosion specialist and checked by a mechanical systems metallurgist. Operation limitations due to the material selected will be identified by mechanical systems and will be checked by operations. The corrosion evaluation, which includes the process chemical conditions, corrosion evaluations, material selected, corrosion allowance, and operating limitations, will be reviewed and approved by a materials and engineering technology specialist, and reviewed by the chief engineer's materials specialist. (PSAR Section 2.9.1.1)

- Architectural material and product selection will minimize the quantity of hazardous waste generated during Decontamination and Decommissioning (D&D) activities. Interior finishes in areas of potential contamination will be non-porous for ease of decontamination. (PSAR, Section 16.3.3).

- Suitable non-permeable surface finishes (where applicable) will be provided for both equipment and buildings to ease the decontamination process. Stainless steel cave liners will be used, where appropriate, and extend up walls as required by design or regulatory requirements. The walls above liners will be sealed with suitable finishes. (PSAR, Section 16.3.5)

- Construction materials will be resistant to radiation, process solutions, and decontamination agents. Equipment and facilities will be constructed from materials amenable to volume reduction and eventual disposal. (PSAR, Section 16.3.5).

[Note: These are statements from the PSAR revision as of the date of this report. BNI identified the following pending changes that will affect these statements:

- (Section 2.9.1.1) The corrosion evaluations are being prepared by the mechanical systems metallurgist and checked by a mechanical systems corrosion specialist. This is because the corrosion specialist is more experienced than the metallurgist. BNI considers this to be an editorial change that will be incorporated at the next annual revision of the PSAR.

- (Section 16.3.3) The amount of coating required will be determined based on operational conditions rather than decontamination reasons pending revision of the Washington Administrative Code (WAC) in accordance with DOE direction.

- (Section 16.3.5) A design change authorization has been implemented that will eliminate coating the walls above the liner plates above black-cells.]

Meeting these in addition to the fundamental functional requirements and design criteria for affected SSCs requires careful selection of materials such as those used for vessels, piping, ducting, valves, pumps, heat exchangers and other functional components as well as coatings, paneling, liners and other structural components that affect long term plant functionality, maintainability and life cycle cost including deactivation and decommissioning costs.

On these bases, the processes used by BNI in selecting materials of construction were selected as the area of review for this technical design oversight.

3.0 OBJECTIVES, SCOPE, AND APPROACH

3.1 Objectives

The specific objectives of this oversight include the following:

3.1.1 Identify and understand the BNI requirements for selection of materials of construction (e.g., compatibility with waste and process chemistry and physical properties) for process vessels, piping, piping system components, and other facility structures (e.g., ducting, wall liners and coatings) considering the corrosive, erosive and radiation environments to which the materials will be exposed.

3.1.2 Understand the technical basis for these requirements and confirm that the technical bases are definitive and supported by substantive analysis, testing or experience.

3.1.3 Identify and confirm the effectiveness of the process applied to control the

implementation of these requirements.

3.2 Scope

This oversight included review of the selection of materials of construction for vessels except the glass melters, piping and piping components, mixers, ducting, cell liners and coatings. The specific products reviewed and the depth of the review are summarized in Appendix A to this report.

3.3 Approach

3.3.1 Preparation

This phase of the oversight included; identifying the BNI Point of Contact for the review, determining the scope and elements of the BNI program for selection of materials of construction and how the program is applied in the WTP design process, reviewing background information as provided by BNI and identified through review of available databases, sampling implementation of the program and reviewing current BNI open issues and the plans for and status of their resolution.

3.3.2 Review and identify, resolve or document issues

Evaluated the selected attributes and developed lines of inquiry and specific questions that were explored with cognizant BNI personnel to meet the oversight objectives. The results of these reviews are documented in the summary tables of Appendix A. This effort included periodic meetings with cognizant BNI personnel to discuss ORP questions and lines of inquiry and BNI responses to these. Summary reports of these meetings are also included in Appendix A.

3.3.3 Reporting

Prepared a draft report that summarized the activities, the results, conclusions and recommendations of the review. The draft report was issued for review and comment of ORP management and cognizant BNI personnel on April 7, 2003. This final report resolves comments received on the draft report.

4.0 RESULTS

4.1 Objective 1

Identify and understand the BNI requirements for selection of materials of construction (e.g., compatibility with waste and process chemistry and physical properties) for process vessels, piping, piping system components, and other facility structures (e.g., ducting, wall liners and coatings) considering the corrosive, erosive and radiation environments to which the materials will be exposed.

Note: Appendix A to this report summarizes the lines of technical inquiry explored and the responses received from BNI to these lines of inquiry as part of this design oversight. The following summarizes the key results of the oversight relative to this objective as well as the other technical objectives discussed in subsequent sections of this report.

4.1.1 Figure 1 summarizes the ORP understanding of the BNI process for selection of materials of construction including the interfaces at the input and outputs of this process. This figure was developed from review of the BNI Material Selection Report [2] and discussions with cognizant BNI personnel. Figure 1 includes comments received from BNI on earlier drafts of this figure. Figure 2, provided by BNI, summarizes the flow of information and review in the material selection process.

4.1.2 With reference to these figures, the bases for selection of materials for constructing a major component, e.g., a vessel or a piping segment, are summarized in a CE performed by corrosion specialists (metallurgists) in the Materials Selection Group. This organization is part of the project-wide BNI WTP Central Engineering Organization and, therefore, supports all of WTP project engineering. A CE evaluates the compatibility of candidate materials with the expected chemistry and fluid conditions for several corrosion and erosion mechanisms. These mechanisms are summarized in the BNI Material Selection Report. They are similar to those covered in the River Protection Project (RPP), WTP Safety Requirements Document (SRD) Volume II, Appendix H, Ad Hoc Implementing Standard for Erosion/Corrosion and Assessments [3]. The Team considers that the corrosion and erosion mechanisms covered by the Material Selection Report are typical and complete for the SSCs in the WTP processes covered by this program.

The process chemistry conditions are provided to the Material Selection Group by Process Engineering in the form of a Material Selection Data Sheet (MSDS) for each component. Process Engineering also provides Process Flow Diagrams that include fluid condition and chemistry data for use in the Corrosion Evaluations. These data are generated from plant process models maintained by Process Engineering.

Standard 2 of the Contract requires that BNI characterize the waste from specific tanks to confirm that the definitions of waste characteristics in the Contract bound the actual waste characteristics. The expectation is that the results of this characterization will be factored into the MSDS for consideration by the Material Selection Group.

The results of the CE include recommendations on the materials of construction and any design, operation or maintenance requirements and/or limitations that were identified during the evaluation. These requirements and/or limitations represent conditions that were assumed to exist in the evaluation to ensure avoidance of corrosion or erosion conditions that could affect the integrity of the component over the 40-year design life of the plant. The recommended materials and any other design considerations are factored into the final design as reflected in the design and procurement documents (e.g., Mechanical Data Sheets, drawings, P&IDs, Bid Specifications).

The Material Selection Group generates Material Selection Guides that summarize the recommended materials for major components and piping in a form similar to a Process Flow Diagram. These are used strictly as quick references for review of design documentation (e.g., Mechanical Data Sheets, drawings, bid specifications).

The operations and maintenance requirements are captured on the cover sheets of the Corrosion Evaluations, logged by the Operations group and ultimately are expected to be reflected in plant procedures.

Oversight of the material selection process includes internal peer reviews and independent reviews by personnel from Bechtel Materials Engineering Technology headquartered in Houston, TX, and the Chief Engineer headquartered in San Francisco, CA. Additionally, a panel of experts in the fields of material corrosion and erosion with experience in a wide range of applications, including radiological facilities, was convened in October 2001 to review proposed materials of construction for specific components [4]. At the recommendation of this panel, similar expert panel reviews are planned in the future.

Economic considerations on the selection of materials are covered by cost analysis reviews performed by BNI purchasing. An objective of the process is to identify the "least-cost acceptable material" [5].

The material selection program recognizes that in the course of the corrosion evaluations a need for additional testing or study may be identified to supplement the data available in the general literature and DOE testing. In this event this need would be added to the WTP project Research and Technology (R&T) program. It is understood that little additional testing requirements have been identified in CEs conducted to the date of this report.

The material selection process is not once through. As the plant design evolves the bases for selecting materials need to be re-evaluated and changes made, if required. The need for re-evaluation of material selection decisions can evolve from the design change process, through changes in an MSDS and through review and/or sign-off of design and procurement documentation by the Materials Selection Group.

4.1.3 The Material Selection Report defines needs and methods to be used for Corrosion Monitoring and Control during operation. Discussions with BNI personnel indicate that the specific corrosion monitoring program has not been developed as of the date of this report. BNI anticipates that the program will include some in-service inspection of accessible piping and components, examination of removed components (e.g., jumpers) to characterize the extent of corrosion and erosion in specific areas, and monitor of the chemistry and fluid conditions during operation to ensure that they are bounded by the conditions considered in the Corrosion Evaluations. In-service-inspection is not currently planned for vessels and piping inside black cells. Instead additional quality requirements, (e.g., additional inspections of welds) are imposed during the procurement of these components, and the surveillance of components outside the cells, but exposed to similar chemistry and fluid conditions as those inside the cells, will be used to infer the material condition of black cell components.

The Team considers that the conceptual approach for monitoring as outlined in the Material Selection Report and described in discussions with BNI personnel has the necessary elements. The Team requests that BNI provide the specific surveillance program requirements when they are available. **(Open Issue 01)**

4.1.4 The BNI Architectural Design Criteria [6] specify requirements for WTP coatings and liners. The criteria cover interior finishes and wall types considering fire protection, functionality, durability and shielding. Interior finishes, including walls and floors are covered by applicable American Society of Texture Materials and National Fire Protection Association codes. Interior finishes in areas processing or storing radioactive materials and those having the possibility of radioactive contamination, and are not covered by stainless steel linings, are non-porous for ease of decontamination per NFPA 801 [7]. Considering D&D requirements cell floors are typically required to be stainless steel and steel linings extend up the wall to at least 6 inches to form a base. Wall liners in cells with vessels extend to a height necessary to ensure containment of a full vessel contents without exceeding the height of the liner.

A stated objective of providing architectural finishes in areas within facilities that contain radioactive materials and processes or have potential of radioactive particulate contamination is "to maintain radioactivity levels from surface contamination as low as reasonably achievable (ALARA) and facilitate deactivation and demolition."

4.1.5 The team explored any special considerations BNI employs within the Materials Selection Process to address the scope of materials behavior issues that can be influenced by welding. BNI identified several considerations within the Corrosion Evaluations that address weld beads, heat affected zone corrosion, and knife-line corrosion. Generally, these are not considered problem areas if proper weld procedures are followed. Accordingly, BNI must approve the welding procedures used by vendors and the procedures must comply with the BNI welding specifications which are part of the material requisitions. BNI also indicated that some special testing has been performed for type 304L and 316L stainless steel pipe welds in nitric acid solutions and additional testing is planned.

4.1.6 On the basis of this understanding, the Team considers that the BNI Material Selection process, in general, includes the necessary elements and structure, including external review, for effective selection of materials of construction for the WTP.

4.2 Objective 2

Understand the technical basis for these requirements and confirm that the technical bases are definitive and supported by substantive analysis, testing or experience.

4.2.1 The Corrosion Evaluations provide the technical bases for selection of the materials of construction of WTP SSCs. The elements of the corrosion evaluations as they relate to materials selection are summarized in the PSAR Section 2.9.1.1 [8] and detailed in the Materials Selection Report [2]. The stated objective of the Material Selection Report is to "document the process of materials selection." It was prepared to "review the basis for selecting materials for RPP-WTP vessels, tanks, heat exchangers, columns, pipe, valves, etc. A description of the process of

performing corrosion reviews during design, construction and operation is included." The elements and inputs and outputs of this process were described above.

With regard to the technical bases for the Corrosion Evaluations, this report provides guidance on areas that need to be considered in these evaluations:

- Factors that affect corrosion and erosion for WTP type processes (e.g., the interaction of temperature, chemistry, flowrate, stress, vibration on corrosion rates for a specific material);
- The areas that should be considered during the several phases of plant design, construction and operation to address corrosion and erosion;
- The operating modes that need to be considered (e.g., shipping, transportation and storage, construction, startup and commissioning, operation, stand-by and idle, cleaning, off-normal or accident and decommissioning);
- Basic corrosion processes. These are similar to those listed in the SRD Appendix H [3] and the PSAR [8];
- Corrosion testing with emphasis on the elements necessary for a successful test; and
- Methods of corrosion control and their application within the design and operational constraints of the plant including technical guidance for corrosion avoidance requirements for plant equipment.

This report also includes a generalized matrix for several materials of construction that provides acceptable chemical/temperature ranges and physical limitations for application of each material. The Hanford Double Shell Tank Operating Specification Limits are also provided for reference.

The technical bases for selection of a material for a specific set of conditions are the multiple references provided in this report. These include general literature on the mechanisms of corrosion and erosion, selections of materials and other considerations to improve resistance to corrosion and erosion for a wide range of chemistries and fluid conditions, and results of testing and focused studies conducted for DOE on these subjects. The Corrosion Evaluations draw on the references in the discussion of the bases for the recommended material.

4.2.2 In discussions with BNI personnel, the Team explored how constituent concentrations and thermal gradients in offgas system components, especially between the melter and SBS and within the catalytic oxidizers/reducers, are characterized to support the selection of the materials of construction in these areas. It is understood that modeling and tests that will provide information to support material selection in these areas is not complete. Based on review of the scope and nature of the modeling and tests, however, the Team is concerned that they may not be adequate to bound the chemical and thermal environments in these components, particularly with respect to the thermodynamic modeling. The failure to bound these conditions could result in selection of non-conservative materials in these areas of the WTP. The Team requests that BNI

provide the results of the modeling and testing that support the material selections in the off-gas system when they are available. The Team also recommends that BNI consider whether additional modeling and testing is required to ensure that material selections for offgas system components are conservative with respect to the expected chemical concentrations within offgas system components, thermal gradients near the melters and catalytic oxidizers/reducers, and the formation of potential detrimental deposits. **(Open Issue 02)**

4.3 Objective 3

Identify and confirm the effectiveness of the process applied to control the implementation of these requirements.

4.3.1 The Team considers that the material selection process is well documented and the CEs include the necessary elements to document the rationale for selection of the material of construction for the WTP Structures, Systems and Components.

4.3.2 As described above in Section 4.1, Material Selection Data Sheets (MSDS), supplied to the Material Selection Group by Process Engineering, define the chemistry conditions considered in the CEs that form the bases for specific material selections. It is understood that the waste constituents reported on the MSDS are partially based on the process engineering steady state material balance model run for Envelope A/D. [BNI adds that Process Engineering uses additional available information. The waste constituents are also based, in many cases, on other sources of information that may be available such as laboratory test results from Vitreous State Laboratory, other technical reports relevant to the WTP.]

The Team has the following issues with its understanding of the bases for the MSDS.

- The Envelope A/D chemistry may not be bounding. For example, envelope B waste constituents contain a higher concentration of halides which may result in a more corrosive materials environment. BNI indicates that envelope A/D represents the majority of the waste to be processed in the original Phase 1 of the project. It is a Contract requirement that the plant be designed for a 40-year design life and to process all waste envelopes. On this basis the most bounding chemistry conditions should be used for evaluating material selections.

- The Contract requires BNI to develop a characterization of the tank waste constituents for the purpose of confirming that the Contract definitions of the waste constituents bound the actual waste envelope definition. The results of that characterization should be considered in the definition of waste constituents in the MSDS. The Team was not able to identify documentation or other evidence that this has been done.

- The Team understands that the corrosion evaluations for vessels are based on the steady state, equilibrium conditions obtained from this material balance model run. The Team questions whether these are limiting from a corrosion and/or erosion perspective. For example:

- The dynamic model runs may identify more erosive/corrosive conditions, particularly in recycle streams, that should be considered to ensure long term material integrity;

- In vessels with multiple inputs of varying pH, the impact of acid and alkaline stream injections and mixing on localized corrosion in the upper penetrations and upper shell of the vessel may be more limiting than the steady state condition (which is considered either acidic or alkaline) in the main body of the vessel. (HLP-VSL-00028 is an example of such a vessel.); and

- The dynamic model runs may identify chemical reactions that could lead to formation of highly corrosive or erosive compounds. These conditions may not be apparent in the steady state runs).

The concern is that the material selection process may not be considering bounding chemistry and fluid conditions. Accordingly, non-conservative materials may be recommended and that could lead to material integrity problems over the long term. The Team recommends that BNI confirm that the information provided to the Materials Selection Group bounds the expected process conditions over the design life of the plant. **(Open Item – 03)**.

4.3.3 Several CEs were reviewed in the course of this evaluation. The results of the evaluations are documented in Appendix A. The CEs reviewed are very comprehensive and detailed in the evaluation of the several corrosion mechanisms. The Team notes that they were prepared and checked by the same two individuals. This assists in promoting consistency in the rationale developed in each evaluation and mitigates a concern the Team discussed with BNI on consistency over the full scope of the corrosion evaluations.

4.3.4 However, the Team did identify inconsistencies in the review of some of the CEs. These included failure to consider aspects of the component operation that may affect selection of the material, identification of concerns that are not reflected in the detailed discussion of the rationale for selection of the material. Inconsistencies were also identified in the open issues and process and operations limitations identified on the front sheet of the CEs with the detailed discussion in the body of the report. It was understood that all open issues should be resolved before the CE is issued as Rev. 0. There is no record, however, of how open issues were resolved. The concern is that key assumptions or conditions that were made in the material selection process may not be carried forward in the design or operating and maintenance procedures, if the cover sheet is not complete and accurate.

[BNI indicates that the Materials Selection Group does not use alphabetical revision numbers during the drafting of corrosion evaluations as is the practice in other parts of the BNI engineering organization. The Rev. 0 drafts are, therefore, works in progress and some of the inconsistencies identified by the Team reflect the evolving nature of the process. As new information on process chemistry conditions is made available to the group the corrosion evaluations are updated.]

The following are examples of the items identified by the Team:

- HLW Feed Blending Vessel (HLP-VSL-00028(PTF)) (24590-PTF-N1D-HLP-00010, Rev 1)

  The MSDS for this vessel indicates that the fluid is generally made up of alkaline constituents and cites a pH of 13. In the discussion on general corrosion a concern is raised about acid cleaning. Process and Operations Limitations on the cover sheet state that a rinsing/flushing procedure should be developed for acid and water. 316L is recommended because of the possibility of acid cleaning in the presence of halides.

  It is noted that the concentrated Cs stream entering this vessel from the Cs Nitric Acid Recovery Process System (CNP) is acidic (Page 19 System Description for Cesium Nitric Acid Recovery Process [8]). This condition is not covered in the MSDS for this vessel. The concern is that excessive localized corrosion rates may be experienced at the injection nozzle for this stream and in the upper regions of the tank wall where this stream mixes with the HLW waste stream which is alkaline.

  This CE discusses the effects of the high temperature on the surface of the steam ejector on deposits. The design data and documentation for this vessel do not include a steam ejector. A steam ejector is not included in the list of Offspring Items for this CE.

  The discussion on corrosion at welds states that heat tint should be removed after construction if it is darker than straw yellow. This requirement is not included on the cover sheet and it is not known how it would be carried into the specifications for welding on this vessel.

- HLW Melter Feed Vessel (HFP-VSL-00002) (24590-HLW-N1D-HFP-00004, Rev. 0)

  The discussion under galvanic corrosion states that thermogalvanic effects of a hot steam line need to be evaluated. This is not included in the list of open items on the cover sheet.

- SBS and Collection Vessel (HOP-SCB-00001 & HOP-VSL-00904) (24590-HLW-N1D-HOP-00010, Rev. 1)

  Microbiologically Induced Corrosion (MIC) is identified as an open issue on the cover sheet, but is cited as not considered a serious problem in the detailed discussion on MIC. The detailed discussions also indicate that further evaluation is required in the areas of Fatigue/Corrosion Fatigue, Vapor Phase Corrosion and Fretting/Wear. These are not included in the list of open items.

Similar issues were identified in five of the seven CEs reviewed for the HLW facility. The Team recommends that BNI determine what steps are necessary to ensure that these evaluations consider all factors that could affect the selection of materials and that all assumptions, requirements and limitations identified in the evaluations are clearly identified. In this regard BNI should also confirm that, as the design progresses and more information becomes available on process chemistry conditions, the original bases for material selections will be re-evaluated

along with the need to conduct testing to supplement available information on the corrosion/erosion behavior of the selected materials for those conditions. **(Open Issue – 04)**

4.3.5 As noted, the CEs make assumptions or establish limitations that affect plant design, operations and maintenance. These are nominally identified on the front sheet of the CEs. It is understood that Operations acknowledges these by a set of initials on the form. The Team was not able to determine, however, how these requirements and limitations are captured for incorporation in operating and maintenance procedures. Based on the discussions in the several CEs reviewed, such requirements and limitations are important to the long term integrity of the selected material (e.g., removing heat tint from welds, flushing after a campaign to ensure no stagnant cleaning solutions or flush water are left, and treating of process water used for flushing). The concern is that these requirements will not be implemented if there is no formal mechanism to track them to completion. Failure to implement these requirements may have an adverse impact on the integrity of the material over the long term. BNI should confirm that there is a formal process to track these requirements and limitations and that the process is functional. **(Open Item – 05)**.

4.4 Summary of Open Issues and Recommendations

Table 1, below, summarizes open issues and recommendations developed as part of this review and discussed in the preceding sections of this report. The Team met with BNI personnel on April 7, 2003 to review these issues and recommendations and to submit the preliminary draft of this report for BNI review and comment. This report resolves BNI's general comments on the report.

As a result of the discussions with BNI on the Draft of this report, and receipt of further information in responses to the Team's questions as documented in Appendix A, the Team closed two open issues from the Draft report. These were Draft Open Issues 2 and 3. These were closed on the following bases:

Draft Open Issue 2 – The Team was not able to identify a document that provides comprehensive guidance on the general limits for application of candidate materials for the WTP process chemistry and fluid conditions. The concern is lack of consistency in implementation of the material selection process. (Draft Report Section 4.2.2)

The Team recommended that BNI consider providing more guidance on the limits for application of the candidate materials in the context of the WTP process chemistry and fluid conditions.

Resolution -- After discussion with BNI, the Team considers that the need for this document is not a current priority. The bulk of the corrosion evaluations have already been initiated and initial revisions issued. The Team considers that the focus in the remaining phases of the design, construction and commissioning of the WTP should be on confirming that the original bases for the selection of a material for a specific application remain valid as more information on the actual process chemistry and fluid conditions becomes available. This should also consider whether changes are needed in the limits or requirements placed on

process conditions, e.g., flushing between campaigns, and the need for testing to supplement information on material corrosion/erosion behavior for that condition. Since this focus is covered in another open issue (current Open Issue 4), the Team closed this draft open issue.

Draft Open Issue 3 -- The Team understands that all but one of the tests considered to supplement information on the corrosion/erosion behavior of candidate materials were cancelled. The Team has not been able to determine if there was a technical basis for cancellation of these programs. The concern is that the lack of information from these programs may lead to inappropriate material selections. (Draft Report Section 4.2.3)

The Team recommended that BNI provide the rationale for cancellation of these programs.

Resolution – BNI provided the requested rationale in responding to Question G.9. This response is as follows:

> Little testing was done under BNFL. Testing was started just prior to the arrival of BNI/WGI. Erosion testing was not conducted because it was felt that simulants would not provide the needed data. Instead, erosion allowances have been determined based on DOE test reports and industry literature.
>
> Erosion tests and filtration tests were deleted when the design for both the evaporator and filter loops were changed from a black cell to a hot cell configuration. This change in design negated the need to perform this testing. This was addressed through the trend/re-baseline process.
>
> Testing continues to examine the effect of Hg in liquid corrosion for alkaline waste.
>
> Recently some scoping studies were completed by Battelle on the effects of mercury. Plans are being prepared to expand these studies into full-scale immersion tests. Testing of offgas conditions have been proposed but are not expected to proceed.

At this stage in the design process, the Team considers that the focus should be on determining if additional testing is required to supplement information on material corrosion/erosion behavior as more data becomes available on the actual process chemistry and fluid conditions. This aspect of material testing is covered in Open Issue 4 of the final report. Open Issue 2 of the final report also addresses issues with the material selection for off-gas system components. Accordingly, the Team considers this draft open issue closed.

5.0 RECOMMENDATIONS

5.1.1 ORP should track the resolution of the open items through assigned Consolidated Action Reporting System (CARS) numbers. ORP should confirm appropriate closure of these issues as part of the continuing technical oversight of WTP design development

5.1.2 The design oversight process should be extended to other systems and areas to continue ORP focused review of critical design features of the WTP

6.0 REFERENCES

1. Design Oversight Plan For Review of the BNI Material Selection Process: D-03-DESIGN-001 prepared in accordance with ORP PD 220.1-12.

2. 24590-WTP-RPT-M-01-001, Materials Selection Report, Rev. 0, (Draft).

3. 24590-WTP-SRD-ESH-01-001-02, Appendix H, AdHoc Implementing Standard for Erosion/Corrosion and Assessments, Rev. 2.

4. Review of Waste Treatment Plant Materials of Construction by Blue Ribbon Panel, October 16-19, 2001.

5. Presentation viewgraph copies, Erosion/Corrosion Evaluation, Presented by Steve Vail, Mechanical Systems Compliance, to OSR Inspection Team, October 29, 2002.

6. 24590-WTP-DC-AR-01-001, Architectural Design Criteria, Rev. 1, September 9, 2002.

7. NFPA 801, Standard for Facilities Handling Radioactive Materials.

8. 24590-WTP-PSAR-ESH-01-002-01, Preliminary Safety Analysis Report to Support Construction Authorization, General Information, Rev. 0, Section 2.9.1.1.

Additional references to reviewed documents are contained in the discussion of the lines of inquiry in Appendix A.

Table 1 – Issues Identified from Technical Oversight of the BNI Material Selection Process, Recommendations for BNI Resolution

Item No	CARS No.	Open Issue Summary	Recommendation for Resolution
1.	5141 Subtask 1	The Material Selection Report defines needs and methods to be used for Corrosion Monitoring and Control during operation. Discussions with BNI personnel indicate that the specific corrosion monitoring program has not been developed as of the date of this report. (Section 4.1.3)	The Team requests that BNI provide the specific surveillance program requirements when they are available.
2.	5141 Subtasks 2 & 3	It is understood that modeling and tests that will provide information to support material selection in the off-gas system are not complete. Based on review of the scope and nature of the modeling and tests, however, the Team is concerned that they may not be adequate to bound the chemical and thermal environments in these components, particularly with respect to the thermodynamic modeling. The failure to bound these conditions could result in selection of inappropriate materials in these areas of the WTP. (Section 4.2.2)	The Team requests that BNI provide the results of the modeling and testing that support the material selections in the off-gas system when they are available. The Team recommends that BNI consider whether additional modeling and testing is required to ensure that material selections for offgas system components are conservative with respect to the expected chemical concentrations within offgas system components, thermal gradients near the melters and catalytic oxidizers/reducers, and the formation of potential detrimental deposits.
3.	5141 Subtask 4	The Team questions whether the material selection process is considering bounding chemistry and fluid conditions. Accordingly, inappropriate materials may be recommended and that could lead to material integrity problems over the long term. (Section 4.3.2)	The Team recommends that BNI confirm that the information provided to the Materials Selection Group bounds the expected process conditions over the design life of the plant.
4.	5141 Subtask 5	Inconsistencies were identified in five of the seven CEs reviewed for the HLW facility. BNI indicates that some of these are due to evolving understanding of the waste processing chemistry and fluid conditions. (Section 4.3.4)	The Team recommends that BNI determine what steps are necessary to ensure that these evaluations consider all factors that could affect the selection of materials and that all assumptions, requirements and limitations identified in the evaluations are clearly identified. In this regard, BNI should also confirm that, as the

Item No	CARS No.	Open Issue Summary	Recommendation for Resolution
			design progresses and more information becomes available on process chemistry conditions, the original bases for material selections will be re-evaluated, along with the need to conduct testing to supplement available information on the corrosion/erosion behavior of the selected materials for those conditions.
5.	5141 Subtask 6	The Team was not able to determine how requirements and limitations identified in the Corrosion Evaluations are captured for incorporation in the plant design and in operating and maintenance procedures. The concern is that these requirements will not be implemented if there is no formal mechanism to track them to completion. Failure to implement these requirements may have an adverse impact on the integrity of the material over the long term. (Section 4.3.5)	The Team requests that BNI identify the process used to track these requirements and limitations and confirm that the process is functional.

Figure 1 -- BNI Material Selection Process Summary

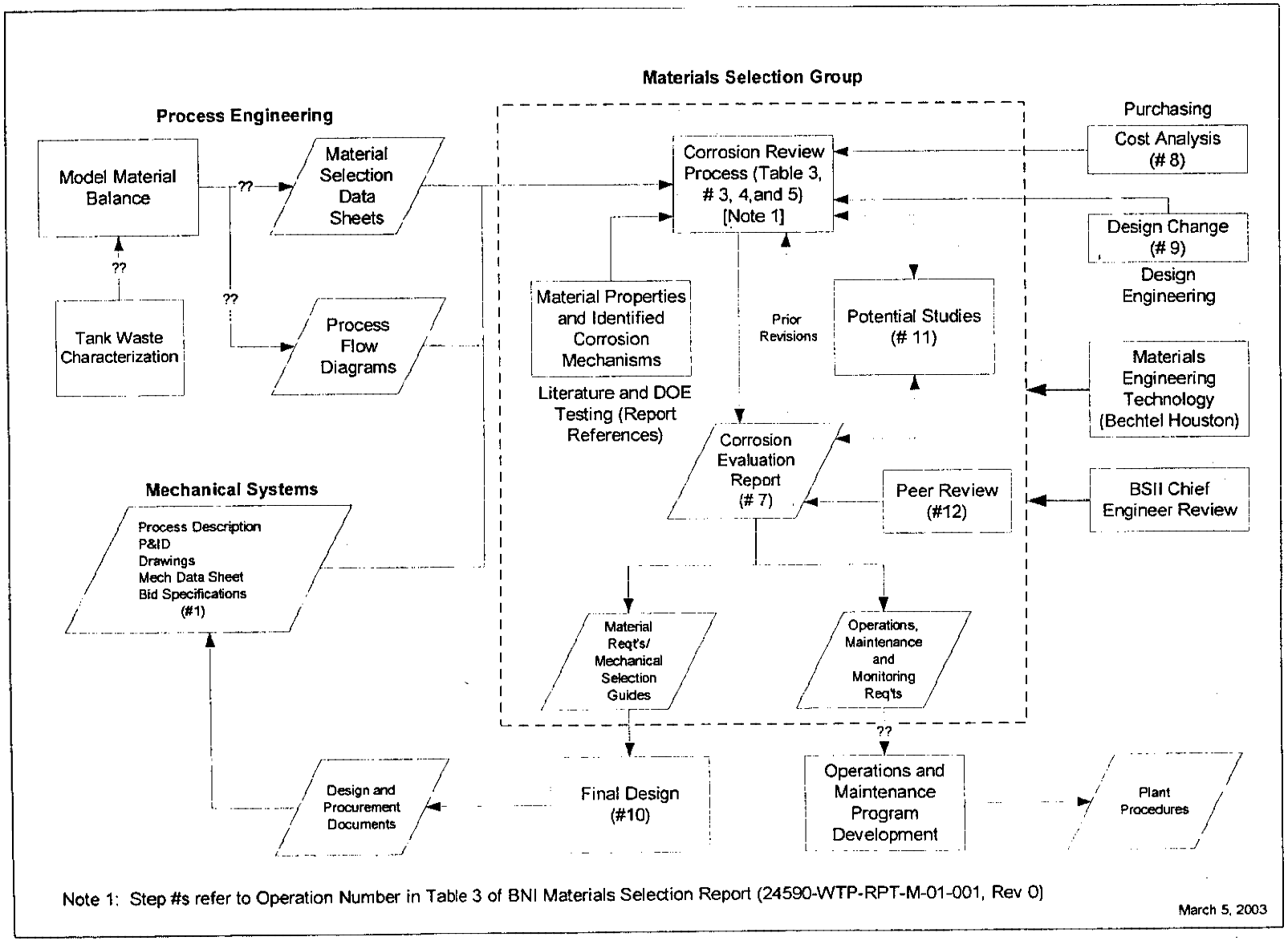
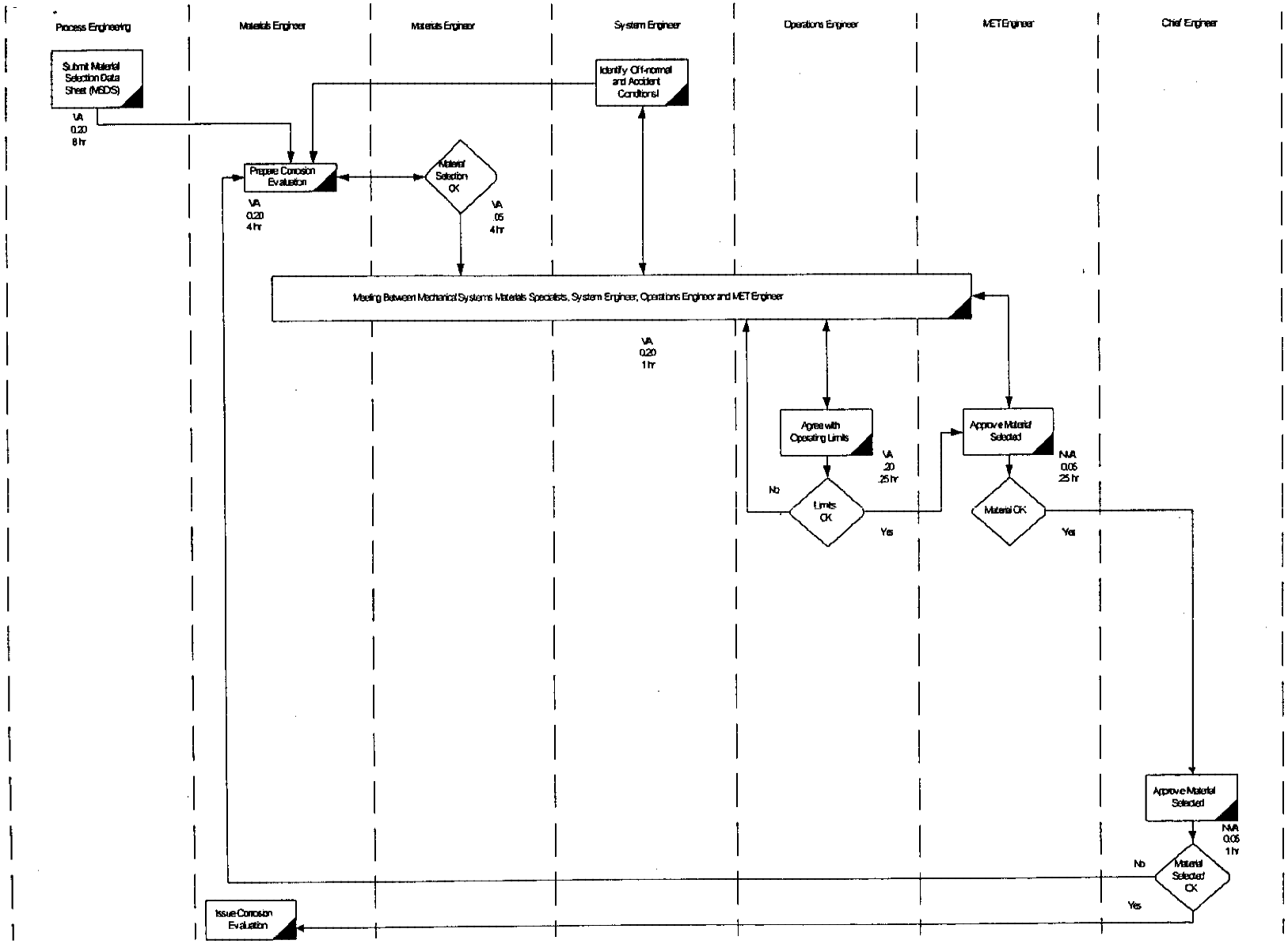


Figure 2 – Materials Selection Process – Information, data and review flow



APPENDIX A

(This is available as a separate document. A copy was provided to BNI on April 9, 2003).

Task Detail Report 04/21/2003 09:17 AM

Task #: ORP-WEC-2003-0018

Parent Task #:
Subject: Concur 03-WEC-018, Submittal of ORP Design Oversight Report for BNI
Category: None
Due Date:
Originator: Hanson, Arlene J

Reference #: 03-WEC-018
Deliverable: None
Status: Open
Priority: None
Originator Phone: (509)373-0068

Assigned By: Self
Assigned Role: Originator

Assigned Date: 04/16/2003
Assigned Due Date:

Routing Lists: ⊞ **Route List - Active**

- ⊡ Hamel, William F - Approve - Approve with comments - 04/17/2003 10:09 (By: Hanson, Arlene J)
- ⊡ Taylor, William J - Approve - Approve with comments - 04/17/2003 10:06 (By: Hanson, Arlene J)
- ⊡ Eschenberg, John R - Approve - Withdrawn - 04/17/2003 14:04
- ⊡ Barr, Robert C - Approve - Approve - 04/17/2003 13:18 (By: Hopkins, Dianne)
- ⊡ Erickson, Leif - Approve - Approve - 04/18/2003 15:53 (By: Deutsch, V Genie)
- ⊡ Schepens, Roy J - Approve - Approve - 04/21/2003 09:00 (By: Poynor, Cathy D)

Instructions:
bcc:
WEC OFF File
WEC Rdg File
MGR Rdg File
J. R. Eschenberg, AMWTP
W. J. Taylor, AMWTP
R. C. Barr, OSR
R. A. Gilbert, WEC
W. F. Hamel, WEC
J. E. Orchard, WEC
E. H. Randklev, WEC
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Attachments: 1. 03-WEC-018.bfh.doc

Comments

Response Comments

Poster / Date : Taylor, William J (Hanson, Arlene J) - 2003-04-17 10:06:55
Subject : Hanson, Arlene J -- Approve
Bill signed hard copy.

Poster / Date : Hamel, William F (Hanson, Arlene J) - 2003-04-17 10:09:51
Subject : Hanson, Arlene J -- Approve
Bill Hamel signed hard copy.

Task Due Date History:

Date Modified	Task Due Date	Modified By

-- End of Report --

Task Detail Report 04/17/2003 02:05 PM

Task #: ORP-WEC-2003-0018

Parent Task #:
Subject: Concur 03-WEC-018, Submittal of ORP Design Oversight Report for BNI
Category: None
Due Date:
Originator: Hanson, Arlene J

Reference #: 03-WEC-018
Deliverable: None
Status: Open
Priority: None
Originator Phone: (509)373-0068

Assigned By: Self
Assigned Role: Originator
Assigned Date: 04/16/2003
Assigned Due Date:

Routing Lists: ⊞ **Route List - Active**

- ⊡ Hamel, William F - Approve - Approve with comments - 04/17/2003 10:09 (By: Hanson, Arlene J)
- ⊡ Taylor, William J - Approve - Approve with comments - 04/17/2003 10:06 (By: Hanson, Arlene J)
- ⊡ Eschenberg, John R - Approve - Withdrawn - 04/17/2003 14:04
- ⊡ Barr, Robert C - Approve - Approve - 04/17/2003 13:18 (By: Hopkins, Dianne)
- ⊡ Erickson, Leif - Approve - Awaiting Response 18 April 2003
- ⊡ Schepens, Roy J - Approve - Awaiting Response

Instructions:
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Poster / Date : Taylor, William J (Hanson, Arlene J) - 2003-04-17 10:06:55
Subject : Hanson, Arlene J -- Approve
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Poster / Date : Hamel, William F (Hanson, Arlene J) - 2003-04-17 10:09:51
Subject : Hanson, Arlene J -- Approve
Bill Hamel signed hard copy.

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Task Detail Report 04/16/2003 09:47 AM

Task #: ORP-WEC-2003-0018

Parent Task #:
Reference #: 03-WEC-018
Subject: Concur 03-WEC-018, Submittal of ORP Design Oversight Report for BNI
Deliverable: None
Category: None
Status: Open
Due Date:
Priority: None
Originator: Hanson, Arlene J
Originator Phone: (509)373-0068

Assigned By: Self
Assigned Date: 04/16/2003
Assigned Role: Originator
Assigned Due Date:

Routing Lists: ⊞ **Route List - Active**

- ☐ Hamel, William F - Approve - Awaiting Response WFH 4/17/2003
- ☐ Taylor, William J - Approve - Awaiting Response WJT 4/17/03
- ☐ Eschenberg, John R - Approve - Awaiting Response
- ☐ Barr, Robert C - Approve - Awaiting Response RCB 4/19/03
- ☐ Erickson, Leif - Approve - Awaiting Response

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Comments

Task Due Date History:

Date Modified	Task Due Date	Modified By

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