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# SPECIFICATION COVER SHEET

**TITLE: Order of Magnitude/Relative Capital Installed Cost Estimate Specification Addendum**
**SPECIFICATION NUMBER: BS2-FGDSCE-052010AD1**

| | |
|---|---|
| PROJECT: | Big Sandy 1 – Incremental FGD/SCR Estimate |
| REVISION: | 1 |
| DATE: | October 11, 2010 |



INTERNAL APPROVAL SIGNATURES

| | Original Issue | Rev. 1 | Rev. 2 |
|---|---|---|---|
| AUTHOR: L. A. Hicks | L. A. Hicks 8/4/2010 | C. A. West 10/11/2010 | |
| REVIEW: G. M. Gibbs | G. M. Gibbs 8/5/2010 | G. M. Gibbs 10/11/2010 | |
| APPROVAL: T. L. Hart | T. L. Hart 8/6/2010 | T. L. Hart 10/11/2010 | |

# REVISION HISTORY

| REV. | SCOPE OF REVISION | APPROVAL |
|---|---|---|
| 0 | Initial Release | TLH 8/5/2010 |
| | [redacted] | |
| | | |
| | | |
| | | |
| | | |

**TABLE OF CONTENTS**

## 1.0 PURPOSE

The purpose of this addendum is to provide additional high level design basis requirements such that a 3rd party consultant can develop an incremental cost estimate for Big Sandy Unit 1 FGD. In addition to the Unit 1 FGD system, a Unit 1 SCR system will also be included as part of the incremental cost estimate.

The following Unit 1 FGD technologies and Unit 1 & 2 flue gas arrangements shall be estimated:

1) Dry FGD – Unit 1 & 2 Stand Alone NID and Fabric Filter without existing dry ESP

The definition of stand alone refers to the gas path. For example, a stand alone arrangement implies that Unit 1 and Unit 2 flue gas enters and exits separate FGD equipment and discharges into separate stack liners contained in a single stack shell.

Although the flue gas path for Unit 1 and Unit 2 is stand alone, all of the FGD auxiliary equipment shall be shared between both units. For example, reagent unloading and preparation shall be sized to accommodate Unit 1 and Unit 2 at full load and full sulfur content, respectively.

## 2.0 TECHNICAL REQUIREMENTS

The technical requirements for Big Sandy Unit 1 FGD system are similar to requirements contained in Big Sandy Unit 2 Order of Magnitude/Relative Capital Installed Cost Estimate Specification BS2-FGDSCE-052010, in which this addendum is part of. Therefore, the technical requirements listed below are items that are only specific for Big Sandy Unit 1.

### 2.1 FGD DESIGN BASIS & PERFORMANCE REQUIREMENTS

[redacted]

[redacted]

Flue Gas Emission [redacted]

[redacted]

Note:
[redacted]

### 2.1.2 FUEL DATA

The Big Sandy Unit 1 FGD installed and design basis fuel is the existing low sulfur coal, which is a 1.7 lb/MMBtu SO2 currently being burned pursuant to compliance purposes. See Table 2.1.2 for the coal analysis.

The following base case fuel for Big Sandy Unit 2 shall be used in conjunction with Unit 1 FGD.

Unit 2 Dry FGD NID and Fabric Filter – 3.0 lb/MMBtu SO2

Table 2.1.2. Big Sandy Unit 1 Fuel Analysis – 1.7 lb/MMBtu SO2.

# 1.7 lb SO2/mmBTU

## 100% Central Appalachian Coal

**Mine Name:** Harris #1

**Mine Location:** Boone County, W. Va.

**Seam Name:** Eagle

| Proximate Data: | As Received: | Dry Basis: (Calc) |
|---|---|---|
| % Moisture: | 6.20% | |
| % Ash : | 11.60% | 12.37% |
| % Volatile Matter: | 30.20% | 32.20% |
| % Fixed Carbon: | 52.00% | 55.44% |
| Total Proximate: | 100.00% | 100.00% |
| % Sulfur: | 0.94% | 1.00% |
| BTU/#: | 12,242 | 13,521 |
| Moist.-Ash-Free BTU/#: | | 14,893 |
| Grindability: | 45 | |

| Ultimate: | Dry Basis: | As Rcvd: (Calc) |
|---|---|---|
| % Carbon: | 74.00% | 69.41% |
| % Hydrogen: | 5.00% | 4.69% |
| % Nitrogen: | 1.40% | 1.31% |
| % Chlorine: | 0.20% | 0.19% |
| % Moisture: | | 6.20% |
| % Ash: | 12.37% | 11.60% |
| % Sulfur: | 1.00% | 0.94% |
| Ultimate subtotal: | | 94.34% |
| % Oxygen by Diff.: | 6.03% | 5.66% |
| % Total: | 100.00% | 100.00% |

# SO2/mmBTU: 1.48

| Mineral Ash Data: | Dry Basis | | SO3 Free Basis |
|---|---|---|---|
| % $SiO_2$: | 56.50% | | 56.90% |
| % $Al_2O_3$: | 28.40% | | 28.60% |
| % $TiO_2$: | 1.30% | 86.20% | 1.31% |
| % $Fe_2O_3$: | 6.50% | | 6.55% |
| % CaO: | 0.80% | | 0.81% |
| % MgO: | 1.30% | | 1.31% |
| % $K_2O$: | 3.78% | | 3.81% |
| % $Na_2O$: | 0.47% | 12.85% | 0.47% |
| % $SO_3$: | 0.70% | | |
| % $P_2O_5$: | 0.10% | | 0.10% |
| % SrO: | 0.05% | | 0.05% |
| % BaO: | 0.08% | | 0.08% |
| % $MnO_2$: | 0.02% | | 0.02% |
| % Undetermined: | 0.00% | | |

| Ash Fusion Temperature Data: | |
|---|---|
| Reducing Temperatures: | |
| Initial Deformation (ID): | 2680 |
| Softening (H=W): | 2700 |
| Hemispherical (H=1/2W): | 2700 |
| Fluid (Fl): | 2700 |
| Oxidizing Temperatures: | |
| Initial Deformation (ID): | 2700 |
| Softening (H=W): | 2700 |
| Hemispherical (H=1/2W): | 2700 |
| Fluid (Fl): | 2700 |
| Other Data: | |
| T250 Temperature: | 2880 |
| Free Swelling Index: | 7.50 |
| Sulfur Forms: | |
| % Pyritic: | 0.20 |
| % Sulfate: | 0.01 |
| % Organic: | 0.70 |
| Equilibrium Moisture %: | 1.80 |

## 2.1.3 GENERATING UNIT / STEAM GENERATOR INFORMATION

Big Sandy Plant is located in Louisa, Kentucky along the Big Sandy River. The physical address is 23000 Highway 23, Louisa, KY 41230.

Road Access: Entrance to the plant is from U.S. Route 23.
Rail Access: CSX Transportation
Barge Access: No; however barge access is available less than 10 miles away from the plant for construction purposes.

**Big Sandy 1**

| | |
|---|---|
| Full Load Firing Rate | 2,670 MMBTU/hr |
| Nominal Unit Rating (Net) | 278* MW |
| Boiler Type | Pressurized Dry Bottom |
| Firing Method | Wall fired |
| [redacted] | |
| Annual Starts (Hot / Cold) | 6 / 4 |
| [redacted] | |
| Minimum Load Firing Rate | 1,017 MMBTU/hr |
| Unit Ramp Rate | 3 MW/min |
| Air Heater Type | Ljungstrom Rotary Bi-Sector |
| Ignition Fuel | #2 Fuel Oil |
| Particulate Control Device | ESP (cold) |
| Combustion Control Devices | Low $NO_x$ Burner |
| Other Emission Control Devices | None |
| Nominal Flue Gas $O_2$ @ Economizer Outlet | 3.5 % (by volume – wet) |
| Max (upset) Flue Gas $O_2$ @ Economizer Outlet | 4.5 % (by volume – wet) |

* Note: The current Net load rating will drop after retrofit of the FGD system.

## 2.1.4 FLUE GAS CONDITIONS

The FGD System shall be designed to treat the expected nominal inlet flue gas conditions downstream of the ESP at full load.

**Big Sandy 1 – FGD System**

| | |
|---|---|
| Mass Flow | 3.236 * million lbs/hr wet |
| Volumetric Flow Rate | 1,085,595* acfm (at 350°F & 0 inwc static pressure) |
| Average Flue Gas Temperature | 350 ° F |
| Flue Gas Particulate Loading w/ ESP | 0.236 lb/MMBtu |
| Flue Gas Particulate Loading w/o ESP | 7.58 lb/MMBtu |
| Flue Gas NOx w/out SCR | 0.50 lb/MMBtu |
| Flue Gas NOx w/ SCR | 0.05 lb/MMBtu |
| Percent of Flue Gas Treated | 100 % |
| Flue Gas $SO_3$ | 6 ppmv @ 1.7 lb/MMBtu SO2 w/out SCR |

* Note: Calculated gas flow rates are based upon operating the steam generator at 21% excess air and an assumed air in-leakage rate of 20 % to account for air heater leakage and any additional leakage due to conversion to balanced draft operation.

[redacted]

[redacted]

[redacted]

| Landfill Ash and Byproduct | | |
|---|---|---|
| Sulfur | lb/MMBtu | 1.7 |
| [redacted] | | |

[redacted]

[redacted]

[redacted]

| [redacted] | | |
|---|---|---|
| Fuel Sulfur | 1.7 | lb/MMBTU |
| [redacted] | | |

[redacted]

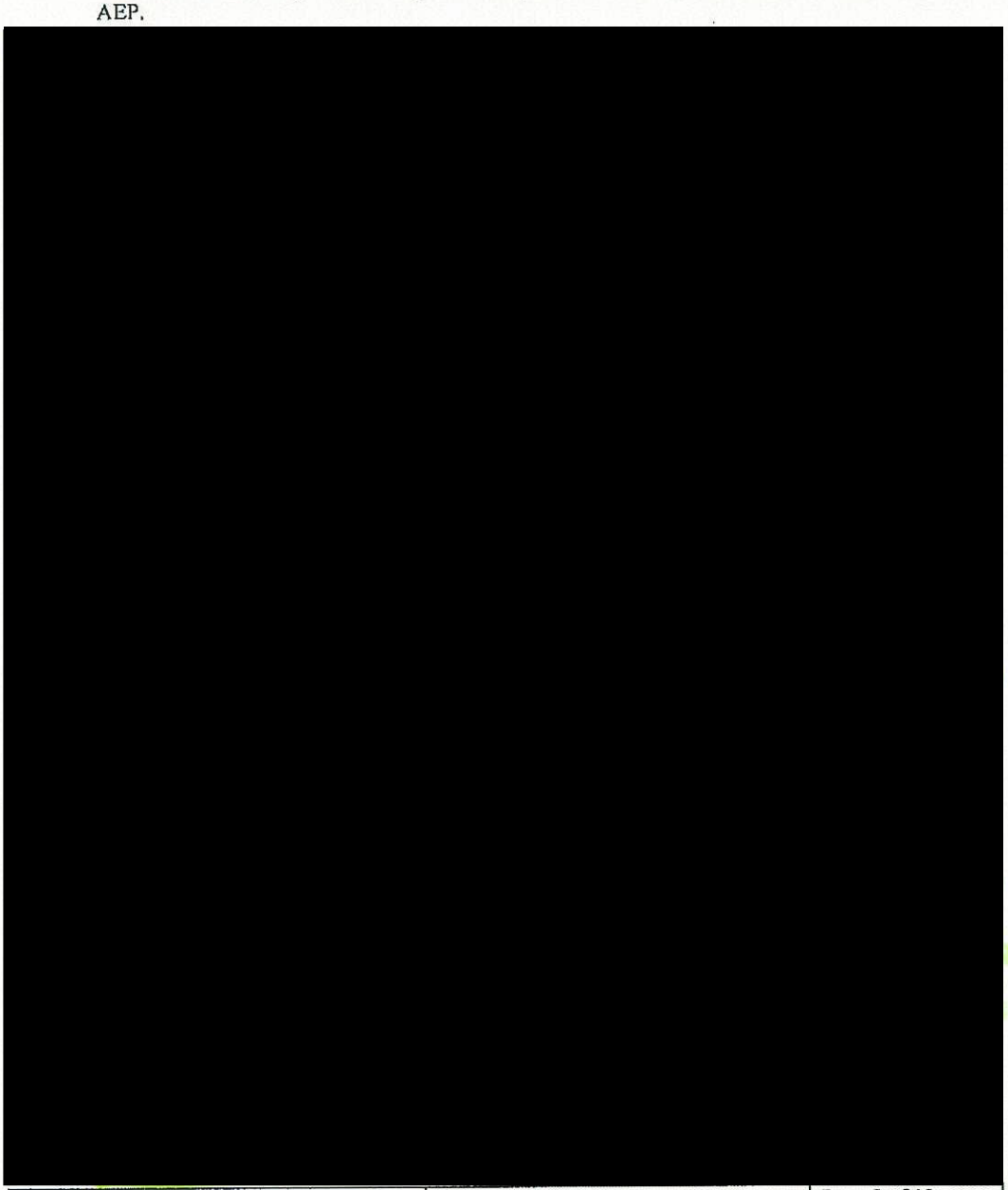
## 2.2 SCR DESIGN BASIS & PERFORMANCE REQUIREMENTS

The following items provide high level design basis requirements for the Unit 1 SCR, which will be included in the Unit 1 FGD incremental cost estimate.

The Big Sandy Unit 1 SCR Technical Performance Specification (BS1-AECE-060805 Rev 0) is attached for reference, but major parts of the specification are described in the following sections.

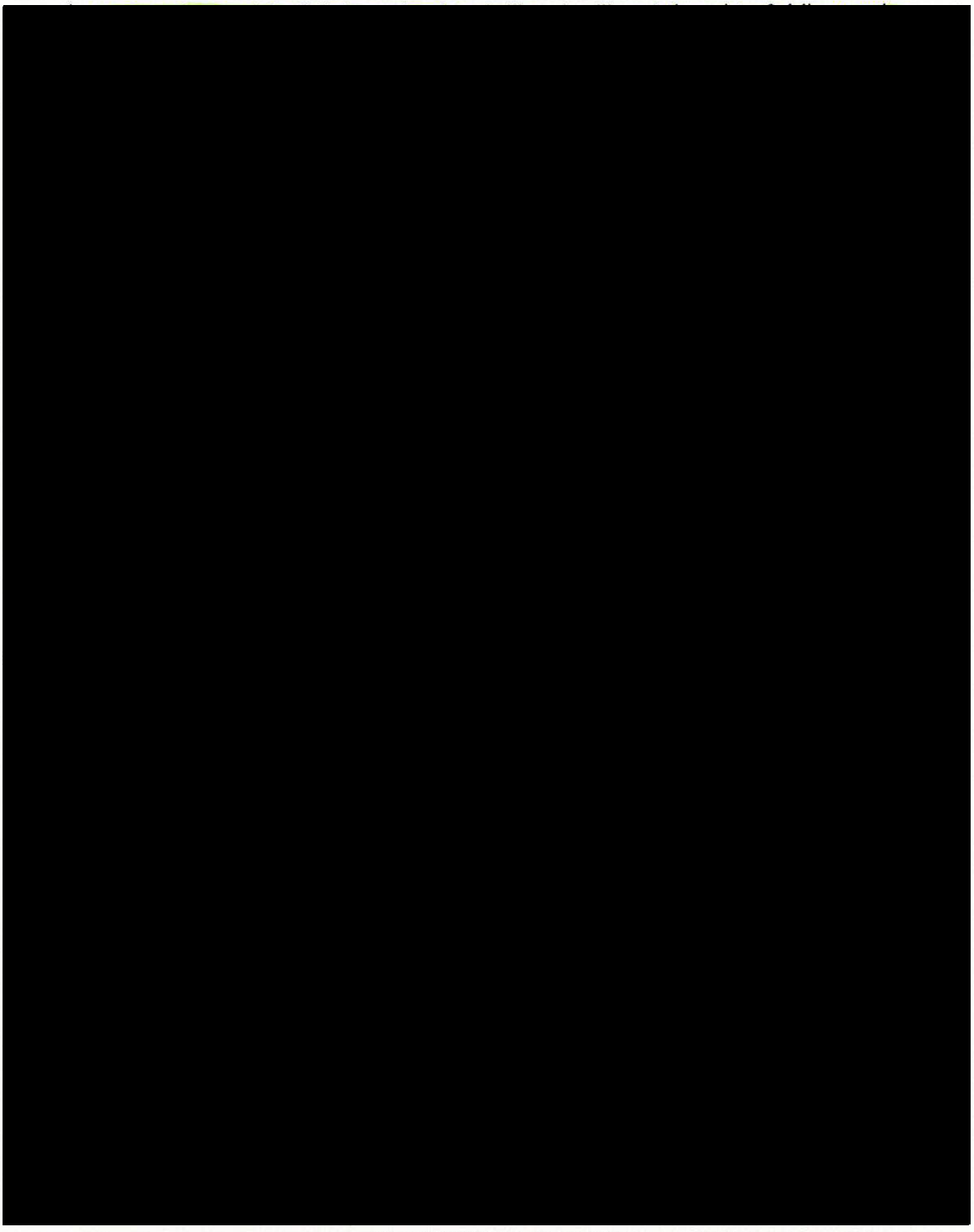
### 2.2.1 NOX REMOVAL EFFICIENCY

The SCR system shall remove a minimum of 90.0% of the NOx produced by the steam generator during all periods of operation from full load to minimum. This includes the unbalanced steam generator firing conditions, which are incurred as pulverizers are removed from service for maintenance or due to normal steam generator load following conditions. Typical load change ramp rates are 3 MW per minute with a maximum of 6 MW per minute. The SCR operation shall not affect the unit ramp rate unless prevented by the SCR heat up rate as reviewed and accepted by AEP.



[redacted]

[redacted]



[redacted]

## 2.2.6 FLUE GAS CONDITIONS

**Table 2.2.6. Unit 1 SCR Flue Gas Conditions.**

| | | |
|---|---|---|
| FULL LOAD | | |
| Load | % MCR | 100 |
| Firing Rate | $10^6$ Btu/hr | 2,670 |
| NUHR | Btu/kWhr | 9,607 |
| Flue Gas Recirc Rate | lb/hr wet | 0 |
| Flue Gas $NO_x$ @ Economizer Outlet | #/MMBtu | 0.55 |
| 1.75 #SO2/MMBtu | | |
| Fuel Flow Rate | lb/hr | 218,163 |
| Flue Gas Flow Rate @ Economizer Outlet | lb/hr wet | 2,696,627 |
| Flue Gas Flow Rate @ Economizer Outlet (–8.0 inwc & 710°F) | acfm | 1,325,832 |
| Flue Gas $O_2$ @ Economizer Outlet (at 21% EA) | % Vol wet | 3 - 4 |
| Flue Gas $SO_2$ @ Economizer Outlet | ppmv | 700 |
| Flue Gas $SO_3$ @ Economizer Outlet | ppmv | 9 |
| Flue Gas Temp – Economizer Outlet | °F | 710 |
| | | |
| MINIMUM LOAD | | |
| [redacted] | | |
| Firing Rate | $10^6$ Btu/hr | 1,017 |
| NUHR | Btu/kWhr | 11,305 |
| Flue Gas Recirc Rate | lb/hr wet | 0 |
| Flue Gas $NO_x$ @ Economizer Outlet | #/MMBtu | 0.27 |
| 1.75 #SO2/MMBtu | | |
| Fuel Flow Rate | lb/hr | 83,111 |
| Flue Gas Flow Rate @ Economizer Outlet | lb/hr wet | 1,098,283 |
| Flue Gas Flow Rate @ Economizer Outlet (–8.0 inwc & 580°F) | acfm | 480,978 |
| Flue Gas $O_2$ @ Economizer Outlet (at 30% EA) | % Vol wet | 4.5 |
| Flue Gas $SO_2$ @ Economizer Outlet | ppmv | 655 |
| Flue Gas $SO_3$ @ Economizer Outlet | ppmv | 8 |
| Flue Gas Temp – Economizer Outlet | °F | 580 |

[redacted]

## 2.2.8 SITE CONDITIONS

The unit is placed in service using No. 2 fuel oil. Coal is then introduced into the furnace and a combination of oil and coal is burned until the unit reaches minimum load and stable coal combustion can be maintained without oil support. A cold startup, from light off to full load, typically requires 12-24 hours. A hot restart typically requires 6 to 12 hours. No. 2 fuel oil is also used at any load for flame stabilization during upset firing conditions. The unit operates between minimum and full load on a daily basis. Typically it is on Automatic Generation Control and will operate at a load change ramp rate of 3 MW/min with a maximum of 6 MW/min.

## 2.3 TECHNOLOGY OVERVIEWS/EQUIPMENT ARRANGEMENTS

The following provides a narrative overview and conceptual process flow chart for each FGD technology being considered for Big Sandy Unit 1 & 2.

[redacted]

## Technical Specifications Checklist

Project Name: Bid Sandy Unit 1 Incremental FGD/SCR Estimate

Originated by: Chad A. West

Checked by: Gregory M. Gibbs Date: 10/11/2010

Description: Addendum for an incremental cost estimate to include Big Sandy Unit 1 FGD in the Unit 2 FGD order of magnitude relative captial installed cost estimate specification revision 1

*Unique Document ID:* BS2-FGDSCE-052010AD1

| | | Checking Engineer's Initials |
|---|---|---|
| 1. | Purpose of technical specification is identified. | GMG |
| 2. | Technical requirements are identified including: design basis criteria, performance requirements, applicable regulatory, statutory & industrial codes, and ambient environmental conditions. | GMG |
| 3. | Auxiliary services such as power supply (voltage, current, source), air supply (pressure, volume, source), cooling water (pressure, temperature, volume, source), steam (pressure, temperature, volume, source), etc. are identified. | N/A |
| 4. | Off-site fabrication and modular construction requirements are identified. | N/A |
| 5. | Quality, inspection, and testing requirements are identified. This includes testing requirements to determine quality, reliability, or performance of the product are listed and acceptance criteria identified; requirements for bidders to submit documentation of their quality assurance program; requirements for nondestructive examination, including inspections or examinations prior to shipment are identified; and equipment or systems which involve special requirements such as fire protection or special features such as Professional Engineer seals on documents or Underwriter certifications are identified. | N/A |
| 6. | Vendor documentation requirements are identified including: types of documentation required, document submittal requirements, submittal due dates, specific warranty requirements, identify drawings subject to liquidated damages, and document format requirements. | N/A |
| 7. | Shipping and storage requirements are identified including: bill of material requirements, tagging requirements, special shipping & handling requirements, storage requirements such as the use of preservatives and inhibitors, weather protection, etc. are identified. | N/A |
| 8. | Guarantee and guarantee basis are clearly identified. | N/A |
| 9. | Requirements to provide operation and/or maintenance training are identified. | N/A |
| 10. | Requirements for spare parts are identified. | N/A |
| 11. | Requirements to provide field support services such as installation, start up and/or testing assistance are identified. | N/A |

## Technical Specification Checklist cont.

| | | Checking Engineer's Initials |
|---|---|---|
| 12. | Attachments are included such as: data sheets which contain detail to provide a clear understanding and evaluation of the design parameters (pressure, temperatures, flows, etc.), design features and materials of construction; drawings, industry standards, addenda or other documents, and a list of other documents that form part of the technical specification. | GMG |
| 13. | Verify technical specification cover sheet has a title, a technical specification number, date, and a technical specification revision number. | GMG |
| 14. | Verify revision index includes revision number and description of revision. | GMG |
| 15. | Verify that supporting calculations have been performed and checked. | GMG |
| 16. | Appropriate interdisciplinary review complete. | GMG |
| 17. | The specified materials, parts, equipment, and processes are suitable for the required application. | GMG |
| 18. | The specified materials are compatible with each other and the design environmental conditions to which the material will be exposed. | GMG |
| 19. | Plant specific operating data have been verified and if necessary, incorporated into design basis | GMG |
| List others below as applicable. | | |
| 20. | | |
| 21. | | |

Note: Use N/A to indicate check is not applicable.

| G. M. Gibbs | GM Gibbs | 10/11/2010 |
|---|---|---|
| Checked by (Print name legibly) | Checked by (Signature) | Date |

Engineering completed in accordance with SOP 730.04, Technical Specifications and reviewed by:

| | Mechanical Eng. & Design | 10/11/2010 |
|---|---|---|
| Engineering Manager for Tom Hunt | Department | Date |