ROSEMONT MINE TRANSMISSION PROJECT

2009 Plan of Service Study Report
ver. 5.0

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Prepared for: Tucson Electric Power

August 26, 2009
Rosemont is pleased to transmit three hardcopy versions as well as two CDs containing an electronic version of the Rosemont Mine Transmission Project 2009 Plan of Service Study Report version 5.0 prepared by KR Saline and TEP. In addition, I am transmitting two hardcopies and one CD containing the electronic version of the document to SWCA.

This document supersedes prior reports regarding the power transmission to Rosemont.
FOREWORD

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EXECUTIVE SUMMARY

This report documents the technical performance of a transmission plan of service proposed by Rosemont in 2009. It builds upon the findings of prior Tucson Electric Power (TEP) studies of transmission service to the Rosemont mine located in southeast Pima County. The plan proposes construction of a 138 kV line to the mine. The point of origin for the line will be a new 138 kV switching station connected to the existing South to Green Valley 138 kV line. This new switching station is located on a site that also serves as one of three well sites for a new water pipe that will also serve the mine.

Rosemont desires construction power in the 3rd quarter of 2010 and actual mine operation will commence in the 2nd quarter of 2011. The construction power will be provided via a 4.5 mile tie to the existing Greaterville Substation. Greaterville is served by an existing TEP 46 kV line that also serves as the emergency backup to Fort Huachuca. The primary function of the 46 kV line beyond Greaterville is backup to the Fort. This study considered the impact of starting and operating shovels during construction at Rosemont. Operation of two shovels yields acceptable voltage flicker while operation of a third shovel may occasionally result in perceptible voltage flicker at Greaterville. Rosemont will explore operational solutions with TEP if perceptible flicker actually occurs with operation of a second or third shovel.

TEP plans to complete a 138 kV loop out of South by constructing a new line from Canoa Ranch to Duval Clear in 2012. TEP also plans to convert the existing UniSource Electric (UNSE) 115 kV line serving Santa Cruz County to 138 kV and interconnect the line to Vail Substation in 2012. A 2013 power flow case was used to study the proposed Rosemont transmission project under all combinations of these planned TEP system changes. This study also considered the outage or starting of one of the three ball or SAG mills once commercial operation commences at the mine. Transient stability and short circuit impacts of the Rosemont project were also studied.

This study indicates Rosemont’s proposed 2009 Plan of Service (POS), with all TEP recommended capital additions identified through this study implemented, is a technically sound transmission project. Additional capital improvements may be necessary depending upon the results of a voltage study to be initiated as of the date of this report. The POS exhibits no power flow contingency performance thermal overload violations that were not already present with the pre-existing system. However, the amount of TEP load shed required for an EHV multiple contingency increases from 180 MW to 320 MW with the Rosemont facility. Studies also show the Rosemont project is not dependent upon the construction of TEP’s Canoa to Duval Clear 138 kV line in 2012. Nevertheless, K. R. Saline, Inc. (KRSA) has recommended that 66 MVars of 138 kV capacitors be dispersed on the 138 kV loop at South, Green Valley, and Hartt to resolve outage voltage problems when this line is placed in service.

Studies show acceptable motor starting of each of the 22,000 hp ball and SAG mills with 54 MVar of Rosemont shunt capacitors. No transient stability problems were
exhibited by Rosemont’s POS. The POS does increase three phase fault duty by 917 amperes at TEP’s South Substation but poses no threat to circuit breaker ratings. Furthermore, Rosemont’s project has no impact on TEP’s 46 kV emergency service to UNSE’s Kantor Substation since the mine’s load cannot be transferred to TEP’s 46 kV circuit 46C552.
INTRODUCTION

Rosemont Copper (the Customer) has requested retail electric service from Tucson Electric Power Company (TEP) to serve mineral extraction operations at its proposed Rosemont Mine facility in southeast Pima County. The transmission project will serve approximately 118 MVA of shovel, conveyor and mill load with service to commence as early as 1st quarter of 2011. The largest loads are 22,000 HP ball mills (two) and a 22,000 HP SAG mill; the motor load for all three will be controlled via cyclo-convertors to provide soft-start and reduce starting in-rush currents.

Initial study work completed in 2008 evaluated three transmission service options (Options A, B and C) between TEP’s Vail 138 kV or South 138 kV substations and the Customer. Rosemont has now asked TEP to evaluate its 2009 Proposed Plan of Service (POS) depicted in Figure 1 along with other existing and planned transmission lines in the vicinity. Rosemont proposes the new 138 kV line originate at a new switching station in the TEP South to Green Valley 138 kV line and that the line be constructed easterly until it intersects with a Rosemont Substation at the mine.

Rosemont also proposes to construct a water pipeline between the same two sites. The new transmission line and the water pipeline must each traverse or go around the Santa Rita Experimental Range located between the two sites. Several separate or
consolidated routes are likely to be considered for these new facilities. However, routing of these new facilities is not the subject of this study.

Rosemont desires construction power commencing the third quarter of 2010 and until the proposed 2009 Plan of Service transmission facilities are fully operational. The 2008 study proposed construction of a 4.5 mile 46 kV tie line from the mine to TEP’s Greaterville Substation to provide such construction power needs. The Greaterville Substation is served by TEP’s existing South to Ft. Huachuca 46 kV line. However, The mine’s construction power will only be available on an interruptible basis due to TEP’s existing 46 kV line already being used as an emergency backup line for service to Ft. Huachuca.

TEP and Rosemont have selected a third party contractor, K. R. Saline, Inc. (KRSA), to perform a technical study of Rosemont’s 2009 Proposed Plan of Service transmission project. The analysis documented in this report includes power flow, motor starting, transient stability, and short circuit assessments. TEP has performed the short circuit evaluation and KRSA has performed all other analysis. A separate voltage regulation/stability study was initiated with a third party consultant to identify mitigation, if necessary, in the form of passive and/or active shunt compensation devices that are applied at the terminal stations. This voltage study will not influence routing of the 138 kV transmission to serve the mine.

PURPOSE OF STUDY

The primary purpose of the study was to ascertain if Rosemont’s 2009 Proposed Plan of Service:

1. Causes any violations of WECC/NERC criteria in the transmission system supplying the Tucson metropolitan area.¹
2. Is dependent upon the presence of TEP’s new Duval Clear to Canoa Ranch 138 kV line proposed for 2012, OR
3. Adversely impacts UniSource Electric (UNSE) use of the existing 46 kV emergency tie from TEP’s Canoa Substation to UNSE’s Kantor Substation.

The size of the mine’s mills have changed since the 2008 Study. Furthermore, operational characteristics of the mills are now also available. Therefore the operational impacts of losing or shutting down one of the mine’s mills and then restarting it was revisited in this study.

This study has also revisited the construction power capabilities of the existing 46 kV line from South to Ft. Huachuca. Motor starting of a shovel at the mine with normal construction power already in service was simulated as the event that would have the maximum impact on TEP’s 46 kV system. This type of study was not previously performed because of the unknown operational characteristics of the mine’s shovels. A separate section of this report is devoted to this topic.

¹ The purpose is to identify transmission system impacts associated with the potential addition of 120 MW of load in the vicinity of TEP’s Vail and South substations.
**ROSEMONT MINE PROJECT INFORMATION**

The Rosemont Mine project design has progressed and project information has been refined since the 2008 Study was performed. Table 1 provides current general project information about the Rosemont Mine. A one-line diagram of the basic Rosemont Mine Substation model is shown in Figure 2. Specifications for all major equipment modeled in this study are provided in Appendix A.

**Table 1 Rosemont Mine Project General Information**

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosemont Mine Substation Location</td>
<td>T 18S, R 16 E, Section 19, southern Arizona</td>
</tr>
<tr>
<td>Type of Load</td>
<td>Two ball mills, a SAG mill, three electric shovels, associated mine infrastructure and five waterline booster pumps (one served off-site)</td>
</tr>
<tr>
<td>Maximum Load</td>
<td>118 MW (includes 4 waterline booster pumps rated 1.4 MVA each)</td>
</tr>
<tr>
<td>Power Factor (^2)</td>
<td>0.97 for Ball and SAG mills and 0.90 for all other mine load</td>
</tr>
<tr>
<td>Main Substation Transformers</td>
<td>Two 3-phase 138/34.5 kV transformers rated at 70/90/116 MVA, Z=10.0%</td>
</tr>
<tr>
<td>Interconnection Voltage</td>
<td>138 kV</td>
</tr>
</tbody>
</table>

\(^2\) Power factor without reactive compensation added at the Rosemont Mine.
Rosemont plans to commence construction at the mine in the third quarter of 2010. Rosemont’s load during construction will consist initially of a single 3.7 MW shovel. Rosemont’s load may grow during construction to 5 megawatts (MW) of traditional construction power and two additional 3.7 MW shovels may be added. The mine’s substation facilities depicted in Figure 1 are not expected to be operational until the 2nd quarter of 2011. Therefore Rosemont plans to construct and utilize a 4.5 mile tie to TEP’s Greaterville Substation for construction power. Therefore operation of shovels with all other Rosemont construction power already in service has been analyzed during this study.

Prior studies determined there is 22 MW of line capacity available for Rosemont construction power on the existing 46 kV line serving Greaterville Substation. However, TEP’s existing 46 kV line is also used as the emergency tie to Ft. Huachuca for the loss of its Vail to Ft. Huachuca 138 kV line. Interruption of Rosemont’s construction power will therefore be required to enable emergency service to be provided to Ft. Huachuca. This interruption will occur via a direct transfer trip (DTT) scheme. The existing 13.8 kV automatic throw-over (ATO) scheme at Ft. Huachuca will be modified for this purpose to include two-way high-speed communication between Ft. Huachuca and Rosemont Mine to trip and confirm load interruption at Rosemont before completing the ATO at the Fort.

The Rosemont Mine Project also constructs a water pipeline to deliver water from three off-site well sites to the mine. The three well sites are located in the Sahuarita...
area and will have a total of seven wells. The southern well site is also envisioned as the location for the 138 kV switching station that will serve as the point of origin for the Rosemont Transmission Project. A total of five booster pumps will be located along the pipeline to lift the water from the well site elevations to the mine site elevation. The well sites and associated main booster pump are located in TEP’s service area and are assumed to be served via TEP’s distribution system. Each of the remaining 4 booster pumps will be located on the eastern half of the pipeline and in close proximity to the mine. These four booster pumps are included in the mine’s load for this study. It may be determined that Trico Distribution Cooperative can serve one or more of these four booster pumps from its existing distribution system. This would result in a corresponding decrease in load served from Rosemont’s Mine Substation.
STUDY DESCRIPTION & ASSUMPTIONS

This study was conducted using a WestConnect 2013 heavy summer power flow base case. Additional study was done using 2012 and 2014 heavy summer power flow cases to assess potential load serving issues as load grows and changes to transmission topology are made through time. TEP provided modeling that represents TEP and UNSE system in more detail and also represents the basics of the Rosemont Mine 138 kV and 34.5 kV systems. The heavy summer base case was revised to model facility upgrades in TEP’s control area and surrounding transmission systems through 2013. Several TEP planned local transmission upgrades germane to this study are described in the power flow analysis section of this report. The base case includes 500 MW of new Bowie generation and 419 MW of maximum unit commitment (MUC) generation within the local TEP 138 kV system. KRSA worked with Rosemont Copper to update the mine load model details for power flow, motor starting and stability analyses.
Three scenarios were studied using the 2013 Heavy Summer base case and are depicted in Figure 3. Scenario 1 was studied to benchmark TEP’s system performance prior to modeling the interconnection of Rosemont’s Transmission Project. Scenario 1 modeled the UNSE 115 kV line to Valencia in Nogales converted to 138 kV and interconnected at TEP’s Vail Substation rather than WAPA’s Nogales Tap Substation. It also assumed the planned Canoa Ranch to Duval Clear 138 kV line was not yet in service.

Scenario 2 was built from Scenario 1 by modeling the interconnection of Rosemont’s 2009 Proposed Plan of Service depicted in Figure 1. This scenario was used to determine the Rosemont Transmission Project system impact on TEP’s system. This post-project scenario demonstrates system performance without the TEP planned Canoa Ranch to Duval Clear 138 kV line. Scenario 2 was also used to perform a steady state motor starting analysis of the SAG Mill and the two ball mills.

Scenario 3 was built from Scenario 2 by assuming the planned Canoa Ranch to Duval Clear 138 kV line was in service. This new line transforms the two existing radial 138 kV lines into a 138 kV loop out of South Substation. Forming this 138 kV loop improves transmission service reliability to all of TEP substations on the loop. This scenario was used to determine if interconnection of Rosemont’s 118 MW of load would pose any performance violations once the 138 kV loop is formed.
STUDY RESULTS

This section of the report documents the technical results of steady state power flow analysis, transient stability simulations, steady state motor starting analysis of Rosemont’s largest motors, and a short circuit analysis. The Study Methodology and Evaluation Criteria utilized for this study are documented in Appendix B. A list of the 161 Category B (N-1) power flow contingencies and 18 credible Category C and D multiple contingencies performed for this study is provided respectively in Appendices C and D.

POWER FLOW ANALYSIS

Base case (N-0) powerflow violations were noted for the three heavy summer study scenarios described in the previous section of this report. It was determined that all loading violations involved generator stepup transformers outside of the study area. It is assumed these elements basically have incorrect element ratings in the case. No voltage violations were observed. The post project scenarios 2 and 3 did not result in any new base case violations.

The power flow contingencies listed in Appendices C and D were also run for each of the three study scenarios using the 2013 heavy summer base case. Any contingency that resulted in a performance criteria violation was noted and has been documented in Table 2. The table offers a comparison of contingency criteria violations for each of the three study scenarios. A discussion of the outages is provided below.

Summary of Power Flow Contingencies

TEP plans on upgrading its Twenty Second to East Loop line in 2009. The Twenty Second to East Loop line would be overloaded for several single contingencies within TEP’s 138 kV system if it were not improved as planned. With this line upgrade modeled in the 2013 case none of the 161 single contingency outages studied caused an overload for any of the three scenarios studied.

A voltage problem did occur in Scenario 3 for loss of the South to Hartt 138 kV line. Scenario 3 assumes the Canoa Ranch to Duval Clear 138 kV line is constructed and forms a 138 kV loop out of South. The voltage problem occurs when the load on that loop (including Rosemont) is served solely by the existing South to Duval Clear line. The outage would not solve in the original case due to excessively low voltages. However, dispersing 138 kV capacitors on the loop at South, Green Valley and Hartt resolves the voltage problem. A total of 66 MVars of capacitors is needed among the three sites to achieve a voltage deviation of less than 5% for the South to Hartt 138 kV outage in Scenario 3 as depicted in Table 2.
Table 2  SCENARIO 3: South - Hartt 138 kV Outage with Proposed Capacitor Placement

<table>
<thead>
<tr>
<th>Bus</th>
<th>Voltage</th>
<th>Capacitor Addition (Mvar)</th>
<th>Base Case Voltage (pu)</th>
<th>Outage Voltage (pu)</th>
<th>Δ Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>138 kV</td>
<td>24</td>
<td>1.030</td>
<td>1.019</td>
<td>1.1%</td>
</tr>
<tr>
<td>Hartt</td>
<td>138 kV</td>
<td>24</td>
<td>1.040</td>
<td>0.996</td>
<td>4.4%</td>
</tr>
<tr>
<td>Green Valley</td>
<td>138 kV</td>
<td>18</td>
<td>1.035</td>
<td>0.994</td>
<td>4.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>66</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TEP has also planned several other system improvements to mitigate overloads that could otherwise occur for several credible multiple contingencies. TEP plans to convert its Tortolita to North Loop 138 kV Circuit 3 into a Tortolita to Rancho Vistoso line in 2010. TEP also plans to upgrade four other 138 kV lines: East Loop to Pantano, Irvington to Twenty Second, Irvington to Tech Park, and Tech Park to Vail. The upgrade of these lines to a higher rated capacity is planned for 2009 and 2010 prior to Rosemont’s 2011 commercial date. With the above TEP planned transmission improvements modeled in the 2013 base case only one of the eighteen credible multiple contingencies studied resulted in line overloads as depicted in Table 3.

Table 3  Credible Multiple Contingency Summary

<table>
<thead>
<tr>
<th>OVERLOADED ELEMENT</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Project</td>
<td>Rosemont POS</td>
<td>Rosemont w/ Canoa Ranch Loop</td>
</tr>
<tr>
<td>FROM NAME</td>
<td>kV TO NAME</td>
<td>kV</td>
<td>CKT</td>
</tr>
<tr>
<td>Apache</td>
<td>230</td>
<td>Butterfield</td>
<td>230</td>
</tr>
<tr>
<td>Butterfield</td>
<td>230</td>
<td>Sloan</td>
<td>230</td>
</tr>
<tr>
<td>Sloan</td>
<td>230</td>
<td>Pantano</td>
<td>230</td>
</tr>
<tr>
<td>Pantano</td>
<td>230</td>
<td>New Tucson</td>
<td>230</td>
</tr>
<tr>
<td>New Tucson</td>
<td>230</td>
<td>Sahuarita</td>
<td>230</td>
</tr>
<tr>
<td>Sahuarita</td>
<td>230</td>
<td>Bicknell</td>
<td>230</td>
</tr>
</tbody>
</table>

Load Shed: ** 180 MW 320 MW 320 MW

Outage Descriptions:
1. Winchester - Vail and Springerville to Vail 345 kV lines
1*. Winchester - Vail and Springerville to Vail 345 kV lines with Bowie units tripped
1**. Winchester - Vail and Springerville to Vail 345 kV lines with Bowie units tripped and Load Shed amount shown
The loss of both the Springerville to Vail 345 kV line and the Winchester to Vail 345 kV line is the only multiple element contingency studied that exhibited performance problems. This outage is a known pre-existing problem and overloads Southwest Transmission Cooperative’s 230 kV lines from Apache to Bicknell. Mitigation measures have previously been studied and planning studies are still being performed by all involved parties to determine the most effective long term solution to power line problems traversing Cochise County.\(^3\)

The Bowie Power Plant Project plans a remedial action scheme to trip its generating units for loss of both 345 kV lines.\(^4\) Tripping the Bowie Power Plant mitigates all overloads except the Apache to Butterfield segment of Southwest Transmission Cooperative’s 230 kV lines. Even after tripping the Bowie generating units, load shedding is required in TEP’s local 138 kV system to mitigate overload of the Apache to Butterfield line. This outage sheds 180 MW for Scenario 1 and 320 MW is shed for Scenarios 2 and 3. Both remedial action schemes (tripping Bowie and shedding TEP load) are currently viewed as acceptable planned solutions for this Category C event.

**Mill Motor Starting Results**

For the motor starting portion of this study, the three large mill motors were modeled as constant current loads with a starting current of 1.5 times operating current. The SAG and Ball mill drives are 22,000 HP each and operate at a power factor of 0.97 lagging.\(^5\) A mill may be shut down and restarted approximately once per month. A 12 MVar capacitor was assumed to be located at each 34.5 kV bus in the Rosemont Mine Substation model as depicted in Figure 2. The two 138/34.5 kV transformers each have load tap changer capability but were assumed to be fixed at 1.0 per unit tap setting for the motor starting studies.

The study process involved determining the additional power factor correction required to maintain a 1.0 per unit voltage at the 34.5 kV bus with all mine load and mills fully operational. It was determined that a total of 54 MVar of shunt capacitors are required to assure suitable voltage regulation with the mills in various states of operation. To achieve and maintain an appropriate voltage profile 17 MVar capacitors are required at each 34.5 kV bus rather than the 12.5 MVar capacitors shown in Figure 2. In addition each mill transformer should have a 6.75 MVar capacitor that is connected at its 138 kV terminus that is automatically switched on and off with the respective mill. This avoids an excessive voltage rise during loss or shutdown of a mill and manages the voltage drop when starting a mill.

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\(^5\) Manufacturer’s data, Appendix A, pages 2-6.
Table 4 Voltage Response During A Mill Shut Down & Restart

<table>
<thead>
<tr>
<th>Mill Operational Status</th>
<th>A Full Operation</th>
<th>B SAG Mill or Ball Mill #2 Events</th>
<th>C Loss / Shut Down</th>
<th>D Re-Start</th>
<th>E Ball Mill #1 Events</th>
<th>F Loss / Shut Down</th>
<th>G Re-Start</th>
<th>H</th>
<th>I</th>
<th>Delta V (%)</th>
<th>Delta V (%)</th>
<th>Delta V (%)</th>
<th>Delta V (%)</th>
<th>Delta V (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Name</td>
<td>kV Mvar Voltage Voltage Delta V (%) Voltage Delta V (%) Voltage Delta V (%) Voltage Delta V (%)</td>
<td>Voltage Delta V (%) Voltage Delta V (%) Voltage Delta V (%) Voltage Delta V (%)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ball Mill #1</td>
<td>4.16 6.8 0.998 1.004 0.60% 0.987 -1.70% 0.996 -0.20% 0.974 -2.20%</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SAG Mill</td>
<td>4.16 6.8 0.996 1.001 0.50% 0.980 -2.10% 1.001 0.50% 0.984 -1.70%</td>
<td></td>
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</tr>
<tr>
<td>Ball Mill #2</td>
<td>4.16 6.8 0.996 0.994 -0.20% 0.971 -2.30% 1.001 0.50% 0.984 -1.70%</td>
<td></td>
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<tr>
<td>rosemont1</td>
<td>34.5 17.0 0.992 0.997 0.50% 0.981 -1.60% 0.996 0.40% 0.978 -1.80%</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>rosemont2</td>
<td>34.5 17.0 0.989 0.994 0.50% 0.975 -1.90% 0.995 0.60% 0.979 -1.60%</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>rosemont</td>
<td>138 0.0 0.990 0.995 0.50% 0.979 -1.60% 0.995 0.50% 0.980 -1.50%</td>
<td></td>
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</tr>
</tbody>
</table>

Total 54.3

Notes: a (+) Delta V is a % voltage rise and (-) is a % voltage drop
All transformer taps locked at 1.0
6.75 MVAR Cap banks switched with Mills
DCA 5-13-09

The Rosemont substation steady state voltages for the full spectrum of operating conditions are recorded in Table 4. After a mill restarts the substation voltages return to a full operation voltage level. The maximum voltage deviation occurs when re-starting the SAG mill or Ball mill #2. Observed operational voltage deviations ranged between a 0.6 % rise and 2.3 % drop depending on which mill is experiencing a status change. Since these motors are typically only started once per month, this is an acceptable performance.

Emergency Service to Kantor

Figure 8 depicts the existing 138 kV and 46 kV systems serving TEP’s Green Valley area. The 138 kV and 46 kV systems are each operated independently as radial lines served by South Substation. South Substation is the only point of interconnection of the two systems. TEP annually performs a summer preparedness study for this area to assure there is sufficient system capacity to serve their Green Valley area load requirements. TEP also utilizes its Green Valley 46 kV system to provide 46 kV emergency service to UNSE’s Kantor Substation for loss of its radial transmission line.

TEP’s 46 kV circuit 46C552 served from South substation is used to back up the Kantor 115/13.2 kV substation for loss of the radial 115 kV line serving the four UNSE substations in Santa Cruz County. The UNSE radial 115 kV line serving Santa Cruz County currently originates at WAPA’s Nogales substation. TEP’s circuit 46C552 is rated at 49 MVA and also serves Canoa, Cyprus Esparanza Wells, Cyprus Raw Water Supply and Cyprus Raw Water Booster. TEP’s load on circuit 46C552 increases to 36.6 MW by 2016 which leaves 12.4 MW of capacity margin to serve the 12.5 MVA rated transformer at Kantor on an emergency basis. TEP’s 2008 Summer Preparedness Study concludes sufficient capacity exists to serve its Green Valley Area.
load and provide emergency service to Kantor through 2016. UNSE’s 46 kV emergency service needs for Kantor are not mitigated by the conversion of its 115 kV line to 138 kV service for Santa Cruz County.

Circuit 46C552 also is currently used to provide backup service for the outage of the South to Green Valley 138 kV line. This 138 kV line will extend to Canoa Ranch in 2009. The 138 kV Green Valley and Canoa Ranch load is transferred to the 46 kV circuit for an outage of the 138 kV line. By 2012 there is insufficient 46 kV substation transformer capacity on circuit 46C552 to accommodate the load transferred for the 138 kV line outage. Therefore, TEP plans to construct an 8.5 mile 138 kV line from Canoa Ranch to Cypress Sierrita to complete a 138 kV loop out of South Substation in 2012. This will negate the need for future backup service via the 46 kV circuit for a South to Green Valley 138 kV line outage.

The Rosemont transmission project proposes to interconnect to the existing South to Green Valley 138 kV line in 2011. Rosemont’s 138 kV line is also a radial and affords no opportunity for transferring the mine’s load to circuit 46C552 for an outage of the line. Therefore, Rosemont’s project poses no exposure to TEP’s practice of using its 46 kV circuit to provide backup service for either an outage of the South to Green Valley 138 kV line or emergency 46 kV service to UNSE’s Kantor Substation for loss of the transmission line serving Santa Cruz County.

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6 TEP’s 2008 Green Valley and Kantor Substation Summer Preparedness Report, April 2008
Figure 4  TEP’s Existing 46 kV South System

7 TEP’s 2008 Green Valley and Kantor Substation Summer Preparedness Report, April 2008
Rosemont Construction Power Considerations

TEP also has another 46 kV line originating at South Substation that is not depicted in Figure 4. It provides 46 kV service to Hartt and Greaterville Substations as depicted in Figure 5. This circuit also serves as an emergency backup to Fort Huachuca for loss of TEP’s 138 kV line from Vail to the Fort. This 46 kV circuit has an emergency service capacity of 22 MVA. Rosemont proposes to take construction power from this 46 kV circuit from the 4th quarter of 2010 until Rosemont’s 138 kV line and substation are operational in the 2nd quarter of 2011.

![Existing 46 kV Line from South to Ft. Huachucha](image)

**Figure 5 Construction Power via Existing 46 kV Line**

Initial construction load at the mine will include the operation of one shovel. The peak power requirement for a shovel is 3706 kW at a 1.0 power factor. A second shovel will likely begin operation in the 1st quarter of 2011; while a 3rd shovel could also commence operation prior to Rosemont’s 138 kV line and substation being operational. Each shovel can complete two cycles of operation per minute as depicted in Figure 6. There will be occasions when all of the shovels can present a coincident load equivalent to the peak load of each shovel in service. The non-shovel load requirements during construction will consist of traditional construction power with a peak in the range of 3 MW. Rosemont anticipates that its construction subcontractors will provide their own power requirements during construction and that non-shovel related construction power will likely not be required of TEP.

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8 Shovel manufacturer’s data, Appendix A, page 17.
A steady state analysis of potential voltage flicker problems has been undertaken due to the operational characteristics of a shovel being repetitive with a short cycle time. The existing system (Scenario 1) base case was used to study shovel operation during Rosemont’s construction period. The existing 46 kV line from South to Greaterville was

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Figure 6 Shovel Operating Characteristics

A steady state analysis of potential voltage flicker problems has been undertaken due to the operational characteristics of a shovel being repetitive with a short cycle time. The existing system (Scenario 1) base case was used to study shovel operation during Rosemont’s construction period. The existing 46 kV line from South to Greaterville was

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9 Shovel manufacturer's data, Appendix A, page 17.
modeled along with a 4.5 mile tie from the Rosemont mine to Greaterville. Two different Rosemont construction tie configurations were studied. The first tie line configuration assumed a 46 kV tie and also modeled a 12/16/20 MVA rated 46/34.5 kV transformer at the mine and a 4 MVA rated 34.5/7.2 kV transformer for each shovel. The second tie line configuration assumed a 138 kV tie with a 138/46 kV transformer located at Greaterville and eliminated the need for a Rosemont construction power 46/34.5 kV transformer at the mine in advance of Rosemont’s two 138/34.5 kV transformers.

Voltage flicker standards have not been adopted on an industry wide basis. However, voltage flicker in excess of 5% would likely be perceptible at a consumer's service voltage when occurring at a rate of two or more fluctuations per minute\(^\text{10}\). A 5% flicker limit seems reasonable to use to as a performance measure since a Rosemont shovel can complete two cycles of operation per minute. Greaterville Substation is the only TEP substation with retail customers on the 46 kV line that will be used by Rosemont for construction power. Therefore, voltage flicker above 5% at the 46 kV Greaterville Substation was used as an indicator of potential flicker perceptibility by distribution customers served by that substation.

The amount of voltage flicker experienced while operating shovels during construction is proportional to the number of shovels in operation and the level of non-shovel construction load served. Table 5 depicts the voltage flicker that can be experienced with unintended synchronized shovel operation with a Rosemont 46 kV tie to TEP’s Greaterville 46 kV circuit. Table 6 depicts voltage flicker for the same shovel operations with a Rosemont 138 kV tie to Greaterville. There is no significant difference in the flicker level experience at Greaterville with either the 46 kV or 138 kV tie. However, the 138 kV tie does result in a lower flicker level at Rosemont.

Table 5 and 6 indicate that Rosemont may be limited to operating two shovels even if no other construction related load is being served. Rosemont’s mine operation application with the US Forest Service already assumes portable generators may be used on-site during construction. Adding an onsite mobile generator called a Motorvator (rated 1.6 MW at 0.85 pf) fails to reduce the voltage flicker at Greaterville below 5% for the operation of three shovels. Nevertheless, addition of a Motorvator generator would enable Rosemont to operate two shovels even with 3 MW of non-shovel load. A generator comparable to the Motorvator may be helpful mitigating flicker if it becomes problematic.

Flicker results depicted in Tables 5 and 6 do not necessarily preclude operation of a third shovel for two reasons. The probability that the shovels would indiscriminately become synchronized for even one operational cycle is very low. Indiscriminate synchronization of three shovels is not likely to occur at a rate of more than several fluctuations per hour where voltage flicker is not perceptible below 7 - 8\%.\(^\text{11}\) Secondly, the amount of flicker that would actually be experienced by Greaterville customers has


\(^{11}\) Ibid
not been determined. In actuality the flicker will attenuate as a result of two additional voltage transformations between the Greaterville 46 kV substation and the customer’s service voltage. Rosemont will explore operational solutions with TEP should the actual flicker experienced by customers become problematic.

**Table 5 Shovel Induced Voltage Flicker with 46 kV Construction Tie**

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* 0.90 pf  
** 0.85 pf Motorvator

**Table 6 Shovel Induced Voltage Flicker with 138 kV Construction Tie**

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* 0.90 pf  
** 0.85 pf Motorvator
TRANSIENT STABILITY RESULTS

Transient stability studies were conducted on both Scenario 1 (pre-project) and Scenario 2 (post-project) using the heavy summer base case. The transient stability runs were simulated for 10 seconds to ensure the system was stable and positively damped. Prior Rosemont studies performed in 2008 for TEP demonstrated that the system is stable and damped for all contingencies studied for the pre-Rosemont Project and post-Rosemont Project cases.\textsuperscript{12} Therefore only the two most critical TEP outages were restudied to confirm prior conclusions are still valid with the 2009 Rosemont Proposed Plan of Service: an Irvington 138 kV bus differential and an outage of the Pinal West to South and Winchester to Vail 345 kV lines.

The two line outage was assumed to be an N-1-1 event since they do not share a common corridor or termination. One of the lines is assumed as initially out of service and then a fault trips the other line. Therefore there are two stability simulations required for this outage – each assumes a different line is initially out of service. A fourth stability simulation modeled loss of the entire Rosemont load due to a fault at the Rosemont 138 kV bus. Three phase faults were applied for each of the four cases studied.

Plots for all four events are provided in Appendix E. The performance of the stability runs were monitored in compliance with the Study Methodology and Evaluation Criteria located in Appendix B. Table 7 summarizes the results of the four transient stability simulations. No stability problems existed for the four events simulated. There is no noticeable difference between the pre-project and post-project plots.

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<th>FAULTED CONDITION</th>
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Table 7 Transient Stability Summary Results

SHORT CIRCUIT RESULTS

To perform the short circuit study, the Rosemont Mine load addition was modeled in the TEP short circuit base case using the ASPEN One-Liner software. This case originated from the proposed Bowie Power Station post-project short circuit model. The data depicted in Figure 8 was used to prepare the short circuit case.

Table 8 summarizes the short circuit magnitude for three-phase and single-line-to-ground faults for the pre-project and Scenario 2 post-project condition. Fault duty data in Table 8 is sorted from the highest incremental three-phase to the lowest in order of magnitude for the regional buses. The fault current at the Point of Interconnection (POI) is highlighted.

The South substation 138 kV bus sees a 917 ampere increase in 3-phase fault current. Otherwise, there appear to be no post-project conditions that appreciably increase fault duty beyond the pre-project values. Mitigation of any fault duty in excess of circuit breaker interrupting capability pre-project may cover mitigation of these issues post-project.
Figure 8  Rosemont Short-Circuit Single-Line Impedance Diagram
## Table 8  TEP System Fault Duties

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Table 8  TEP System Fault Duties

August 26, 2009  23
CONCLUSIONS

This study indicates Rosemont’s proposed 2009 Plan of Service (POS) is a technically sound transmission project. Performance of the POS under a variety of system configurations has been examined. It exhibits the following traits under different operational conditions.

TEP has already planned transmission improvements prior to Rosemont’s interconnection. No single contingency outages resulted in overloads with the TEP planned improvements modeled. Rosemont’s POS exhibits no multiple contingency power flow contingency performance violations that were not already present with the pre-existing system. An outage of the Winchester to Vail 345 kV line and the Springerville 345 kV line requires tripping of the Bowie generators and the shedding of TEP load. The amount of load that TEP must shed for this event increased from 180 MW to 320 MW with the Rosemont facility.

The only single contingency that exhibited a voltage violation was the loss of the South to Hartt 138 kV line in Scenario 3. Redistribution of 66 MVar of TEP planned capacitors among South, Green Valley, and Hartt potentially resolves this voltage issue. A separate comprehensive voltage/stability study has been initiated to determine the optimal size and location of 138 kV capacitor banks. Maintaining the recommended level of shunt capacitance on the system may alleviate low voltage following the South to Hartt contingency. However, it is prudent for the transmission system to be evaluated for overvoltage during light load and Delta-V when specified capacitor bank are switched. To the extent capacitors may become the equivalent of must-run devices, they may impact TEP’s ability to perform long-term capacitor planning in the most economical manner. Fast switched banks (as part of a local area protection scheme) or a source of dynamic VArS may be required. With the relocation of the capacitors for Scenario 3 the Rosemont POS performs in a common fashion with and without the Canoa Ranch to Duval Clear 138 kV line planned for 2012. Therefore, the Rosemont project is not dependent upon the construction of the Canoa Ranch to Duval Clear line.

Studies show acceptable performance for motor starting or loss of each 22,000 hp ball and SAG mill with 54 MVar of Rosemont shunt capacitors. Each 34.5 kV bus serving a mill requires a 17 MVar capacitor to achieve and maintain a 1.0 per unit bus voltage at full mine operation. Each mill should also have an additional 6.75 MVar capacitor switched on and off with the mill. The range of voltage excursions that occur with these capacitors in place ranges between a 0.6 % voltage rise and a 2.3 % voltage drop when losing and restarting one of the mills.

Rosemont prefers that its construction power be provided via a 138 kV tie from Greaterville to Rosemont rather than a 46 kV tie. The operation of two shovels is void of voltage flicker concerns at Greaterville with either tie. However, the voltage flicker experienced at Rosemont with the operation of more than one shovel is lower with a 138 kV tie. Use of a 138 kV tie also eliminates the need for a construction power 46/34.5 kV transformer at the mine. Operation of a third shovel during Rosemont
construction may occasionally result in perceptible voltage flicker for Greaterville customers. Rosemont will explore operational solutions with TEP if actual flicker problems are experienced by TEP customers with operation of a third shovel during construction.

The transient stability and short circuit study of the Rosemont POS yielded favorable results. No transient instability was exhibited for the three phase fault events studied. The three phase fault current at South increased only 917 amperes in the short circuit study. This is the maximum fault current increase observed. This minimal fault current increase does not pose a threat for circuit breaker ratings.

There is no physical means for Rosemont’s load to be switched from its 138 kV line to TEP’s 46 kV circuit 46C552. This is the 46 kV circuit that TEP uses to provide emergency serve to Kantor for loss of the UNSE line serving Santa Cruz County. Therefore, Rosemont’s transmission project has no impact on TEP’s 46 kV emergency service to UNSE’s Kantor Substation.
Appendix A

Major Equipment Specifications

SAG Mill Drive Motor Page 2
Ball Mill Drive Motors Page 3
Motor Characteristics Page 4
Motor Starting Curve Page 6
495 Shovels Page 7
**Electrical Data**

Date 26-06-2008  
Rev 1  
Project ROSEMONT SAG 36’  
Type WAZ 1410/88/72  
Comments 16.41 MW (22000 HP)

### Electrical data table

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* Basic wave, line to line voltage

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Electrical Data

Date: 11-12-2007
Rev: 0
Project: ROSEMONT BALL 26'
Type: WAZ 1110/118/60
Comments: 16.41 MW (22000 HP)

Electrical data table

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* Basic wave, line to line voltage
Starting curve

SAG Mill, Starting in Normal Mode

- SAG mill starts in "normal mode" (load about 70%)
- Speed to start in normal mode is about 1.3rpm, remaining for about 40s to check frozen charge
- Material is cascading at about 55°
- Starting current during cascading is about 75% of nominal, for about 3 sec.
- After cascading, static current is about 50% of nominal
CH1 [V/div]: MOTOR SPEED (100 V = 12rpm)
CH2 [V/div]: AIR GAP PR0.08E
CH3 [V/div]: MOTOR CURRENT (8V = nominal current)
CH4 [V/div]: MOTOR VOLTAGE (8V = nominal voltage)
CH5 [V/div]: EXCITATION CURRENT (10V = nominal current)
CH6 [V/div]: MOTOR FLUX (8V = nominal flux)
ELECTRICAL SPECIFICATIONS
STANDARD EQUIPMENT
ACUTROL™ PWM (IGBT)
495HR DUAL PROPEL SHOVEL

POWER REQUIREMENTS

Voltage

The machine is designed to operate on a nominal system voltage of 7,200 volts. This means that the instantaneous voltage at the terminals of the shovel may not drop lower than 5,760 volts or rise above 7,920 volts.

Power Requirements

The repetitive peak power required by this machine may rise as high as 3,706 kW, at 1.0 power factor assuming that the standard machine is purchased. Optional equipment may require that larger power peaks be supplied. The 15-minute demand is expected to range between 926 and 1,297 kW for the standard machine.

Recommended Power Supply Transformer

If this machine is to be the major load on the distribution system, our experience shows that a 4,000 KVA transformer must be used to supply the machine its power. This size of transformer allows for normal distribution system impedance and usually will help to maintain the voltage limitations listed in paragraph one.

If this machine is connected to a large distribution system where voltage fluctuation at the machine terminals is not of concern, then 2,040 KVA must be reserved within the system to supply this machine.

Recommended Trail Cable at 2000 Ft. (609 meters) Length

Type SHD-GC three conductor 1/0 at 8000V cable can be used to supply this machine with normal distribution system capability (at 40°C ambient).

A ground wire and a pilot wire for a ground check system must be supplied for proper personnel safety.

Customer Provided Protection

It is normal for excavators to be supplied without overcurrent or thermal overload protection for the main transformer.

These devices are omitted because:

1. The customer must provide them for trail cable protection.
2. Sensitive relays such as these often misoperate due to vibration, thus, it is better to locate them off of the machine.

Because of the above, it is recommended that the customer provide a minimum of:

1. Instantaneous overcurrent protection.
2. Grounding of the machine.
3. Inverse time overcurrent protection.
4. Ground check system.

**A-C HIGH VOLTAGE APPARATUS AND CONTROL**

**Main Transformer**

2,400 KVA, 7,200 – 900 volts, 3 phase, 60 HZ, ±5% taps. Air-cooled with special bracing for excavator service.

**Switchgear and Control**

The main collector rings are located between the revolving frame and the truck frame. The rings are made of steel and the shoes are a graphite impregnated type. Fused disconnect is included in the primary of auxiliary transformer.

The main transformer is energized automatically. A vacuum contactor of 7,200 volts, 400 amp, 50,000 KVA interrupting rating is provided for this function. Fused for 200 MVA short circuit.

Other features provided for protection and for improved operation are:

1. Phase reversal protection.
2. Undervoltage release.

**AUXILIARY AND CONTROL TRANSFORMERS**

**Auxiliary Transformer**

One 350 KVA, 7,200 volt primary, 480 with ±2.5% and ±5% taps “WYE” volt secondary, floor mounted dry type, auxiliary transformer is included. This unit is specially braced for shovel service. The secondary of the auxiliary transformer is connected to an auxiliary power breaker (APB) in the motor control center (MCC). The APB feeds all of the other 3-Phase auxiliary loads on the machine. All 3-Phase auxiliary loads can be isolated with a dedicated MCC breaker.
Control Transformers
Two 25 KVA, 480 volt primary, 120/240 - volt secondary, dry type lighting transformers are included. A 20 KVA 480V/190V transformer is used for the dipper trip system. Also, a 5kVA 480V/240V/120V constant voltage transformer is used to power the PLC system.

A-C POWER APPARATUS AND CONTROL

A-C Motors

1. General

All A-C motors used to power the main motions of this machine have AISE tapered shafts. These standardized shovel motors are especially designed to meet severe operating conditions encountered in excavator service.

All units are connected to variable voltage, variable frequency pulse width modulated inverter drive systems. All main motion motors are force ventilated and have side air discharge for improved cooling.

2. Hoist

The hoist motion uses one 2,600 HP (1,938.8 kW), A-C motor rated 1,400 volts to provide its power. A-C power for the hoist motor is provided by two 1,245 KVA inverters rated 1,400 volts. The motor is speed regulated and torque limited.

3. Crowd

The crowd motion uses one 700 HP (522 kW), A-C motor rated 1,400/700 volts to provide its power. A-C power for the crowd motor is provided by one 1,245 KVA inverter rated 1,400 volts. The motor is speed regulated and torque limited.

4. Swing

The swing motion uses two 505 HP (376.6 kW), A-C motors rated 1,400/700 volts to provide its power. A-C power for the swing motors is provided by one 1,245 KVA inverter rated 1,400 volts. The motors are torque regulated and speed limited.

5. Propel

The propel motion uses two 700 HP (522 kW), A-C motors rated 1,400/700 volts to provide its power. A-C power for the propel motors is provided by the hoist and crowd inverters. The motors are speed regulated and torque limited.

Automatic transfer from hoist to propel is achieved by operation of a selector switch at the operator’s station. The propel transfer motor is rated ½ Hp (0.37)kW.
IGBT Acutrol Drive System

The AC motors for the main motions are controlled from the Bucyrus IGBT Acutrol drive system. The IGBT Acutrol drive system is a digital microprocessor based variable voltage, variable frequency drive that was specifically designed for mining applications. A brief description of the drive system follows.

Motors - IGBT Acutrol uses heavy, excavator duty AC squirrel cage motors that have no commutator maintenance, do not have flashovers, have simple maintenance, and better thermal capabilities as compared to DC motors. These motors are specially designed to Bucyrus specifications.

Productivity - Superior performance is the result of using excavator duty AC squirrel cage motors. The absence of commutation limits enables the AC drive to operate with a greater area under the speed torque curve than a comparable static DC system. Faster lowering speeds result in reduced times during the swing return to the pit, especially for smaller swing angles.

Power and control electronics - The IGBT system provides modular, solid state power and digitally controlled electronics, which are extremely reliable and easily maintained. The system also uses a diagnostic computer (Maintenance Station) with graphic and text troubleshooting aids. This Maintenance Station provides rapid diagnosis of machine faults via graphics, schematics and text. The IGBT system has been designed in a modular fashion to permit interchangeability of parts, consequently reducing the parts inventory essential for good availability.

Compatibility - IGBT Acutrol provides a breakthrough in compatibility with mine distribution systems. The rectifier portion of the power electronics, which provides conversion of the incoming AC power to a fixed voltage DC bus, is done with an active front end (AFE). The AFE uses the same IGBT cells as the inverters but is configured as a step up converter. The AFE is fully regenerative and can provide leading or lagging power factor in both motoring and regenerative modes within the AFE thermal limits. In addition to being able to control power factor, the AFE is configured to reduce harmonic currents.

The standard machine configuration will be adjusted to provide unity power factor, both motoring and regen, as well as a total harmonic distortion of less than 8% without the use of inefficient and troublesome RPC units. The AFE is much more immune to line voltage dips than SCR rectifiers (+10% to -20%).

IGBT DRIVE TROUBLESHOOTING

The Acutrol III IGBT control system features a Maintenance Station Computer as part of the integrated power skid, which comprises the major components of the main motion motor drive control system. The Siemens S7-416-2 PLC is carefully integrated together with the drive system to offer the best diagnostics in the industry for an excavator. Included in the Maintenance Station Computer is monitoring, troubleshooting including an Active Logic screen, superior graphic displays indicating system status, fault diagnostics, and specific testing capabilities. Fault history is logged and can be off loaded onto disk as standard.
Additionally, a PC based operator’s display terminal is provided for indications, annunciations, and miscellaneous adjustments such as lubrication system settings and motion limit calibration. Indications are such items as brake status, control status, transfer switch position, boom jack activated, system status, boarding ladder status, etc. Other display screens are used for lube system testing, rope reeving, PLC troubleshooting, etc. The operator’s display also shows every alarm and warning that is active with a general text message. It also displays more than the last 200 historical alarms. Alarms can be sent to a printer or computer directly from the display terminal if desired. Faults, warnings and operating hours of the motions and machine are also grouped and counted on a fault counter/operating hour’s screen that is available on the display. More detailed troubleshooting information and assistance is available on the Maintenance Station, which is an integral part of the drive system.

A-C LOW VOLTAGE APPARATUS AND CONTROL

Auxiliary Equipment – Rated at 460 Volts, 3-phase, 60Hz

The following features are provided as standard:

1. Air compressor rated 30 HP (22.4 kW), 73 cfm, for continuous run service. The air compressor system also contains a drain valve.

2. Each of the two propel motors are cooled by a 3HP (2.2kW) blower*. One 20HP (14.9kW) blower is used to cool the Hoist motor. Each of the two Swing motors are cooled by a 3HP (2.2kW) blower. A 5HP (3.7kW) blower is used to cool the Crowd motor.

3. Two 25HP (18.6kW) filtering and pressurizing intake fans rated 26,200 cfm each cool the machinery house. One 25HP (18.6kW) fan rated 26,200 cfm cools the electrical room. A set of self-cleaning filters is included. Thus, some of the intake air is used to purge and clean the filters while the rest is used to cool the machine. A static positive pressure of between .25 and .5 inches water gauge is maintained within the house.

4. The oil pump motors for each of the two swing gearcases are 1.5HP (1.1kW).

5. A 20HP (14.9kW) motor is used for the Hoist gearcase Radiator and a 15HP (11.19kW) motor is used for the Hoist gearcase oil pump.

6. Two Cabinet cooling fans for the air-cooled inverters and AFEs, typically rated 10HP (7.4kW) each.

7. Two Reeving Winches rated at 5 HP (3.7kW) each.

8. The control room has two 25kW heaters. The lube room has one 7.5kW heater.

9. There are two ventilator units in the operator’s cab. Each of the two units is capable of 31K BTU/hour air conditioning, and two stage 13.8kW heating. These ventilator

*495HF uses a 5 HP (3.7kW) blower.
units are also equipped with a self cleaning filter/pressurizing system. They are individually controlled by a five stage electronic thermostat.

10. A Crowd take up unit rated at 20Hp (14.9kW) uses a hydraulically controlled mechanism to adjust for slack in the rope system for the crowd.

**Auxiliary Equipment** - Single phase and DC

1. Two 3HP (2.2kW) D-C motors, powered from a static exciter, operate a reel type dipper trip. The D-C dipper trip is powered using a full wave rectifier bridge on the secondary of the dipper trip transformer and a half wave rectifier bridge is used to provide power for the relay coils in the MCC and the propel transfer switch motor.

2. Electro/hydraulic controlled boarding ladder with status indication on the operator's screen.

3. Operator's cab window washer/wiper system.

4. Operator's cab radio with cassette player.

5. The telephone system consists of three stations, one located on the operator's cab control console, one in the control room, and one in the machinery house. The telephone system also contains 3 speakers, one in the control room, one in the machinery house, and one outside near the operator's cab.

6. Motor anti-condensation heaters and cabinet heaters are rated at a total of approximately 6.52kW and 2.6kW respectively.

**Control**

Short circuit protection is provided by molded case circuit breakers and all thermal overload relays are three coil, eutectic alloy type. Pushbuttons are oil tight, heavy-duty type. All auxiliary motor control is housed in a standard motor control center. A programmable controller (PLC) manufactured by Siemens is utilized to provide control of all normal shovel logic, lubrication systems and fault annunciation systems.

**AUTOMATIC LUBRICATION SYSTEM**

The automatic lubrication system applies lubricant and grease via the PLC. This system uses six lube pumps (four for lubricant and two for grease), each feeding individually PLC controlled circuits. High-pressure hose with reusable fittings is utilized.

The lube system is located in an insulated and double walled lube room, which is heated for cold weather operation. The one ton hoist provided with the machine can be used to raise supplies from the ground onto the left-hand house platform and into the lube room. Lube points on the electric motors are manually accessed. All other lube points are fed from the automatic system or by oil bath.

The six independent lubrication systems function as follows:
• System A1 provides open gear lube for the upper works bushings.
• System A2 provides open gear lube for the lower works bushings.
• System B1 provides open gear lube for the upper works gearing and swing rails.
• System B2 provides open gear lube to the dipper handle.
• System C1 provides grease to the upper works anti-friction bearings.
• System C2 provides grease to the lower works anti-friction bearings.

Each system has its own pressure gauge located in the lube room of the machine. System maximum pressure, vent pressure and timing values are entered via the operator’s display screen. All six systems are independently controlled (separate on/off switch, manual lube button, etc.). A lube system test mode is available on the operator’s display screen that allows testing of up to three lube systems simultaneously. Additionally, the PLC annunciates low pressure, vent pressure and lube system power off faults on the display screen for each of the lube systems.

LIGHTING SYSTEM

Following are the specifications for the standard 240V/120V light plant used on the machine:

1. **Boom feet**: 2 - 400W High Pressure Sodium lights (one on each side).

2. **Top of the A-frame**: 2 - 400W High Pressure Sodium lights (one on each side).

3. **Ground lights**: 4 - 100W incandescent lights (one on each lower corner of the revolving frame).

4. **Walkways**: 14 - 100W incandescent lights (1 outside lube room, 1 outside L.H. house door, 2 in L.H. house, 1 on L.H. lower walkway, 2 in control room, 1 on R.H. lower walkway, 2 in R.H. house, 1 on R.H. upper walkway, 1 outside the utility room door, 1 for the utility room walkway and 1 for the dipper trip walkway).

5. **Machinery House, Lube Room, Control Room and Utility Room**: 17 - 100W High Pressure Sodium lights, 9 mounted inside the machinery house, 6 inside the control room, 1 inside the lube room and 1 inside the utility room.

6. **Receptacles**: 15 - dual receptacles (2 in L.H. house, 1 in lube room, 2 in control room, 1 in R.H. house, 1 in the utility room, 1 above the boom foot, and 7 in the operator’s cab).

7. **Portable lights**: 2 - 100W incandescent portable lights (1 mounted near L.H. house receptacle and 1 mounted near R.H. house receptacle).

8. **Floodlights**: 6 - 1000W High Pressure Sodium floodlights (2 on rear house roof, 2 on front of operator’s cab, and 2 on front of lube room).

9. **Operator’s Cab**: 4 - 75W incandescent lights in the operator’s cab and 3 - 100W incandescent lights outside of the operator’s cab doors and by walkway.
WIRE AND CABLE

High voltage cables are a SHD-GC trail cable type, Ethylene-Propylene rubber insulated with CPE jacketing, rated 15 kV, 90°C. Low voltage wiring is routed in flexible, galvanized steel, liquitite, and polyvinyl covered conduit. Low voltage wiring is Hypalon insulated, rated 600 and 1,000 volts, 90°C. Control panel wiring is silicone rubber insulated, extra flexible, rated 600 volts, 150°C continuous, 200°C transiently. Light plant wiring is THHN thermoplastic insulated with standard stranding, rated 600 volts. All terminations are pressure crimp type and control leads have an insulation as well as a conductor crimp.
OPERATOR’S CAB

Two, stepless, joystick master switches control hoist, swing and crowd motions, the right hand for hoist and swing and the left hand for crowd. Two control consoles contain all rotary and pushbutton switches used during normal operation. An operator display terminal is provided for indications, annunciation and miscellaneous adjustments such as lubrication timers and limit switch calibration.

The operator’s seat has the following features:

- Adjustable headrest.
- Air adjustable lumbar support
- Adjustable flip-up armrests with height and angle adjustments.
- Removable/replaceable cushions.
- Document pouch on back of the seat.
- Seat adjustment independent of the console.
- Fully hydraulic and spring-dampened suspension system with automatic compensation for the operator’s weight.
- Adjustable foot rest. Lap belts for additional safety. Adjustable fingertip joystick control.

ELECTRICAL EQUIPMENT ENClosures

Every effort has been made to provide safe, convenient, equipment enclosures. High voltage switchgear is completely isolated in its independent non-pressurized lockable cabinet. This can, and should, be made a restricted area for operating personnel. Low voltage miscellaneous equipment is housed in rugged steel gasketed cabinets. Standard motor control centers house the auxiliary motor starters. This construction eliminates the need for operating personnel to enter these cabinets during normal operation. The cabinets can, therefore, be locked with the integral locks provided. In addition to these features, when electricians do require access to the cabinets, they will find the medium voltage A-C equipment isolated completely from the D-C control equipment. Considering that the high voltage A-C equipment is also isolated, it becomes evident that all equipment is isolated according to type and voltage rating.

Power electronic inverter, active front end (AFE) and bus assemblies are electrically isolated from the low voltage electronic control, and are in a common enclosure.

*It is the policy of Bucyrus International, Inc. to continually improve its products. The right is reserved to make changes in specifications or design which in the opinion of this Company are in accord with this policy, or which are necessitated by the unavailability of materials. The description herein is for the purpose of identifying the type of machine and does not limit or extend the express warranty or guarantee provisions in any contract of sale.*
100% PEAK POWER = APPROXIMATELY 3,706 KW
100% CYCLE TIME = APPROXIMATELY 30 SECONDS
AVERAGE 15 MINUTE DEMAND = APPROXIMATELY 1,112 KW
POWER FACTOR @ RATED LOAD = 1.0
Appendix B

Study Methodology and Evaluation Criteria
STUDY METHODOLOGY AND EVALUATION CRITERIA

Power flow, motor starting, transient stability, and short circuit analyses will be performed on both the pre-project and the post-project cases to determine the impact of the Rosemont Mine Project on the TEP transmission system. Specific studies to be conducted and their evaluation criteria are outlined below:

Power Flow Analysis

Power flow analysis will be performed on both the pre-project and post-project base cases for the modified heavy summer operating conditions. The light winter (lw) and heavy summer (hs) base cases will be used to simulate the impact of the Project during normal operating conditions (N-0) as well as selected single (N-1) and multiple contingencies. KRSA, with TEP’s assistance, will create a list of N-1 and selected multiple contingencies to use in the simulations including:

- All single 138 kV transmission circuit and transformer outages on the TEP system.
- All single EHV transformer outages at South, Vail and Tortolita.
- Selected multi-element common-mode outages within the South and Vail 138 kV system.
- Selected N-2 and multi-element common-mode outages on the 345 kV system emanating from South, and Vail including lines connected to the Springerville and Pinal West substations.

The WECC/NERC and TEP planning standards will be used to assess the adequacy of the study results. The power flow analysis related evaluation criteria that will be used are summarized below:

- Pre-contingency bus voltage outside the TEP control area must be between 0.95 per unit and 1.05 per unit.
- Post-contingency 138 kV average voltage must be between 0.98 and 1.05 per unit.
- TEP EHV voltages between 1.03 and 1.04 pu, if possible.
  - Fictitious buses to model transformer terminated lines are not subject to this criteria.
- TEP 138 kV bus voltages between 1.0145 and 1.025 pu.
- TEP 138 kV average voltage must be between 1.0210 and 1.0235 pu.
- Maximum voltage deviation allowed at all buses under contingency conditions will be 5% for N-1 and 10% for N-2 contingencies.
- Pre-disturbance loading to remain within continuous ratings of all equipment and line conductors.
- Post-disturbance loading to remain within emergency ratings of all equipment and line conductors.
- Load shed will be allowed for N-2 outages involving only EHV elements and for single-event 138 kV contingencies identified as TOLS-activating.
- Pre-contingency VAR flow will be from Tortolita into Saguaro 500 as monitored at Saguaro 500.

**Transient Stability Analysis**

Transient stability studies will be conducted on both the pre-project and post-project base cases for the heavy summer operating conditions. Transient stability runs will be simulated for 10 seconds to ensure the system is stable and positively damped. Only selected critical contingencies agreed upon by TEP will be simulated. Transient stability responses to loss of the entire Rosemont load will be studied. Prior studies for Rosemont have demonstrated that the system is stable and damped for all contingencies studied for the pre-Rosemont Project and post-Rosemont Project cases. Therefore only the two most critical TEP outages will be restudied to confirm prior conclusions are still valid with the 2009 Rosemont Proposed Plan of Service. Provided below are the outages:

- Full load rejection of proposed project
- Irvington 138 kV bus differential
- Pinal West to South and Winchester to Vail 345 kV lines

Additional outages may be necessary depending upon the study results.

The following WECC transient voltage dip and transient frequency criteria will be used to evaluate the impact of the Project. A summary of the transient stability analysis evaluation criteria is provided in Table 2 and depicted graphically in Figure 3.

- WECC transient voltage dip criteria: The transient voltage dip must not exceed 25% at load buses or 30% at non-load buses for N-1 contingency. For N-2 contingency, the transient voltage dip must not exceed 30% at any bus. The maximum duration of the voltage dip of 20% at load buses must not exceed 20 cycles for N-1 contingency or 40 cycles for N-2 contingency.
- WECC transient frequency criteria: The minimum transient frequency for N-1 contingency is 59.6 Hz; if below 59.6 Hz, the duration must not exceed 6 cycles at load bus. For N-2 contingencies, the minimum transient frequency is 59.0 Hz; if below 59.0 Hz, the duration should not exceed 6 cycles at load bus.
<table>
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<th>NERC and WECC Categories</th>
<th>Outage Frequency Associated with the Performance Category (outage/year)</th>
<th>Transient Voltage Dip Standard</th>
<th>Minimum Transient Frequency Standard</th>
<th>Post Transient Voltage Deviation Standard</th>
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<td>A System normal</td>
<td>Not Applicable</td>
<td>Nothing in addition to NERC</td>
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<tr>
<td>B One element out-of-service</td>
<td>≥ 0.33</td>
<td>Not to exceed 25% at load buses or 30% at non-load buses.</td>
<td>Not below 59.6Hz for 6 cycles or more at a load bus.</td>
<td>Not to exceed 5% at any bus.</td>
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<tr>
<td>C Two or more elements out-of-service</td>
<td>0.033 – 0.33</td>
<td>Not to exceed 30% at any bus.</td>
<td>Not below 59.0Hz for 6 cycles or more at a load bus.</td>
<td>Not to exceed 10% at any bus.</td>
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<tr>
<td>D Extreme multiple-element outages</td>
<td>&lt; 0.033</td>
<td>Nothing in addition to NERC</td>
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Table 2: Stability and Post-transient Analysis Evaluation Criteria

Figure 3: Graphical Representation of Stability Analysis Evaluation Criteria
Appendix C

Category B (N-1)
Contingency List
COMM Contingency List created by cont_list.p
COMM Parameters to create contingency List
COMM ZONE 160, and 165
COMM 138 - 500 kV
COMM Tie Lines Included: YES
COMM OOS elements included: YES
COMM Single Contingencies only
COMM " "
COMM " "
CATEGORY A
RUN 0
CATEGORY BR
LINE 14000 "CHOLLA " 500.0 14004 "SAGUARO " 500.0 1
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CATEGORY BR
LINE 15016 "PINAL_SO" 500.0 16000 "TORTOLIT" 500.0 1
RUN 2
CATEGORY BR
LINE 14004 "SAGUARO " 500.0 16001 "TORTLIT2" 500.0 1
RUN 3
CATEGORY BR
LINE 14004 "SAGUARO " 500.0 16000 "TORTOLIT" 500.0 1
RUN 4
CATEGORY BR
LINE 14004 "SAGUARO " 500.0 16000 "TORTOLIT" 500.0 2
RUN 5
CATEGORY BR
LINE 16126 "3PTS345 " 345.0 16103 "SOUTH " 345.0 1
RUN 6
CATEGORY BR
LINE 17005 "BICKNELL" 345.0 16105 "VAIL " 345.0 1
RUN 7
CATEGORY BR
LINE 17010 "GREEN-AE" 345.0 16101 "GREENLEE" 345.0 1
RUN 8
CATEGORY BR
LINE 16101 "GREENLEE" 345.0 16900 "COPPERVR" 345.0 1
RUN 9
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LINE 16101 "GREENLEE" 345.0 16112 "WILLOW " 345.0 1
RUN 10
CATEGORY BR
LINE 16101 "GREENLEE" 345.0 16109 "WINCHSTR" 345.0 1
RUN 11
CATEGORY BR
LINE 11080 "HIDALGO " 345.0 16101 "GREENLEE" 345.0 1
RUN 12
CATEGORY BR
LINE 16102 "MCKINLEY" 345.0 16104 "SPRINGR " 345.0 1
RUN 13
CATEGORY BR
LINE 16102 "MCKINLEY" 345.0 16104 "SPRINGR " 345.0 2
RUN 14
CATEGORY BR
LINE 16114 "PINALWES" 345.0 16126 "3PTS345 " 345.0 1
RUN 15
CATEGORY BR
LINE 16114 "PINALWES" 345.0 16103 "SOUTH " 345.0 1
RUN 16
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RUN 17
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LINE 10292 "SAN_JUAN" 345.0 16102 "MCKINLEY" 345.0 2
RUN 18
CATEGORY BR
LINE 16103 "SOUTH " 345.0 16108 "GATEWAY " 345.0 1
singles.pin

RUN 19
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LINE 16103 "SOUTH " 345.0 16108 "GATEWAY " 345.0 2

RUN 20
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LINE 16115 "TORTOLIT" 345.0 16124 "NLOOP345" 345.0 1

RUN 25
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LINE 16105 "VAIL " 345.0 16103 "SOUTH " 345.0 1

RUN 26
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LINE 16107 "WESTWING" 345.0 16114 "FINAWES" 345.0 1

RUN 27
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LINE 16112 "WILLOW " 345.0 16111 "BOWIE " 345.0 1

RUN 28
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RUN 29
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singles.pin 3/20/2009

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XFMR 16217 "TORTOLIT" 138.0 16000 "TORTOLIT" 500.0 1
RUN 155
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XFMR 16217 "TORTOLIT" 138.0 16000 "TORTOLIT" 500.0 2
RUN 156
CATEGORY BR
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RUN 157
CATEGORY BR
XFMR 16217 "TORTOLIT" 138.0 16000 "TORTOLIT" 500.0 4
RUN 158
CATEGORY BN
XFMR 16503 "SUNDTGE4" 18.0 16334 "IRVMID4 " 138.0 1
RUN 159
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XFMR 16514 "DMPCC#1" 13.8 16200 "DMP " 138.0 1
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XFMR 16520 "DMPCC#2" 13.8 16200 "DMP " 138.0 1
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XFMR 16521 "DMPCC#3" 13.8 16200 "DMP " 138.0 1
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XFMR 16504 "SUNDTCT " 13.8 16204 "IRVNTN " 138.0 1
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XFMR 16509 "SUNDTGE3" 13.8 16333 "IRVMID3 " 138.0 1
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LINE 16242 "HARTT " 138.0 16919 "ROSETP_2" 138.0 1
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CATEGORY BN
LINE 16918 "ROSET punishment" 138.0 16919 "ROSETP_2" 138.0 1
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CATEGORY BN
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RUN 167
CATEGORY BN
LINE 16216 "SOUTH " 138.0 16920 "ROSEMP" 138.0 1
RUN 168
CATEGORY BN
LINE 16220 "VAIL " 138.0 16920 "ROSEMP" 138.0 1
RUN 169
DONE
Appendix D

List of Credible Category C & D Contingencies
CREDIBLEMULTISR1.pin

COMM
COMM Credible Multi-Element Contingencies
COMM Rosemont dca 3-10-09
COMM
COMM
COMM VAIL
CATEGORY A
RUN 0
CATEGORY CT
COMM "WIN-VL&SPR-VL2"
LINE 16105 "VAIL " 345.0 16109 "WINCHSTR" 345.0 1
LINE 16104 "SPRINGR " 345.0 16106 "VAIL2 " 345.0 1
RUN 1
CATEGORY CT
COMM "WIN-VL & VL T2"
LINE 16105 "VAIL " 345.0 16109 "WINCHSTR" 345.0 1
XFMR 16105 "VAIL " 345.0 16220 "VAIL " 138.0 2
RUN 2
CATEGORY CT
COMM "VL-S & VL-BKNL"
LINE 16105 "VAIL " 345.0 16103 "SOUTH " 345.0 1
LINE 16105 "VAIL " 345.0 17005 "BICKNELL" 345.0 1
RUN 3
CATEGORY CN
COMM "VL-RBW&VL-TKPK"
LINE 16220 "VAIL " 138.0 16222 "RBWILMOT" 138.0 1
LINE 16220 "VAIL " 138.0 16233 "TECHPARK" 138.0 1
RUN 4
CATEGORY CN
COMM "TKPK-IR&VL-RBW"
LINE 16233 "TECHPARK" 138.0 16204 "IRVNGTN " 138.0 1
LINE 16220 "VAIL " 138.0 16222 "RBWILMOT" 138.0 1
RUN 5
CATEGORY CN
COMM "TKPK-IR&RBW-IR"
LINE 16233 "TECHPARK" 138.0 16204 "IRVNGTN " 138.0 1
LINE 16222 "TECHPARK" 138.0 16204 "IRVNGTN " 138.0 1
RUN 6
CATEGORY CN
COMM "TKPK-IR & IR-S"
LINE 16233 "TECHPARK" 138.0 16204 "IRVNGTN " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16216 "SOUTH " 138.0 1
RUN 7
CATEGORY CN
COMM "IR-DX & IR-SC 
LINE 16204 "IRVNGTN " 138.0 16201 "DREXEL " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16214 "SN.CRUZ " 138.0 1
RUN 8
CATEGORY CN
COMM "DX-MV & IR-SC"
LINE 16206 "MIDVALE " 138.0 16201 "DREXEL " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16214 "SN.CRUZ " 138.0 1
RUN 9
CATEGORY CN
COMM "IR-DX &SC &TUC"
LINE 16204 "IRVNGTN " 138.0 16201 "DREXEL " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16214 "SN.CRUZ " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16218 "TUCSON " 138.0 1
RUN 10
CATEGORY CN
COMM "DX-MV&IR-SC&TUC"
LINE 16206 "MIDVALE " 138.0 16201 "DREXEL " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16214 "SN.CRUZ " 138.0 1
LINE 16204 "IRVNGTN " 138.0 16218 "TUCSON " 138.0 1
RUN 11
CATEGORY CN
COMM "VL-CN &CN-SP TR"
CREDIBLEMULTISR1.pin

6/19/2009

LINE 16220 "VAIL " 138.0 16243 "CIENEGA " 138.0 1
LINE 16243 "CIENEGA " 138.0 16213 "S.TRAIL " 138.0 1
RUN 12
CATEGORY CN
COMM * "VL-CN & VL-LR"
LINE 16220 "VAIL " 138.0 16243 "CIENEGA " 138.0 1
LINE 16220 "VAIL " 138.0 16223 "LOSREALS" 138.0 1
RUN 13
COMM SOUTH
CATEGORY CN
COMM * "IR-SO & MV-SO"
LINE 16204 "IRVNGTN " 138.0 16216 "SOUTH " 138.0 1
LINE 16206 "MIDVALE " 138.0 16216 "SOUTH " 138.0 1
RUN 14
CATEGORY CN
COMM * "MV-DX & MV-SO"
LINE 16206 "MIDVALE " 138.0 16201 "DREXEL " 138.0 1
LINE 16206 "MIDVALE " 138.0 16216 "SOUTH " 138.0 1
RUN 15
COMM TORTOLITA
CATEGORY CN
COMM * "TO-NL dbl1"
LINE 16217 "TORTOLIT" 138.0 16207 "N. LOOP " 138.0 1A
LINE 16217 "TORTOLIT" 138.0 16207 "N. LOOP " 138.0 2A
RUN 16
CATEGORY CN
COMM * "TO-NL dbl2"
LINE 16217 "TORTOLIT" 138.0 16207 "N. LOOP " 138.0 3
LINE 16217 "TORTOLIT" 138.0 16207 "N. LOOP " 138.0 4
RUN 17
CATEGORY CT
COMM IRVINGTON
COMM * "IRV BD T"
BUS 16204 "IRVNGTN" 138.0
RUN 18
DONE
Appendix E
Stability Plots

Pre Project Irvington Bus
Irvington Bus

Pre Project Pinal West – South Initially Out of Service and Winchester-Vail

Pinal West – South Initially Out of Service and Winchester-Vail

Pre Project Winchester – Vail Initially Out of Service and Pinal West – South

Winchester – Vail Initially Out of Service and Pinal West – South

Full Load Rejection
ROSEMONT STABILITY PLOTS

Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
### Rosemont Stability

**Irvington Bus Outage Run**

2013 Heavy Summer case

Before the Rosemont project

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**ARIZONA VOLTAGES STABILITY PLOTS**

- **Rosemont Stability**
- **Irvington Bus Outage Run**
- **2013 Heavy Summer case**
- **Before the Rosemont project**
Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
Rosemont Stability
Irvington Bus Outage Run
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Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Before the Rosemont project
ROSEMONT STABILITY PLOTS

Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
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Irvington Bus Outage Run
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Includes the Rosemont load
Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Includes the Rosemont load
ROSEMONTE STABILITY PLOTS

Voltage

0.75 0.80 0.85 0.90 0.95 1.00 1.05 1.10 1.15 1.20 1.25

Frequency

58.00 58.40 58.80 59.20 59.60 60.00 60.40 60.80 61.20 61.60 62.00

Angle

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Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Includes the Rosemont load
Rosemont Stability
Irvington Bus Outage Run
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2013 Heavy Summer case
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Rosemont Stability
Irvington Bus Outage Run
2013 Heavy Summer case
Includes the Rosemont load
ROSEMONTE STABILITY PLOTS

Rosemont Stability
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2013 Heavy Summer case
Includes the Rosemont load
ROSEMONT STABILITY PLOTS

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Final West-South IOS and Winchester-Vail Outage Run
2013 Heavy Summer case
Before the Rosemont load
ARIZONA VOLTAGES STABILITY PLOTS

Rosemont Stability
Pinal West-South IOS and Winchester-Vail Outage Run
2013 Heavy Summer case
Before the Rosemont load
### Rosemont Stability

**Final West-South IOS and Winchester-Vail Outage Run**

**2013 Heavy Summer case**

**Before the Rosemont load**

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Appendix E  Page 25
Rosemont Stability
Final West-South IOS and Winchester-Vail Outage Run
2013 Heavy Summer case
Before the Rosemont load
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ROSEMONTE STABILITY PLOTS

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ROSEMON'T STABILITY PLOTS

Voltage

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Frequency

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Final West-South IOS and Winchester-Vail Outage Run

2013 Heavy Summer case

Includes the Rosemont load
ROSEMONTE STABILITY PLOTS

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ARIZONA VOLTAGES STABILITY PLOTS

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- **Rosemont Stability**
- Winchester-Vail IOS and Final West-South Outage Run
- 2013 Heavy Summer case
- Before the Rosemont project
ROSEMONT STABILITY PLOTS

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Winchester-Vail IOS and Final West-South Outage Run
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ARIZONA VOLTAGES STABILITY PLOTS

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ROSEMONST STABILITY PLOTS

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**Rosemont Stability**

Winchester-Vail IOS and Final West-South Outage Run

2013 Heavy Summer case

Before the Rosemont project
ROSEMONT STABILITY PLOTS

Rosemont Stability
Winchester-Vail IOS and Pinal West-South Outage Run
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ARIZONA VOLTAGES STABILITY PLOTS

Rosemont Stability
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### Rosemont Stability

**Winchester-Vail IOS and Final West-South Outage Run**

**2013 Heavy Summer case**

Includes the Rosemont project

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<td>40.00</td>
<td>60.00</td>
<td>80.00</td>
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</tbody>
</table>
Rosemont Stability
Winchester-Vail IOS and Final West-South Outage Run
2013 Heavy Summer case
Includes the Rosemont project
## Rosemont Stability

Winchester-Vail IOS and Final West-South Outage Run

2013 Heavy Summer case

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ROSEMONT STABILITY PLOTS

Rosemont Stability
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ARIZONA VOLTAGES STABILITY PLOTS

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Voltage

Frequency

Angle

Rosemont Stability
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ROSEMON STABILITY PLOTS

Rosemont Stability
Full Load Rejection Run
2013 Heavy Summer case
Includes the Rosemont load
Rosemont Stability
Full Load Rejection Run
2013 Heavy Summer case
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