Appendix B – Process Design Criteria

The source of this appendix is the Piñon Ridge Project Basic Engineering Report prepared by CH2M HILL Engineers, Inc., dated February 4, 2009 (CH2M HILL 2009).

PIÑON RIDGE PROJECT

BASIC ENGINEERING

ENERGY FUELS RESOURCES CORPORATION

PROCESS DESIGN CRITERIA

MM-2600-DC-001

Project No. 365541

Rev. No.	Issue Date	Revision Subject	Discipline Approval	Management Approval	Client Approval
A	04/01/08	Initial Issue	CBB	MDSB	
B	05/19/08	Issued for Review	CBB	MDSB	
C	06/10/08	Issued for Approval	CBB	MDSB	
D	10/05/08	Issued for Basic Engineering Draft Report	CBB	MDSB	
E	02/04/09	Issued for Basic Engineering Report	CBB	MDSB	

TABLE OF CONTENTS

1.0 GENERAL 1
1.1 Introduction 1
1.2 Source Codes 1
1.3 Definition of Design Value Terms 1
2.0 PROCESS DESCRIPTION 3
2.1 Introduction 3
2.2 Ore Receiving 3
2.3 Grinding 3
2.4 Pre-Leaching 4
2.5 Leaching 4
2.6 Counter Current Decantation (CCD) 4
2.7 Tailings Disposal 5
2.8 Uranium Recovery 5
2.9 Vanadium Recovery 6
2.10 Reagents Storage & Handling 7
3.0 MEASUREMENT UNITS AND SYMBOLS 8
4.0 SITE DATA 13
4.1 Location 13
4.2 Meteorological Data 13
4.3 Other Site Data 13
5.0 ENVIRONMENTAL CRITERIA 14
5.1 General Applicable Regulations and Standards 14
5.2 Special Considerations/Comments 14
5.3 Effluent, Emission, and Pollution Control Criteria 14
5.3.1 General 14
5.3.2 Air 15
5.3.3 Water 15
5.3.4 Solids 16
5.3.5 Fencing 16
6.0 DESIGN CRITERIA REFERENCE LIST 17
6.1 *Energy Fuels Resource Corporation Uranium Mill Licensing Support Climatological Report Piñon Ridge Mill Site Montrose County, Colorado* Kleinfelder Report, December 2007 17
6.2 *Autogenous and Semi-autogenous Grinding Studies on Blanding, Utah, Operation Ores* CSMRI Report, July 1978. 17
7.0 PRODUCTION SUMMARY 18
7.1 Annual Production Parameters 18
7.1.1 Annual Production 18
7.1.2 Daily Production 18
7.2 Concentrate Grade 18

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

7.3 Recovery 18
7.4 Operating Schedule 18
8.0 CHARACTERISTICS OF PROCESS MATERIALS 19
8.1 Introduction 19
8.2 Mineralogy, Process Raw Materials 19
8.3 Chemical Composition of ROM Ore 19
8.4 Physical Characteristics of ROM Ore 19
9.0 COARSE ORE STORAGE 20
9.1 Operating Time 20
9.2 Equipment 20
9.3 Coarse Ore Stockpile 20
10.0 GRINDING 21
10.1 Operating Time and Grinding Tonnage Rate 21
10.2 Grinding Power Requirements 21
10.2.1 Work Index 21
10.2.2 Mill Power 21
10.3 Equipment 21
10.3.1 Coarse Ore Reclaim Feeders 21
10.3.2 SAG Mill Feed Conveyor 21
10.3.3 SAG Mill 22
10.3.4 SAG Mill Discharge Trommel 22
10.3.5 SAG Mill Discharge Pumps 23
10.3.6 SAG Mill Classifying Screen 23
10.3.7 Pulp Storage Tanks 23
11.0 LEACHING 24
11.1 Pre-leach 24
11.2 Leach 25
12.0 COUNTER CURRENT DECANTATION AND TAILINGS 26
12.1 Counter Current Decantation 26
12.2 Tailings 27
13.0 URANIUM SOLVENT EXTRACTION 28
13.1 Polishing Filters 28
13.1.1 Extraction 28
13.1.2 Scrub 29
13.1.3 Strip 29
13.1.4 Uranium SX pumps 29
14.0 URANIUM PRECIPITATION, DRYING AND PACKAGING 30
14.1 Uranium Precipitation 30
14.2 Uranium Recovery, Drying and Packaging 30
15.0 VANADIUM SOLVENT EXTRACTION 31
15.1 Vanadium Oxidation 31
15.1.1 Extraction 31
15.1.2 Scrub 32

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

15.1.3 Strip 32
15.1.4 Vanadium SX pumps 32
16.0 VANADIUM PRECIPITATION, FUSION AND PACKAGING 33
16.1 Vanadium Precipitation 33
16.2 Vanadium Fusion and Packaging 34
17.0 Reagents 35
17.1 Sulfuric acid (93%) 35
17.2 Anhydrous ammonia 35
17.3 Ammonium sulfate 35
17.4 Sodium hydroxide (50%) 35
17.5 Sodium carbonate (31%) 36
17.6 Flocculant 36
17.7 Kerosene (SX 12) 36
17.8 Amine (Alamine 336) 36
17.9 Isodecanol (Exxal 13) 36
17.10 Sodium chlorate (39%) 37
17.11 Hydrogen peroxide (50%) 37
17.12 Diatomaceous earth 37

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

1.0 GENERAL

1.1 Introduction

The following design criteria are for the engineering, design, and specification of the process requirements for a uranium extraction plant. These criteria encompass the following operations:

- Ore handling and grinding
- Leaching
- Counter current decantation (CCD) and tailings disposal
- Uranium solvent extraction
- Uranium precipitation
- Vanadium oxidation and solvent extraction
- Vanadium precipitation

1.2 Source Codes

The source code letters listed for each criterion refer to the origin of that criterion value. Where an integer is entered as a source code, this code number refers to specific source documents that are referenced in Section 6. In certain cases, two source codes may be referenced. The following letter code designators are used:

Code	Description
A	Criteria provided by Owner
B	Standard industry practice
C	CH2M HILL recommendation
D	Vendor-originated criteria
E	Criteria from process calculations
F	Engineering handbook data
G	Assumed data
H	Criteria provided by technology supplier
K	Metallurgical test results

1.3 Definition of Design Value Terms

The process criteria are listed as Flowsheet **BALANCE** and/or **DESIGN**. The context in which these terms are used is in accordance with the following definitions:

Annual Rate: Flow rate per 350 calendar days.

Operating Days: The number of plant operating days per year is 350 days.

Utilization: A utilization factor of unity represents the capability of, and requirement for, any equipment or facility being on-line for 24 hours per day for all operating days in the year. A utilization of less than unity reflects the combined effect of

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

allowed availability for that facility and the utilization effect from the online time of upstream or downstream equipment, or from other factors.

Flowsheet Balance: The values in the "Flowsheet Balance" column (generally flow rate) that represent the steady-state average rate during the design utilization time per operating day for any facility or equipment. Thus,

Annual Rate = Flowsheet **BALANCE** daily rate

x number of operating days per year

= Flowsheet **BALANCE** hourly rate

x 24 hours (18 hours for the conveying and grinding facilities)

x equipment utilization factor

x number of operating days per year

Where criteria flow values are for time units of less than one hour, they are intended to represent the equivalent of continuous hourly rates in the relationship above.

In accordance with this definition, all Flowsheet **BALANCE** flow rates, together with the respective utilization factors, should be consistent with a single annual mass balance.

Balance throughput of the uranium extraction plant is based on an annual ore treatment of 350,000 short tons of uranium ore.

Design Value: The criterion values in this column provide the instantaneous process criterion values that take account of flows that operate for less than 24 hours during one operating day, or where it is intended that the particular equipment will have an additional capacity to allow for maintenance, catch-up capability, or for variability in process parameters. The **DESIGN** values are intended as attainable continuous rates and do not include any additional design allowance(s), by engineer or vendor, to ensure attainment. The combinations of **DESIGN** values neither relate to the annual productions defined nor integrate to represent a metallurgical balance. The **DESIGN** values are individual rates used for sizing equipment.

The feed conveyor and grinding facilities would operate up to 18 hours per day, 350 days per year, with a design allowance of 60 percent for the conveyor facility. Leaching through solvent extraction to tailings disposal facilities will be designed to operate on a continuous basis 350 days per year, with a design allowance of 8 percent. Pumps will be designed using a design allowance of 20 percent.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

2.0 PROCESS DESCRIPTION

2.1 Introduction

The Piñon Ridge Project is designed to treat 1,000 tons of ore per day and to produce both uranium, in the form of uranyl peroxide ($UO_4 \cdot nH_2O$) which is referred to as yellowcake or U_3O_8, and vanadium in the form of vanadium pentoxide (V_2O_5). If the Piñon Ridge Mill is built according to the design provided in this Basic Engineering Report, then the plant would operate as described in the balance of this report.

The plant is designed to operate either at the nameplate capacity of 1,000 tons per day or at a reduced rate of 500 tons per day. In order to most effectively handle the reduced throughput, certain sections of the plant have been designed with two equal and parallel trains. These sections are the extraction stages of both the uranium and vanadium solvent extraction circuits.

2.2 Ore Receiving

Ore would be delivered to the Piñon Ridge plant site by truck. The trucks would drop the ore over a discharge platform where it would gravitate onto the ore pad. A front-end loader would relocate the ore from the drop zone to the appropriate stockpile area. Fixed dust mitigation water sprays would be provided, both at the upper discharge platform and at the lower drop zone. A mobile tanker would provide water sprays across the ore pad.

Ore feed to the plant would be transported from the stockpiles by means of a front-end loader, or possibly trucks, to a 50 ton subsurface feed hopper with an 12 inch by 12 inch grizzly. The feed hopper would be enclosed on three sides with the fourth side enclosed by heavy duty curtains; the enclosure would be equipped with a bag house for dust control.

The ore would be discharged from the feed hopper by means of a 36 inch wide by approximately 17 foot long apron feeder to a 42 inch wide belt conveyor which would pass the ore over a weightometer and transport it to the vibrating feeder preceding the semi autogenous grinding (SAG) Mill.

2.3 Grinding

Grinding would be accomplished in a 14 foot diameter by 5 foot effective grinding length (EGL) SAG Mill. The mill would be driven through a reducer by a 500 horsepower reversing motor, in closed circuit with two vibrating screens. One scrubber would be provided to minimize the amount of fugitive dust from the grinding circuit with a removal efficiency of 97–99 percent. The grinding circuit would be located in the main mill building. The 0.023 inch (28 Tyler mesh) vibrating screen undersize product, at 50–60 percent solids, would be sampled by a two stage vezin sampler, with interstage sample swirl tank, and then distributed to one of two pulp storage tanks. Each of these storage tanks would be 39 feet in diameter by 39 feet high and equipped with a 125 horsepower agitator.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

2.4 Pre-Leaching

From the pulp storage tanks, the slurry would be pumped to two 21 foot diameter by 24 foot high chlorobutyl rubber lined pre-leach tanks in series. Agitation in these tanks would be provided by 40 hp agitators. Prior to discharge into the tanks, the pulp would be sampled by means of an automatic, vezin sampler for mill head grade analysis. In the pre-leach tanks the pulp would react with pregnant liquor overflow from counter current decantation (CCD) thickener 1. The pre-leach or "acid kill" stage is designed to contact fresh feed ore with the excess acid in the overflow from CCD thickener 1. The addition of this pregnant liquor to the new pulp feed in the pre-leach tanks results in a pre-leach pulp density of 22–25 percent solids.

The pulp from pre-leach tank 2 would report to the 60 foot diameter, epoxy coated, pre-leach thickener. Thickener overflow would gravitate to a 50 foot diameter clarifier. Clarifier overflow would be pumped to the uranium pressure filtration system and, ultimately, would report to the uranium solvent extraction feed tank. Underflow from the pre-leach thickener would be pumped to the first leach tank online (either leach tank 1 or 2.)

2.5 Leaching

The leach train would consist of eight 21 foot diameter by 24 foot high chlorobutyl rubber lined steel tanks. The tanks would also be lined with acid bricks along the bottom and up to the height of the propeller. Each tank would be provided with a 40 horsepower agitator. The tanks are arranged in a cascading and staggered pattern to allow by-passing of individual tanks. The 21 hours of required residence time for leaching would be achieved using all eight tanks. Leaching is designed to be accomplished at approximately 185 ºF. The pulp would be heated by means of live steam sparging. The leach tanks are designed to be covered and a demister system would be provided for fume acid mist extraction from each tank using a scrubber. Sulfuric acid addition, as well as sodium chlorate oxidant addition, would be provided as necessary.

2.6 Counter Current Decantation (CCD)

Leached pulp would be pumped to a series of seven or eight 40 foot diameter, epoxy coated, CCD thickeners. The layout is designed for eight thickeners, but only seven may be constructed. The thickener circuit is located outdoors. Each thickener overflow, with the exception of the overflow from CCD thickener 1, would be pumped to a 4 foot diameter by 6 foot high thickener feed box which would feed the upstream thickener where the flow would be combined with the underflow from the appropriate preceding thickener. The CCD thickener underflows would be pumped by variable speed pumps. Individual flocculant dosing pumps would be provided to supply flocculant to the flocculant dilution box feeding each thickener. The flocculant would be diluted by a bleed stream of the thickener overflow from the subsequent thickener. The diluted flocculant stream would gravitate to a number of addition points in the thickener feed launder. Bypass piping has been designed such that both the thickener underflow and the overflow streams would be able to bypass a thickener.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

2.7 Tailings Disposal

The underflow from CCD thickener 7 or 8, a portion of the vanadium raffinate, and the backwash streams (intermittent flows) from both the uranium and vanadium polishing filters would be combined in a tailings sump of approximately 1,500 gallon capacity and would be pumped to the tailings impoundment area by means of centrifugal pumps. The combined discharge to tailings would pass through a two-stage vezin sampler. The tailings pumps discharge to a pipe line reporting to the tailings pond. The design of the lined tailings pond is by others.

2.8 Uranium Recovery

Overflow from the clarifier in the pre-leach circuit would be further clarified in one of two polishing filters. These filters would be provided with precoat and body feed make up tanks and pumps. The uranium solvent extraction (SX) feed tank would provide buffer storage between the uranium polishing filter and the A and B uranium SX circuits. The pregnant solution would be treated in a series of four stages of extraction mixer settler units. The sizes of the stainless steel settlers would be 19 feet 8 inches long, by 10 feet 5 inches wide, by 3 feet 4 inches deep. The treatment would recover uranium from the pregnant solution by using a tertiary amine extractant in an organic solvent that would flow countercurrent to the clarified solution. In the extraction section, the total mixer residence time in the two mixers would be 3 minutes. A fifth raffinate settler would be provided to reduce the loss of organic into the raffinate solution.

The reactions that would occur in the extraction section are shown below. Barren organic flows counter-currently to the pregnant solution so that the lowest grade pregnant solution would be contacted with the lowest loaded organic, driving the equilibrium shown below to the right and maximizing extraction.

$$[2R_3N]_{org} + H_2SO_4 \Rightarrow [(R_3NH^+)_2SO_4^{2-}]_{org}$$

$$[2(R_3NH^+)_2SO_4^{2-}]_{org} + UO_2(SO_4)_3^{4-} \Rightarrow [(R_3NH^+)_4UO_2(SO_4)_3^{4-}]_{org} + 2SO_4^{2-}$$

The design includes two extraction trains; therefore, buffer storage is designed for the loaded organic solution between the extraction and the scrub and strip stages.

The uranium-bearing organic would be washed in a scrubber mixer-settler with acid and water. The uranium would then be stripped from the solvent in two stripping mixer-settlers with a total of 6 minutes retention in two mixers (3 minutes in each mixer), using a sodium carbonate solution. The mixer-settlers used for washing the loaded organic and for stripping have stainless steel settlers. The sizes of these settlers would be 14 feet 9 inches long, by 7 feet 7 inches wide, by 3 feet 4 inches deep.

Uranium would be stripped from the loaded organic according to the equilibrium shown below.

$$[(R_3NH^+)_4UO_2(SO_4)_3^{4-}]_{org} + 5Na_2CO_3 \Rightarrow [4R_3N]_{org} + Na_4UO_2(CO_3)_3 + 2H_2O + 3CO_2 + 3NaSO_4$$

The uranium would be continuously precipitated from the stripping liquor in five agitated tanks arranged in series. Uranium precipitation tanks 1 and 2 would be 5 feet in diameter by 6 feet high,

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

while uranium precipitation tanks 3, 4, and 5 would be 8 feet in diameter by 8 feet high. The tanks are different in size due to the process requirements and retention times required during the crystal growth process. Precipitation would be caused by the addition of hydrogen peroxide to form yellowcake. The precipitate would then be partially dewatered and washed in a 32 foot diameter thickener. The thickener underflow would be further dewatered on a 15 foot long by 4 foot wide belt filter to produce a filter cake of approximately 35 percent moisture which would be dried in a steam vacuum dryer. The dryer would discharge cake to a holding bin for packaging. The yellowcake would be packed, weighed, and sealed in 55 gallon drums for shipment. One scrubber would be provided to treat the dryer off-gas and fugitive dust, with a removal efficiency of 97–99 percent.

2.9 Vanadium Recovery

When uranium-vanadium ores are treated, the raffinate solution from uranium recovery is prepared for vanadium recovery by oxidizing the vanadium ion species in solution with the addition of sodium chlorate, and reducing the acid concentration slightly by the addition of ammonia. The equation for the oxidization of the vanadium is shown below.

$$30VOSO_4 + 5NaClO_3 + 39H_2O \Rightarrow 3H_6V_{10}O_{28} + 5NaCl + 30H_2SO_4$$

These steps are designed to be accomplished under conditions of continuous flow by the addition of the reagents to a three-tank adjustment circuit, followed by a three-tank retention circuit. Total residence time would be 360 minutes. A polishing filter is included in the design to clarify the feed to the vanadium solvent extraction section.

In a similar fashion to the uranium recovery, the vanadium circuit is designed to extract vanadium into a tertiary amine solvent. The two vanadium extraction trains would each have five stages of extraction followed by an organic recovery settler. The two mixers per stage would have a total retention time of 4 minutes and the sizes of the stainless steel settlers would be 21 feet 4 inches long, by 10 feet 6 inches wide, by 3 feet 4 inches deep.

Vanadium would be extracted from the pregnant solution according to the equilibrium shown below.

$$H_6V_{10}O_{28} + 4[(R_3NH^+)HSO_4^-]_{org} \Rightarrow [(R_3NH^+)_4H_2V_{10}O_{28}^{4-}]_{org} + 4H_2SO_4$$

The vanadium-bearing organic would be scrubbed in a mixer-settler with an acid solution. The vanadium would be stripped from the solvent in three mixer-settler stages with a total retention time of 3.5 minutes in the two mixing stages. The sizes of these settlers would be 14 feet 9 inches long, by 8 feet 2 inches wide, by 3 feet 4 inches deep.

Vanadium would be stripped from the loaded organic according to the equilibrium shown below.

$$[(R_3NH^+)_4H_2V_{10}O_{28}^{4-}]_{org} + 4Na_2CO_3 \Rightarrow 4R_3N + Na_4H_2V_{10}O_{28} + 4NaHCO_3$$

The vanadium specie would be converted to metavanadate and then precipitated from the stripping liquor in three, fiberglass reinforced plastic (FRP) batch precipitation tanks by the addition of ammonium sulfate to precipitate the vanadium as ammonium metavanadate (AMV) (NH_4VO_3). There would be a fourth tank that would act as a storage tank to blend a bad precipitation batch with

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

a normal batch so that they could be advanced to the belt filter. The residence time in precipitation is designed to be 48 hours. The AMV would be dewatered on an 8 foot wide by 30 foot long belt filter, dried in a steam vacuum dryer, and deammoniated in an indirect-fired kiln. The V_2O_5 discharging from the kiln would be melted in a 10 foot long by 5 foot outer diameter direct fired furnace. The furnace would discharge to a casting water wheel where the V_2O_5 melt would be solidified into a fused black-flake product. The revolving casting water wheel would be nominally 12 feet in outer diameter and comprised of eight water cooled 1 foot wide sections fabricated of mild steel. The unit would be fitted with a roller-breaker to reduce the flake to an appropriate size for shipment. A simple scraper would continuously remove the broken flake product from the wheel into a bin for packaging. The black-flake would be packed, weighed, and sealed for shipment in labeled 55 gallon drums.

There would be two scrubbers in this area: one servicing the steam dryer and rotary kiln and the other one servicing the furnace, casting water wheel, and the packaging system. Both scrubbers would have removal efficiencies of 97–99 percent.

2.10 Reagents Storage & Handling

Reagents, to be provided by a supplier, would be delivered via truck and would be offloaded by pump, air, or forklift as necessary according to the supplier's recommendations. The truck offloading area would be bermed and sloped to a sump for containment. A safety shower would be located in the offloading area. Throughout the plant, reagents would be stored close to where they would be used. All storage areas would be bermed for containment and would include a safety shower. Unless otherwise mentioned, reagent storage is designed for 2 weeks.

Sulfuric acid, 93 percent by weight, would be piped on a ring main. The line size has been determined by a maximum fluid velocity of 1 foot per second to prevent corrosion.

Ammonium sulfate would be stored in a silo and added to a solution tank via weigh hopper and conveyor.

Sodium hydroxide would be delivered in 275 gallon totes and diluted to 8 percent by weight. The totes would be stored in a heated room and the dilution tank would be heated and insulated. All piping would be heat traced.

Sodium carbonate crystals would be offloaded using a water eductor to create a 31 percent, by weight, solution. The solution would then be diluted and stored as a 15 percent, by weight, solution. Available storage time would be 1 week.

Flocculant would be delivered in super-sacks that would be stored in a dry area. The dry flocculant would be blown into the wet area to minimize globule formation of the flocculant.

Amine (Alamine 336) would be delivered in 275 gallon totes.

Isodecanol (Exxal 13) would be delivered in 55 gallon drums.

Sodium chlorate would be delivered and stored as a 50 percent, by weight, solution and then diluted and stored as a 39 percent, by weight, solution in FRP tanks. Both tanks would be heated and insulated; all piping would be heat traced.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

Hydrogen peroxide would be offloaded using a stainless steel centrifugal pump and would be stored in a stainless steel tank. Available storage time would be 7 weeks.

Diatomaceous earth would be delivered in bulk bags.

3.0 MEASUREMENT UNITS AND SYMBOLS

The US Customary System (USCS) of measurement used in this CH2M HILL design criteria is generally in accordance with the ANSI/IEEE Standard 260, IEEE Standard Letter Symbols for Units of Measurement.

A period is used as the decimal marker. The reference conditions for gas volume are 60°F and 29.92 in. mercury, corresponding with a molar (ideal) gas volume of 379.4 ft^3/(lb•mol). This is shown as standard cubic feet or abbreviated to "scf."

The exception to the use of US Customary units is the measurement of solution concentration which is given in grams per liter (gpl).

Base Units: (dimensionally independent)

Measured Attribute	Unit	Symbol
length	foot	ft
mass	pound	lb
time	second	s
electric current	ampere	A
thermodynamic temperature	degree Rankine	°R
amount of substance	mole[1]	mol
luminous intensity	Candela[1]	cd

Other Base Units Used:

Measured Attribute	Unit	Symbol	Formula
length	inch	in.	1/12 ft
	yard	yd	3 ft
mass	grain	gr	1/7 000 lb
	ounce (avoirdupois)	oz	0.06250 lb
	ounce (troy)	tr. oz	0.06857 lb
	ton (short)	t	2,000 lb

[1] Indicates equivalence with International System of Units (SI) modernized metric system. SI prefixes are not used except with terms that are common to the SI system.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

Measured Attribute	Unit	Symbol	Formula
	gram	g	0.0022046 lb
temperature	degree Fahrenheit	°F	°R – 459.67
time	minute	min	60 s
	hour	h	60 min
	day	d	24 h
	year (calendar)	y	365 d
volume (liquid)	gallon (us)	gal	231 in^3
	liter	l	0.2642 gal

Selected Derived Units:

Note: The ASTM permitted form Wh is used rather than W h.

frequency (periodic)	hertz(1)	Hz	1/s
force	pound-force	lbf	lbf
pressure, stress	pound-force per square foot	lbf/ft^2	lbf/ft^2
energy, work, heat quantity	British thermal unit	Btu	0.2931 Wh
power, electrical	watt(1)	W	V × A
	kilowatt(1)	kW	W × 103
	megawatt(1)	MW	W × 106
	kilovolt ampere	kVA	V × A × 103
	megavolt ampere	MVA	V × A × 106
quantity of electricity	coulomb(1)	C	A × s
electric potential, emf	volt(1)	V	W/A
electric capacitance	farad(1)	F	C/V
electric resistance	ohm(1)	Ω	V/A
electric conductance	siemens(1)	S	A/V
magnetic flux	weber(1)	Wb	V·s
magnetic flux density	tesla(1)	T	Wb/m^2
inductance	henry(1)	H	Wb/A
Fahrenheit temperature	degree Fahrenheit	°F	°R – 459.15
plane angle	radian(1)	rad	dimensionless
solid angle	steradian(1)	sr	dimensionless
luminous flux	lumen(1)	lm	cd·sr
illuminance	lux(1)	lx	lm/m^2
activity (of a radionuclide)	becquerel(1)	Bq	1/s
absorbed dose	gray(1)	Gy	J/kg
dose equivalent	sievert(1)	Sv	J/kg

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

Selected Common Units of USCS:

Measured Attribute	Unit	Symbol
acceleration	feet per second squared	ft/s^2
angular acceleration	radian per second squared	rad/s^2
angular velocity	radian per second	rad/s
electric flux density	coulomb per square foot	C/ft^2
energy	foot-pound force	ft·lbf
energy (electrical)	kilowatt-hour(1)	kWh
heat flux density	Btu per square foot	Btu/ft^2
luminance	candela per square foot	cd/ft^2
loudness of sound	decibel(1)	dB

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

Measured Attribute	Unit	Symbol
molar energy	Btu per mole	Btu/mol
molar heat capacity	Btu per mole degree Rankine	Btu/(mol·°R)
specific heat capacity	Btu per pound degree Fahrenheit	Btu/(lb·°F)
thermal conductivity	Btu ft per hour area degree Fahrenheit	Btu·ft/(h·ft^2·°F)

Abbreviations of Other Terms:

Term	Abbreviation
alternating current	ac
atmosphere	atm
barrel	bbl
boiling point	bp
chlorofluorocarbon	CFC
cosine	cos
cotangent	cot
diameter	dia
diameter, inside	i.dia
diameter, outside	o.dia
direct current	dc
electromotive force	emf
fiberglass reinforced plastic	FRP
gallon	gal
gallon per minute	gpm
gram per liter	gpl
height	H
horsepower	hp
induced draft	ID
length	L
maximum	maxm
mile per hour	mph
minimum	minm
mole percent	mol %
molecular mass (weight)	mol wt
number	no.
particles ≤ 10 micrometers	PM_{10}
parts per billion	ppb
parts per million	ppm
parts per million by volume	ppmv
parts per million by mass (weight)	ppmw
power factor	PF

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

Term	Abbreviation
pressure, absolute	psia
pressure, gage	psig
radio frequency	RF
revolutions per minute	rpm
revolutions per second	rps
root mean square	rms
sine	sin
specific gravity	S.G.
specific heat	Sp.Ht.
tangent	tan
temperature	temp
tons per day (short)	tpd
tons per hour	tph
tons per year	tpy
ultra high frequency	UHF
very high frequency	VHF
volume	vol
volume percent	vol %
weight (mass)	wt
weight (mass) percent	wt %
width	W

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

4.0 SITE DATA

4.1 Location

The Piñon Ridge project site is located approximately 8 miles southeast of Bedrock, in Colorado.

4.2 Meteorological Data

The following abbreviated meteorological data apply for the purpose of this specification.

	Units	Value	Code
Mean barometric pressure	in. Hg	24.4	A
Ambient air temperature			
Average Daily Maximum	°F	67.2	A: 6.1
Average Daily Minimum	°F	38.4	A: 6.1
Daily Minimum (Design)	°F	-20	C
Wind velocity			
Maximum gust (Design)	mph	70	A
Prevailing direction		West	A: 6.1
Precipitation			
Rainfall, average	in./y	7.68	A: 6.1
Rainfall, maximum for 24 hour period	in.	4.43	A
Snowfall	in./y	negligible	A: 6.1

4.3 Other Site Data

Elevation above mean sea level	ft	5,600	A

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

5.0 ENVIRONMENTAL CRITERIA

5.1 General Applicable Regulations and Standards

The Piñon Ridge project would conform to applicable federal, state, and local environmental laws, regulations, and permit conditions, as furnished by the Energy Fuels Resources Corporation (EFR).

These environmental criteria would require updating as an environmental impact report, the related environmental permits, zoning/land use permits, and public health laws with their attendant regulations, permit conditions, and other constraints become established. It would be the ultimate responsibility of the EFR to identify these project requirements and determine the completeness of the environmental criteria.

5.2 Special Considerations/Comments

The ore pads, tailings cells, and evaporation ponds are designed by Golder Associates Inc. and become an integral part of the overall project water balance and water handling/treatment planning for the construction, operation, and closure phases of the project.

5.3 Effluent, Emission, and Pollution Control Criteria

5.3.1 General

The environmental criteria section will be organized by media (e.g., water, air, solids). The intent of these criteria is to set forth the design requirements in the engineering and construction terms rather than reciting the regulatory language.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

5.3.2 Air

	Units	Balance	Design	Code
Opacity for fugitive particulate sources	%		TBD	B
Opacity of particulate point sources for materials handling and processes controlled by baghouse or scrubber	%		TBD	B
Emissions limits	mg/Nm^3 (dry basis)	40	TBD	B
Dust in enclosed spaces (e.g., reclaim tunnels)				
Total dust	mg/m^3		30/silica[2] + 2 TBD	B
Respirable dust	mg/m^3		10/silica[2] + 2 TBD	B

Particulate point source PM_{10} emissions would not exceed 50 mg/sdm^3.
Storage tanks for hydrocarbons with vapor pressure in excess of 1.5 psia would be reviewed for possible vapor recovery requirements; e.g., fitted with organic vapor recovery cartridges. No vapor recovery would be furnished for storage tanks for hydrocarbons with vapor pressures less than 1.5 psia.
Fire protection extinguishing agents would be free of ozone-depleting CFCs (e.g., halon).

5.3.3 Water

	Units	Value	Code
Plant discharge for all precipitation events up to 100 year, 24 hour storm		Zero	B

[2] silica = quartz silica (SiO_3) in ore expressed as a percentage

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

Waste Water

Washdown water would drain to sumps and would be returned to process or discharged to the tailings pond	B
Analytical laboratory sinks would drain through lime chip neutralization and would be discharged to the tailings pond	G
Sanitary sewage would be piped to leach fields	A

5.3.4 Solids

Domestic

Recyclable and non-recyclable trash would be, decontaminated, stored in dumpsters, and transferred off site	A
Non-decontaminated trash would be transported and deposited in an active tailings cell	A

Process

Wastes would be segregated for recycle or recovery	G
Nonrecyclable/nonrecoverable waste would be disposed in a permitted onsite facility	G
Equipment or materials (including hydraulic systems and transformers) containing PCBs would not be used	B
Designated hazardous wastes would be transported offsite to an approved disposal facility after decontamination	G
Spent oils and solvents from the maintenance facilities would be stored in containers for recycling	G

5.3.5 Fencing

A 6 foot high chain link fence would surround the entire licensed property. The fence would have three-strand barbed wire on top and the buried depth for burrowing animal protection would be 2 feet. Separate fencing would be provided around the main substation. Game fencing would surround the Piñon Ridge property.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

6.0 DESIGN CRITERIA REFERENCE LIST

6.1 *Energy Fuels Resource Corporation Uranium Mill Licensing Support Climatological Report Piñon Ridge Mill Site Montrose County, Colorado* Kleinfelder Report, December 2007

6.2 *Autogenous and Semi-autogenous Grinding Studies on Blanding, Utah, Operation Ores* CSMRI Report, July 1978.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

7.0 PRODUCTION SUMMARY

7.1 Annual Production Parameters

7.1.1 Annual Production

	Units	Balance	Design	Code
Plant feed, ore (dry basis)	tpy	350,000		A
Uranium concentrate (U_3O_8)	tpy	840		E
Vanadium concentrate (V_2O_5)	tpy	2,646		E
Final tailings	tpy	365,690		E

7.1.2 Daily Production

Plant feed, ore (dry basis)	tpd	1,000	1,080	A
Uranium concentrate (U_3O_8)	tpd	2.4		E
Vanadium concentrate (V_2O_5)	tpd	7.6		E
Final tailings	tpd	1,046.4		E

7.2 Concentrate Grade

Uranium (U_3O_8)	%	98.2	98.2	E
Vanadium (V_2O_5)	%	100.0	100.0	E

7.3 Recovery

Uranium	%	96	96	A
Vanadium	%	85	85	A

7.4 Operating Schedule

Operating days per year	d	350	350	A
Operating hours per day	h	24	24	A
Plant availability	%	95	95	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

8.0 CHARACTERISTICS OF PROCESS MATERIALS

8.1 Introduction

The two groups of economic minerals in the ores to be treated by the Piñon Ridge plant are uranium minerals and vanadium minerals. The predominant uranium mineral is pitchblende. The predominant vanadium minerals are montrosite and vanadium chlorite.

8.2 Mineralogy, Process Raw Materials

	Code
Principal rock and mineral types – sandstone: quartz and calcite	A

8.3 Chemical Composition of ROM Ore

	Units	Balance	Design	Code
Uranium content (U_3O_8), average	%	0.2	0.2	A
Vanadium content (V_2O_5), average	%	0.8	0.8	A

8.4 Physical Characteristics of ROM Ore

Maximum ROM ore size	in.		12	A
Shape			blocky	A
Moisture content	%	5	5	A
ROM bulk density, dry				
For weight purposes	lb/ft^3		100	A
For volume purposes	lb/ft^3		100	A
ROM bulk density, wet				
For weight purposes	lb/ft^3		105	A
Ore hardness			medium	A

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

9.0 COARSE ORE STORAGE

9.1 Operating Time

	Units	Balance	Design	Code
Feed	tpy	350,000	350,000	A
Operating days per year	d		350	A
Operating days per week	d		7	A
Operating shifts per day	shift		2	A

9.2 Equipment

Haul truck	h		16.5	A
Front end loader	h		16.5	A
Rock breaker (mobile)	h		intermittent	B

9.3 Coarse Ore Stockpile

Live capacity inside license boundary	acres		5+1	A
Angle of repose				
For volume	degree		40.0	A
For area	degree		34.0	A
Drawdown angle	degree		37.0	G

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

10.0 GRINDING

10.1 Operating Time and Grinding Tonnage Rate

	Units	Balance	Design	Code
Operating days per year	d		350	A
Operating days per week	d		7	A
Operating shifts per day	shift		2	A
Operating hours per day	h		16.5	A
Availability	%		95	A
Operating hours (350 x 16.5 x 0.95)	h		5,486	E
Feed rate	tph	63.8	70	E

10.2 Grinding Power Requirements

10.2.1 Work Index

SAG Mill	kWh/t	7.4	7.4	K: 6.2

10.2.2 Mill Power

Specific power				
SAG Mill	kWh/t	3.78	3.78	K: 6.2
Installed power per line				
SAG Mill	hp		500	D

10.3 Equipment

10.3.1 Coarse Ore Reclaim Feeders

Apron Feeder	no.		1	A
Drive	type		adjustable speed	B
Design capacity, each	tph	63.8	100	C

10.3.2 SAG Mill Feed Conveyor

Design capacity	tph	63.8	100	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

10.3.3 SAG Mill

	Units	Balance	Design	Code
Mill	no.		1	A
Size of mill				
Diameter, inside shell x length, EGL	ft		14 x 5	A
New feed rate	tph	63.8	70	E
Design circulation load				
Percentage of new feed	%	100	100	A
Rate	tph	63.8	70	E
Total feed to SAG Mill	tph	127.6	140	E
Discharge density	% solids	66	70	B
Installed power	hp		500	D
SAG Mill critical speed	%		TBD	D
Loading, by volume	%		TBD	D
Discharge	type		slotted grate	B
Grate aperture	in.	0.75	TBD	D
Size of ball, diameter	in.		3 or 4	B
Ball charge, by volume				
Nominal	%	8	15	C
Ball consumption	lb/t		0.4	G
New feed size, 100% passing	in.	12	12	A

10.3.4 SAG Mill Discharge Trommel

Feed rate to trommel	tph	127.6	137.8	E
Percent solids in feed	wt %	74	75	B
Oversize	tph	0.2	0.22	B
Solids	wt %	80	80	B
Undersize	tph	127.4	137.6	E
Solids	wt %	74	75	E
Trommel opening				
Aperture shape			slotted	B
Aperture	inch		0.75	B
Material			polyurethane	B
Wash water to trommel	gpm	1	2	B

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

10.3.5 SAG Mill Discharge Pumps

	Units	Balance	Design	Code
Pump	no.		2 (1 operating + 1 uninstalled standby)	A
	Type		Cetrifugal Metal	B
Flow rate	gpm	449	485	E
Pulp density	% solids	66	71	E
Specific gravity of pulp	S.G.	1.76	1.85	E
Drive				
Speed			adjustable	C
Control			sump level	B

10.3.6 SAG Mill Classifying Screen

Screen	no.		2	D
Screen size	ft		15.7 L x 4.8 W	D
Screen aperture	mesh		28	A
Screen feed (slurry)	gpm	449	485	E
Screen wash water	gpm	13	14	E
Screen oversize				
Solids	tph	62.9	70	E
Flow rate	gpm	154	166	E
Percent solids	wt %	80.5	85	G
Screen undersize				
Solids	tph	62.9	70	E
Flow rate	gpm	308	333	E
Percent solids	wt %	54	58	E
Product size, P80	mesh		48	A

10.3.7 Pulp Storage Tanks

Holding tanks	no.		2	A
Material			Rubber lined carbon steel	
Tank volume total (ea.)	gal		348,486	C
Tank volume live (ea.)	gal		214,526	C
Tank diameter	ft		39	C
Tank height	ft		39	C
Tank agitator	hp		125	D
Feed rate	tph	62.9	70	E
Storage time (ea.)	h	11.6*	10.7*	E
		*Based on balance flowrate	*Based on design flowrate	

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

11.0 LEACHING

11.1 Pre-leach

	Units	Balance	Design	Code
Pre-Leach Tank				
Number required	no.		2	A
Type			Vigorous Agitation	A
Material			Rubber lined (Chlorobutyl) carbon steel with acid bricks	A
Retention time per tank	h		1.5	A
Tank volume (ea.)	gal		62,187	C
Tank diameter	ft		21	C
Tank height	ft		24	C
Tank agitator	hp		40	D
Feed rate, solids	tph	42	45.4	A
Temperature	ºF	106	175	E&C
Percent solids	wt %	23	25	E
Thickener				
Number required	no.		1	A
Type			High capacity	C
Diameter	ft		60	A
Specific capacity			TBD	E
Material			Epoxy coated carbon steel	C
Solids feed rate	tph	43.2	46.6	E
Solids specific gravity	S.G.		2.7	E
Slurry feed rate	gpm	575	621	E
Feed temperature	ºF	105	150	E
Thickener unit area	ft^2/(tpd)		2.83	E
Flocculant			TBD	D
Flocculant dosage	lb/t	0.2	0.25	G
Flocculant concentration	wt %		0.5	B
Feed pulp solids	wt %	24	26	E
Underflow pulp solids	wt %	54	58	A
Underflow pumps				
Type			Peristaltic	C
Flow rate	gpm	200	216	E
Overflow solids	ppm	200	100-200	G

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

	Units	Balance	Design	Code
Clarifier				
Number required		no.	1	A
Type		Clarifier/ Thickener	B	
Diameter		ft	50	A
Material			Epoxy coated carbon steel	C
Solids feed rate	tph	0.03	0.05	E
Solids specific gravity	S.G.		2.7	E
Slurry flowrate	gpm	505	545	E
Feed temperature	ºF	106	150	E
Underflow solids	wt %	20	20	G
Overflow solids	ppm	50	50	G

11.2 Leach

Leach tank				
Number required	no.		8	C
Type			Vigorous agitation	A
Material			Rubber lined (Chlorobutyl) carbon steel with acid bricks	A
Tank volume (ea.)	gal		62,187	E
Tank diameter	ft		21	C
Tank height	ft		24	C
Tank agitator	hp		40	D
Retention time (total)	h		21	A
Feed rate	tph	43	47	E
Operating temperature	ºF	185	190	A
Steam addition	lb/h	10,000	11,000	E
Percent solids	wt %	54	50	E
Sulfuric acid supply	lb/t	340	400	A
Sulfuric acid feed, maintain free acid	gpl	80	100	A
	gpm	16	18	E
Oxidant consumption	lb/t	4.7	10	E
U_3O_8 extraction	% of total		96.4	A
V_2O_5 extraction	% of total		85.4	A

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

12.0 COUNTER CURRENT DECANTATION AND TAILINGS

12.1 Counter Current Decantation

	Units	Balance	Design	Code
Thickener				
Number required	no.		7 or 8	A
Number in design	no.		8	A
Diameter	ft		40	A
Material			Epoxy coated carbon steel	A
Solids feed rate	tph	43	47	E
Solids specific gravity	S.G.	2.7	2.7	E
Slurry feed rate	gpm	218	235	E
Thickener unit area	ft^2/(tpd)		1.25	E
Flocculant			TBD	D
Flocculant addition rate	lb/t	0.8	0.9	A
CCD thickener 1	lb/t	0.20		C
CCD thickener 2	lb/t	0.15		C
CCD thickener 3	lb/t	0.13		C
CCD thickener 4	lb/t	0.10		C
CCD thickener 5	lb/t	0.08		C
CCD thickener 6	lb/t	0.06		C
CCD thickener 7	lb/t	0.04		C
CCD thickener 8	lb/t	0.03		C
Flocculant concentration	wt %		0.5	B
Feed pulp solids	wt %	49.7	53	E
Underflow pulp solids	wt %	50	50	B
Thickener underflow pumps				
Type			Peristaltic	C
Number required	no.		8	A
Flow rate	gpm	226	253	E
Percent solids	wt%	50	50	B
Slurry specific gravity	S.G.	1.56	1.6	E
CCD Thickener 1 overflow	gpm	377	407	E
Overflow specific gravity	S.G.	1.1	1.1	G
Overflow solids	ppm	200	100-200	G
Overflow temperature				
CCD thickener 1	ºF	117	150	E
CCD thickener 8	ºF	67	150	E
Thickener overflow pumps				
Number required	no.		8	C
Flow rate	gpm	375	456	E
Type			Centrifugal	C
Material			rubber lined	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

12.2 Tailings

	Units	Balance	Design	Code
Total plant tailings	tph	43.6	50	E
Flow rates	gpm	503	543	E
Pulp specific gravity	S.G.	1.28	1.35	E
Solids	%	27	30	E
Temperature	ºF	88	105	E
pH	pH	1.8 – 2	2.0	E
Iron Sulfate concentration	gpl $Fe_2(SO_4)_3$	38		E
Barge pump*	no.		2	A
*The barge pump from tailings cell B would be used as the standby pump for the mill startup				
Flow rate	gpm	375	450	E

The design of the tailings cells and evaporation ponds is by Golder Associates Inc.

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

13.0 URANIUM SOLVENT EXTRACTION

13.1 Polishing Filters

	Units	Balance	Design	Code
Number required	no.		2	A
Filter feed	gpm	378	408	E
Filter feed solids	ppm	50	100	G
Filter discharge solids	ppm		5	C
Filter feed surge capacity	gal		30,000	C

13.1.1 Extraction

SX Aqueous feed surge capacity	gal		79,433	C
Number of extraction mixer/settler trains	no.		2	C
Number of extraction mixer/settlers per train	no.		4	A
Aqueous feed rate per train	gpm	189	204	E
Recycle flow, organic	gpm	129	139	E
Barren organic surge capacity	gal		64,302	C
Tank material			FRP	C
Loaded organic surge capacity	gal		64,302	C
Tank material			FRP	C
Organic feed rate per train	gpm	80	86	E
Continuous phase	type		Organic	B
Mixer organic to aqueous ratio			1.1/1	A
Number of mixers per settler	no.		2	D
Mixer retention time (total)	min		3	A
Settler area	gpm/ft^2		2.5	C
Material			316L SS	D
Organic composition				
Amine	vol%		1 vol% per gpl U_3O_8 in feed	C
Isodecanol	vol%		3	C
Kerosene	vol%		remainder	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

13.1.2 Scrub

	Units	Balance	Design	Code
Number of scrub mixer/settlers	no.		1	A
Aqueous advance rate	gpm	1	1-10	E
Organic feed rate	gpm	160	165	E
Recycle flow, aqueous	gpm	31	21-31	E
Mixer organic to aqueous ratio			5/1	A
Mixer retention time (total)	min		1.5	A
Number of mixers per settler	no.		2	D
Settler area	gpm/ ft^2		2.5	C
Material			316L SS	D
Aqueous scrub composition				
Sulfuric Acid	wt%	93	93	C
	gpm	.001	.01	E
Raw water	gpm	1	1-10	E
pH of mixture		pH	1.5	E

13.1.3 Strip

Number of strip mixer/settlers	no.		2	A
Aqueous advance rate	gpm	3.9	5	E
Recycle flow, aqueous	gpm	60	65	E
Organic feed rate	gpm	159	165	E
Mixer organic to aqueous ratio			2.5/1	A
Mixer retention time (total)	min	3	3	A
Number of mixers per settler	no.		2	D
Settler area	gpm/ft^2		2.5	C
Material			316L SS	D
Aqueous strip composition				
Sodium Carbonate	wt%	15	15	C

13.1.4 Uranium SX pumps

Barren organic pump				
Flow rate	gpm	80	96	E
Material			316L SS	C
Raffinate pump				
Flow rate	gpm	379	456	E
Material			316L SS	C
Type			Centrifugal	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

14.0 URANIUM PRECIPITATION, DRYING AND PACKAGING

14.1 Uranium Precipitation

	Units	Balance	Design	Code
Pregnant strip surge capacity	gal		3,760	C
Pregnant strip flow rate	gpm	3.9	5	E
Dilution water	gpm	14.6	15.8	E
Precipitation operating temperature	ºF	84-88	100	E
Precipitation Tank				
Number required	no.		5	C
Type			Vigorous Agitation	
Material			Steel, Chlorobutyl rubber lined	C
Tanks 2 – 3 size	gal		881	C
Retention time	h		0.5	C
Tanks 4 – 6 size	gal		3,008	C
Retention time	h		1.9	C
Sulfuric Acid required	gpm	0.4	0.6	E
Hydrogen Peroxide required	gpm	0.1	0.12	E

14.2 Uranium Recovery, Drying and Packaging

Thickener type			High capacity	C
Number required	no.		1	C
Size (diameter)	ft		32	C
Material			Steel, Rubber lined	C
Thickener unit area	ft^2/(tpd)		23.7	E
Solids feed rate	lb/h	398	432	E
Flocculant addition rate	lb/t	.005	.01	G
Belt filter				
Number required	no.		1	C
Type			Vacuum	
Size	ft		15.25 L x 4.3 W	D
Solids feed rate	lb/h	398	432	E
Feed percent solids	wt%	60	60	C
Steam vacuum dryer				
Type			Hollow screw	A
Temperature, max	ºF		300	B
Dryer feed rate	lb/h	200	216	E
Feed percent solids	wt%	75	60	E
Packaged Uranium 55 gal drums	no./day		7	E
Weight of drum	lb		700	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

15.0 VANADIUM SOLVENT EXTRACTION

15.1 Vanadium Oxidation

	Units	Balance	Design	Code
Vanadium Oxidation tanks				
Number required	no.		6	A
Tanks 1 – 3 size	gal		7,109	C
Agitator (1-3)	hp		3	G
Tanks 4 – 6 size	gal		73,578	C
Agitator (4-5)	hp		15	G
Bottom			cone (160°)	G
Material			FRP	A
Sodium chlorate addition	gpm	3.1	3.5	E
Anhydrous ammonia (vaporized)	lb/h	273	300	E

15.1.1 Extraction

SX Aqueous feed surge capacity	gal		79,438	C
Number of extraction mixer/settler trains	no.		2	C
Number of extraction mixer/settlers per train	no.		5	A
Aqueous feed rate per train	gpm	191	206	E
Recycle flow, organic	gpm	132	143	E
Barren organic surge capacity	gal		64,302	C
Tank material			FRP	C
Loaded organic surge capacity	gal		64,302	C
Tank material			FRP	C
Organic feed rate	gpm	79	85	E
Mixer organic to aqueous ratio			1.1/1	A
Mixer retention time (total)	min		4	A
Number of mixers per settler	no.		2	D
Settler area factor	gpm/ft^2		2.5	C
Material			316L SS	D
Organic composition				
Amine	vol%		3	C
Isodecanol	vol%		2.5	C
Kerosene	vol%		remainder	C
Anhydrous ammonia per train	lb/h	40	45	E
Sulfuric acid	gpm	0.25	0.3	E

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

15.1.2 Scrub

	Units	Balance	Design	Code
Number of scrub mixer/settlers	no.		1	A
Aqueous advance rate	gpm	1	1-10	E
Recycle flow, aqueous	gpm	31	21-31	E
Organic feed rate	gpm	159	172	E
Mixer organic to aqueous ratio			5/1	A
Mixer retention time (total)	min		2	A
Number of mixers per settler	no.		2	D
Settler area factor	gpm/ft^2		2.5	C
Material			316L SS	D
Aqueous scrub composition				
Sulfuric Acid	wt%	93	93	C
	gpm	0.001	0.01	E
Raw water	gpm	1	1-10	E
pH of mixture		pH	1.5	E

15.1.3 Strip

Number of strip mixer/settlers	no.		3	A
Aqueous advance rate	gpm	7	10	E
Recycle flow, aqueous	gpm	73	79	E
Organic feed rate	gpm	159	172	E
Mixer organic to aqueous ratio			2/1	A
Mixer retention time (total)	min		3.5	A
Number of mixers per settler	no.		2	D
Settler area	gpm/ft^2		2.5	C
Material			316L SS	D
Aqueous strip composition				
Sodium Carbonate	wt%	15	15	C
	gpm	4.7	5	E

15.1.4 Vanadium SX pumps

Barren organic pump				
Flow rate	gpm	79	96	E
Material			316L SS	C
Type			Centrifugal	C
Vanadium raffinate return pump				
Flow rate	gpm	277	332	E
Material			316L SS	C
Type			Centrifugal	C
Vanadium raffinate pump				
Flow rate	gpm	107	130	E
Material			316L SS	C
Type			Centrifugal	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

16.0 VANADIUM PRECIPITATION, FUSION AND PACKAGING

16.1 Vanadium Precipitation

	Units	Balance	Design	Code
Feed tank capacity	gal		4,511	C
Material			FRP	A
Precipitation tank 1 (conversion)				
Type			Mild agitation	A
Material			FRP	A
Tank volume	gal		3,760	C
Anhydrous ammonia	lb/h	119	129	E
Steam	lb/h	60	65	E
Temperature	ºF		150	E
Precipitation tanks (2 – 4)				
Type			Mild agitation	A
Material			FRP	A
Tank volume (ea.)	gal		9,991	C
Bottom			Cone (120°)	A
Ammonium sulfate	lb/t	41.6	45	E
Precipitation tank 5				
Type			Mild agitation	A
Use			Mixing batches	
Material			FRP	A
Tank volume	gal		9,991	C
Bottom			Cone (120°)	A

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

16.2 Vanadium Fusion and Packaging

	Units	Balance	Design	Code
Belt filter				
Number required	no.		1	A
Type			Vacuum	A
Size	ft		30 L x 8 W	C
Solids feed rate	lb/h	805	869	E
Feed percent solids	wt%	40	40	E
Steam vacuum dryer				
Type			Hollow screw	C
Temperature, max	ºF		300	B
Solids feed rate	lb/h	805	869	E
Feed percent solids	wt%	75	60	E
Rotary kiln (de-ammoniator)				
Type			Indirect fired	C
Temperature, max	ºF		800	B
Solids feed rate	lb/h	808	990	E
Feed percent solids	wt%	97	95	E
Retention time	h		1	C
Fusion furnace (melting furnace)				
Type				
Temperature, max	ºF		1,300	B
Retention time	h		2	C
Casting water wheel				
Capacity	lb/h	630	650	E
Packaged Vanadium 55 gal drums	no./day		21	E
Net weight	lb		700	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

17.0 Reagents

17.1 Sulfuric acid (93%)

	Units	Balance	Design	Code
Consumption	lb/t	400	470	E
Storage duration	weeks		2	A
Storage capacity (total)	t		2,960	E
Storage tank size	gal		128,963	C
Number	no.		3	C
Material			Steel	C

17.2 Anhydrous ammonia

Consumption	lb/t	11.6	12.5	E
Storage duration	weeks		2	A
Storage capacity (total)	gal		24,000	E
Storage tank size	gal		12,000	C
Storage type			Horizontal	C
Number	no.		2	C
Material			Steel	C

17.3 Ammonium sulfate

Consumption	lb/t	41.6	45	E
Storage duration	weeks		2	A
Storage capacity (total)	t		350	E
Storage tank (hopper) size	ft^3		6,280	C
Number	no.		1	C
Material			Steel	C
Solution tank	gal		11,845	C
Number	no.		1	C
Material			Steel	C

17.4 Sodium hydroxide (50%)

Consumption	gal/t	0.09	0.1	E
Storage duration	weeks		2	A
Storage capacity (total)	gal		1,375	E
Storage type			275 gal totes	C
Number	no.		5	C
Dilute storage tank	gal		4,512	C
Number	no.		1	C
Material			Steel	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

17.5 Sodium carbonate (31%)

	Units	Balance	Design	Code
Consumption	lb/t	16.5	17.8	E
Storage duration	weeks		1	C
Storage tank size	gal		26,438	C
Number	no.		1	C
Material			Steel	C
Dilute storage tank	gal		15,228	C
Number	no.		1	C
Material			Steel	C

17.6 Flocculant

Consumption	lb/t	1.0	1.1	E
Storage duration	weeks		2	A
Storage capacity (total)	lb		16,500	E
Storage type			1,650 lb supersacks	C
Number	no.		10	C

17.7 Kerosene (SX 12)

Consumption	gal/t	0.55	0.6	E
Storage duration	weeks		2	A
Storage tank size	gal		38,069	C
Number	no.		1	C
Material			Steel	C

17.8 Amine (Alamine 336)

Consumption	lb/t	0.15	0.17	E
Storage duration	weeks		2	A
Storage capacity (total)	gal		550	E
Storage type			275 gal totes	C
Number	no.		2	C

17.9 Isodecanol (Exxal 13)

Consumption	lb/t	0.04	0.043	E
Storage duration	weeks		2	A
Storage capacity (total)	gal		220	E
Storage type			55 gal drums	C
Number	no.		4	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.

17.10 Sodium chlorate (39%)

	Units	Balance	Design	Code
Consumption	lb/t	45.1	48.7	E
Storage duration	weeks		2.5	C
Storage tank size	gal		98,139	C
Number	no.		1	C
Material			FRP	C
Mix tank	gal		18,425	C
Number	no.		1	C
Material			FRP	C

17.11 Hydrogen peroxide (50%)

Consumption	lb/t	1.37	1.48	E
Storage duration	weeks		7	C
Storage tank size	gal		7,138	C
Number	no.		1	C
Material			316 SS	C

17.12 Diatomaceous earth

Consumption	lb/t	0.1	0.11	E
Storage duration	weeks		2	A
Storage capacity (total)	lb		14,160	E
Storage type			bulk bags	C
Number	no.		15	C

USE OF THIS REPORT IS SUBJECT TO THE RESTRICTIONS SET FORTH IN THE IMPORTANT NOTICE ON THE TITLE PAGE OF THIS REPORT.