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UC Category: 61
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Economic Feasibility Study of an Acid Hydrolysis-Based Ethanol Plant

A Subcontract Report

Badger Engineers, Inc.
Cambridge, MA

April 1987

SERI Technical Monitor:
J. D. Wright

Prepared under Subcontract No. ZX-3-03096-2

Solar Energy Research Institute
A Division of Midwest Research Institute

1617 Cole Boulevard
Golden, Colorado 80401-3393

Prepared for the
U.S. Department of Energy
Contract No. DE-AC02-83CH10093

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BADGER ENGINEERS, INC.

A Raytheon Company

CAMBRIDGE, MASS.

EQUIPMENT LIST

DESIGN CASE I

25 MM GAL/YR ACID BASED WOOD TO ETHANOL PLANT

FOR

SOLAR RESEARCH INSTITUTE

GOLDEN, COLORADO

BADGER JOB NO. E-0461

SERI S/C NO. 2X-3-03096-2

ISSUE	DATE	DESCRIPTION	CH'K'D	APP'D
1	12-7-84	For Final Report		

CERTIFIED

ENG ---------- DATE ----------

---------- DATE ----------

CLIENT ---------- DATE ----------

SHEET 1 OF

SPE-0461-EL-5C

BE-UE-3-1 (8/82)

UNIT	DESCRIPTION
100	Wood Chip Handling
200	Acid Hydrolysis
300	Fermentation
400	Ethanol Purification
500	Furfural Purification
600	Offsite Tankage
700	Environmental
800	Utilities

EQUIPMENT PIECE COUNT*

EQUIPMENT ACCOUNT	ACTUAL	UNIQUE	EQUIVALENT	REMARKS
AS Towers	6	6		
MT	21	19		
MF	4	4		
MR	8	4		
MS/MB	39	36		
PP	169	75		
PB	7	4		
PC	4	3		
PE	2	2		
PD	13	6		
TT	35	34		
TP	2	2		
TY	8	6		
GA		16		
GF	12	10		
G (Balance)	68	41		
H	3	2		
JC	-	-		
Totals	419	270		
B (Bldg)	12	12		

BE-UE-3-2 (Rev. 3/83)

EQUIPMENT LIST
ACCT. "G"

Client SERI | Signature

Unit Feedstock Handling | Location Unit 100

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GE-101	Wood Bucket Conveyor	CS	1	To remove chips from washing pond at 500 tons per hour (2,000 cu. yd/hr). Consider possibility of using radial stacker.
GS-102	Jet Belt Conveyor	CS	1	150 tons/hr chips (612 yd^3/hr) to process (package unit).
GF-103	Chip Pile Screen	CS	1	Vibrating screen with 6" apertures; dim's 20' x 25' wide.
GM-104 A,B,S	Front End Loader	-	1	Caterpillar Type 936 CAT 7.3 yd^3 bucket - one F/E Loader to manage chip pile one to feed belt conveyor.
GS-105	Magnetic Chip Cleaner	CS	1	5 kw Ding (Lexington, MA) to remove down to ½" nuts and bolts
GM-106 A,B	Yard Switching Engines	-	1	100 HP diesel
GY-107	Wood Chip Truck Unloader	-	1	100 HP, hydraulic oil oper.
GY-108	Wood Chip Truck Scale	-	1	In-ground mech. lever type
GY-109	Wood Chip Rail Car Scale	-	1	

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Feedstock Handling **Location** Unit 100

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-101	Flume Pump	2000	5	10	CS	1	To wash chips and drain washing pit

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
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BE-UE-2-3 (8/82)

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EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-210	Sugar Stripper	13' 6" / 40' 0"	20 Sieve	15 FV	275	CS	5	25' skirt
AS-201T	Lot Sieve Trays for AS-201		20			CS	5	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 6 OF	SPE-0461-UE-5

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Dia. ft. / Lth. ft.	H / V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-201 A,B	Slurry Vessel	4000 gal 525 cu ft conical	V	150 FV	500	316L	2	Jayco/Vrieco Conical mixer (see quotation)
MR-202 A,B,S	Hydrolysis Reactor	0'-10" 25'-0"	V	1200 FV	750	See remarks	2	Zirconium lined carbon steel
MS-203	High Pressure Flash Drum	10'-0" 16'-0"	V	200 FV	420	316L	2	With 16'6" long 30° cone bottom
MS-204	Low Pressure Flash Drum	11'-6" 22'-0"	V	50 FV	310	316L	2	
MR-206	Neutralisation Reaction Tank	9'-0" 25'-0"	V	50 FV	250	CS	3	
MS-207	Gypsum Hydroclone	10'-0" 30'-0"	V	50 FV	250	CS	4	
MS-209	Aqueous Furfural Drum	8'-0" 24'-0"	H	50 FV	25	304L	5	
MS-210	1st Stage Wash Tank	6'-0" 18'-0"	V	50 FV	25	304L	3	
MS-211	2nd Stage Lignin Feed Tank	6'-0" 18'-0"	V	50 FV	200	304L	3	
MS-212	Lignin Sludge Tank	7'-0" 20'-0"	V	Atmos	200	304L	3	with agitator 60° cone bottom
MS-213	Gypsum Wash Tank Tank	6'-0" 18'-0"	V	50 FV	200	CS	4	
MS-214	Gypsum Filter Feed Tank	4'-0" 12'-0"	V	50 FV	200	Rubber lined CS	4	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

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ACCT. M - VESSELS

Client SERI | Signature

Unit Acid Hydrolysis | Location Unit 200

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MB-216	Chip Feed Bin	15'-0" 40'-0"	V	Atm.	100	CS	2	Activated Bottom Disch.
MB-217	Ground Wood Bin	20'-0" 20'-0"	V	Atm.	250	CS	2	Activated bottom disch. ~~60° sloped btm.~~
MS-218	Lime Mix Tank	8'-0" 8'-0"	V	25	200	CS	6	Flat top with agitator
MT-219 A,B	Lime Slurry Day Tanks	21'-0" 24'-0"	V	Atm.	150	CS	6	API with top agitator
MB-220	Lime Storage Bin	25'-0" 50'-0"	V	Atm.	150	CS	6	Storage silo with 21'-0" lg ~~60° cone base~~
MT-221	Sulfuric Acid Day Tank	15'-0" 16'-0"	V	Atm.	150	CS	6	API
MT-222	Sugar Stripper Feed Tank	32'-0" 32'-0"	V	Atm.	200	CS	5	API with 4' x 2' DP sump and internal ~~baffles on inlet~~ and outlet
MT-223	Hydrolysis Process Water Tank	14'-6" 16'-0"	V	Atm.	200	CS	6	API Epoxy lined
MF-224	Lime Unloading Pit	20'x50' x3'	-	Atm.		Conc.	6	Below ground
MS-225	2nd Stage Wash Tank	6'-0" 18'-0"	V	25	250	304L	3	
MS-226	3rd Stage Lignin Feed Tank	6'-0" 18'-0"	V	25	250	304L	3	
MS-227	Dewatering Centrifuge Feed Tank	6'-0" 18'-0"	V	25	250	304L	3	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PD-201 A,B,S	Hydrolysis Feed Pump	815 Worthington	860	700	Alloy	2	See A,B,S quotation
PP-202 A,S	Feed Water Pump	1100	340	300	CS	6	
PP-204 A,S	Lignin Slurry Pump	1850	36	60	Duriron	2	
PP-207 A,S	1st Stage Underflow Pump	570	15	15	Duriron	3	25-30% Lignin Slurry
PP-208 A,S	2nd Stage Underflow Pump	500	20	20	Duriron	3	25-30% Lignin Slurry
PP-209 A,S	Alkaline Hydrolysate Pump	1570	20	25	CD4 MCU	3	
PD-210 A,S	Acid Dosing Pump	0.1	20	0.1	Duriron	6	Gear Type
PP-211 A,S	Gypsum Hydroclone Feed Pump	1650	50	60	CD4 MCU	4	
PP-212 A to G	Gypsum Hydroclone Pumps	200	30	15	CD4 MCU	4	7 total
PP-213 A,S	Gypsum Wash Pump	100	35	10	CS	4	
PP-214 A,S	Gypsum Filter Pump	100	20	10	CD4 MCU	4	
PP-215 A,S	Sugar Stripper Feed Pump	1550	35	40	CS	5	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 9 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-216 A,S	Lime Slurry Liquor Pump	100	40	10	CS	5	Intermittent Operation (Batch)
PP-217 A,S	Sugar Stripper Pump	1550	50	60	CS	5	
PP-218 A,S	Aqueous Furfural Pump	800	55	40	Duriron	5	
PO-219 A,S	Sulphuric Acid Feed Pump	10	275	10	Duriron	6	Gear
PP-220 A,S	Lime Mixing Pump	250	25	10	Duriron	6	
PP-221 A,B,S	Lime Slurry Pump	150	35	10	Duriron	6	
PP-223 A,S	Gypsum Filter Wash Pump	60	20	5	CS	4	
PP-224	Sump Pump	250	35	15	CS	5	Intermittent Operation
PP-225	3rd Stage Lignin Underflow Pump	500	20	20	Duriron	3	25-30% Lignin Slurry
PP-226	Sugar Stripper Reboiler Pump	300	125	40	Duriron	5	
PP-227	Hydrolyzate Reheater Pump	150	15	2	Duriron	4	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 10 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Area ft^2	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-201	Primary Feedwater Preheater	16,000	304L 200/FV 420	CS 400 400	BEM	2	
TT-202	H.P. Flash Vapor Aftercooler	4,000	304L 200/FV 420	CS 400 350	BEM	2	
TT-203	Sugar Stripper Reboiler	8,500	304L 200 420	304L 40 400	CEN	5	Vertical Thermosyphon
TT-205	Aqueous Furfural Cooler	5,100	304L 200 320	CS 100 150	BEM	2	
TT-206	Hydrolysate Cooler	11,000	CS 120 275	CS 100 200	BEM	5	
TT-207	Acid Water Heater	2,500	304L 400 500	CS 1250 600	BEM	2	
TT-209	Slurry Cooler	11,000	304L 100 300	CS 400 300	BEM	3	
TT-210	Sugar Stripper Preheater	11,000	CS 100 250	CS 120 275	BEM	5	
TT-211	Secondary Feedwater Preheater	13,000	304L 25/FV 300	CS 400 300	BEM	2	
TT-212	L.P. Flash Vapor Aftercooler	3,000	304L 100 300	CS 100 150	BEM	2	
TT-213	Hydrolyzate Reheater	12,500	304L 100/FV 300	CS 25/FV 300	BEM	4	
TT-214	Overflow Cooler	7,400	CS 100 150	CS 100 150	BEM	4	
TT-215	Slurry Vessel Vent Condenser	100	CS 150 400	CS 100 150	BEM	2	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC. (A Raytheon Company) | ISSUE | DATE | SHEET 11 OF | SPE-0461-EL-5C

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI | Signature

Unit Acid Hydrolysis | Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GS-201 A,B,C	Chip Screen	CS	2	110,000 lb/hr, 1" raw wood chips HP-20 RPM Diam. Length 10'0" (approx.)
GG-202 A,B,C	Grinder	CS	2	110,000 lb/hr "through 20 mesh wood" grinds HP - 3,000 See C.E. Bauer quote.
GS-203 A,B,C	Wood Grinds Conveyor	CS	2	110,000 lb/hr wood grinds (thru 20 mesh) HP - 25 Height - 60'-0"
GA-204 A/B	High Pressure Feeder	316L	2	210,000 lb/hr wood grinds (thru 20 mesh) from atmos. press. to 150 psig 30 HP See Ingersoll Rand quote.
GA-205 A,B	Wood Slurry Agitator	316L	2	HP-75 (approx) conical screen mixer. See Jayco Vrieco quote.
GA-207	Static Mixer	316L	2	790 gpm (1.2% H_2SO_4 @ 350°F) Diam: 10"
GC-209 A/B	1st Stage Lignin Centrifuge	316L	3	1500 gpm P 35 psi Type H-36 Dorr Oliver (Merco) 200 HP See Dorr Oliver Quotation
GC-210 A/B	2nd Stage Lignin Centrifuge	316L	3	450 gpm; 200 HP, Type H-36 Dorr Oliver Merco
GS-211 A,B,C	Lignin Sludge Screws	304L	3	95000 lb/hr moist lignin sludge HP-10 RPM GPM 300 Length 100 feet (Allowance)
GA-212	1st Stage Lignin Feed Tank Agitator	304L	3	HP 3 Prop. type Diam 3'-0"
GA-213	Neutralization Tank Agitator	CS	3	HP-10 Propellor type Diam. = 5'-0"
GC-214 A/B	Lignin Dewatering Centrifuge	316L	3	250 GPM Feed; 200 GPM discharged sludge; HP=150 Type Solid Bowl (See quote)
GC-215	Primary Gypsum Hydroclone	Nylon	4	1650 GPM solid See Bauer & Dorr-Oliver Quotes

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 12 OF	SPE-0461-EL-3C

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI Signature

Unit Acid Hydrolysis Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GC-216 A to G	Gypsum Washing Hydroclones	Nylon	4	190 GPM Total of 7 See Bauer quote or Dorr quote
GA-217	Gypsum Filter Tank Agitator	304L	4	HP - 1 Diam = 24"
GA-219	Gypsum Hydroclone Feed Tank Agitator	CS	4	20 HP Diam = 5'-0"± Prop. type
GF-220	Gypsum Rotary Filter	CS	4	50,000 lb/hr feed slurry (30% solids) to wash and produce 70% solids cake; 20 ft^2 rotary filter; includes vacuum equipment
GA-222	Lignin Sludge Tank Agitator	316L	3	10 HP; helical or prop type; diam = 5'-0"
GC-232A/B	3rd Stage Lignin Centrifuge	316L	3	450 GPM; Type H-36 Dorr Oliver (Merco); 200 HP
GA-233	2nd Stage Lignin Feed Tank Agitator	304L	3	HP-3; Diam 3'-0"; Prop type
GA-234	3rd Stage Lignin Feed Tank Agitator	304L	3	HP-3; Diam 3'-0"; Prop type

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI | Signature

Unit Acid Hydrolysis | Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GS-223	Lime Unloading Conveyor	CS	6	Intermittent Operation 200,000 lb/hr pulverised lime 120 ft. high; 50 HP; Redler type
GA-224	Lime Mix Tank Agitator	304L	6	10 HP; propellor type
GS-225	Lime Solids Feeder	CS	6	20,000 lb/hr rotary feed valve
GS-226	Lime Mixing Conveyor	CS	6	20,000 lb/hr horizontal belt type conveyor weigh feeder
GC-227	Lime Dust Cyclone	CS	6	250 ASFM Air; 15 lb/hr solids
GA-228A/B	Lime Slurry Day Tank Agitator	304L	6	25 HP Propellor type
GY-229	Oversize Wood Grind Screen	CS	2	Vibrating screen Diam - 20'0"
GA-230	Gypsum Wash Tank Agitator	CS	4	5 HP; propellor type Diam 4'-0", length 8'-0"
GS-231 A,B	Wood Grinds Belt Feeder	CS	2	3'-0"x10'-0" LG 170,000 lb/hr wood @ 50% moisture

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-301	Scrubber	7'-3" 23'-0" Packed height 16'-5"	Packed	1.5	110	CS	8	
		1" Plastic Raschig Rings Packing volume 36.9 m^3						

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC. (A Raytheon Company)	ISSUE	DATE	SHEET 15 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MR-301 A,B	#1 Fermenter	17'-0" 60'-0"	V	1.5	105	CS	7	Internal Draft-tube (see sketch)
MR-302 A,B	#2 Fermenter	17'-0" 60'-0"	V	1.5	105	CS	7	Internal Draft-tube (see sketch)
MS-303 A,B	IMY Regeneration Tank	13'-0" 25'-6"	V	50	105	CS	8	With jacket (see sketch)
MS-304	Air Receiver	6'-0" 14'-0"	V	75	150	CS	7	(see sketch)
MS-305 A,B	PBM Tank	7'-0" 12'-0"	V	Atmos + water full	150	CS	7	(see sketch)
MF-306	Blowdown Pit	250 m^3		Atmos + full water		Conc	7	In-ground
MS-311	Resin Tank	4'-0" 4'-0"	V	Atmos + water full	125	304L	9	
MS-312	Yeast Liquid Tank	2'-0" 2'-0"	V	Atmos + water full	125	304L	9	
MS-313	Alginate Tank	2'-6" 2'-6"	V	Atmos + water full	125	304L	9	With jacket designed to 35 psig +125°F (see sketch)
MS-314	CA Tank	6'-0" 8'-0"	V	Atmos + water full	105	Epoxy Coated CS	9	
MF-315	IMY Storage Pit	30'x40' x10' deep	V			Conc	9	nground

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 16OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-301 A,B,S	#1 Broth Recycle Pump	1295	50	50	CI	7	
PP-302 A,B,S	#2 Broth Recycle Pump	1100	50	40	CI	7	
PP-303 A,B,S	Broth Transfer Pump	450	35	20	CI	8	
PP-304 A,B,S	IMY Transfer Pump	450	35	20	CI	7	
PP-305 A,S	Chemical Feed Pump	350	50	25	CI	7	
PP-306 A,S	Scrubber Pump	250	35	15	CI	8	
PD-307 A,S	PBM Pump	3	50	1	PVC	7	Reciprocating
PC-308 A,S	Air Compressor	350 SCFM	50	75	CI	7	Oil Free Reciprocating
PB-309 A,S	Recycle Blower	850 SCFM	50	160	CI	8	Nash/root Blower
PP-311 A,S	Polymer Pump	10	25	1.5	304SS	9	
PP-312 A,S	Yeast Pump	10	25	1.5	304SS	9	
PD-313 A,S	Feed Pump	0.2	25	0.5	304SS	9	
PP-314 A,S	IMY Feed Pump	100	35	5	304SS	9	
PP-315 A,S	CA - Pump	1.5	35	1.5	304SS	9	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 17OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI Signature

Unit Fermentation Location Unit 300

Item No.	Name	Area ft²	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TY-302 A,B	#1 Broth Cooler	4600	Plate 304L	Frame 304L	Plate & Frame	7	NBR Gaskets
TY-303 A,B	#2 Broth Cooler	3200	Plate 304L	Frame 304L	Plate & Frame	7	NBR Gaskets
TP-304	Air Heater	4	CS	CS	Double Pipe	7	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 18 OF | SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. "G"

Client SERI | Signature

Unit Fermentation | Location Unit 300

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-301	Air Prefilter	PVA	7	Glass Wool Packed; 350 SCFM Design Pressure 50 psig
GF-302	Air Filter	PVA	7	Depth Filter ; ; 350 SCFM Design pressure = 50 psig
GF-303 A,B	#1 Auto Strainer	304L SS	7	Rotary Brush Type 1300 GPM Design Pressure 60 psig
GF-304 A,B	#2 Auto Strainer	304L SS	7	Rotary Brush Type 1100 GPM Design Pressure 60 psig
GA-305	PBM Tank Agitator	CS	7	HP 2 Propellor type
GA-311	Line Mixer	304L SS	9	Mechanical in-line mixer 0.3 HP 0.3 GPM
GZ-312	Yeast Immobilising Unit	304L SS	9	Package Unit 0.5 GPM 50 HP Total cost for Seattle - 40.5 million yen (JGC)
GY-313	Chiller Unit		9	80,000 BTU/hr 20 HP Brine circulation supply temp. 0°C Package unit
GA-314	Resin Tank Agitator	304L SS	9	0.5 HP Propellor type
GA-315	Yeast Liquid Tank Agitator	304L SS	9	0.5 HP Propellor type
GA-316	Alginate Tank Agitator	304L SS	9	0.5 HP Propellor type
GA-317	CA Tank Agitator	304L SS	9	5 HP Propellor type
GY-318	Emergency Chiller Unit		7	1.1 mm BTU/hr Package unit 250 HP
GL-319	Lab Equipment		-	For Fermentation unit see attached sheets.

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI — Signature

Unit Ethanol Purification — Location Unit 400

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-401	Beer Column	12'-6" / 32'-0"	16 sieve	15 / FV	300	CS	10	20 ft. skirt
AS-401T	Lot Sieve Trays for AS-401		16			CS	-	
AS-402	Rectification Column	10'-0" / 44'-0"	24 sieve	15 / FV	300	CS	11	20 ft. skirt
AS-402T	Lot Sieve Trays for AS-402		24			CS	-	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 20 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Dia. ft. / Lth. ft.	H / V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-401	Degasser Drum	6'-0" / 18'-0"	V	15 / FV	300	CS	10	
MS-402	Beer Column Reflux Drum	3'-6" / 11'-0"	H	50 / FV	250	CS	10	
MS-403	Fusel Oil Decanter	3'-6" / 12'-0"	H	25 / FV	150	CS	11	with baffle
MT-404	Molecular Sieve Feed Tank	20'-0" / 16'-0"	V	Atm.	250	CS	11	API
MS-405	Rectification Column Reflux Drum	6'-0" / 18'-0"	H	50 / FV	250	CS	11	
MT-406	Dilute Beer Feed Tank	26'-0" / 32'-0"	V	6"WG / Atm.	200	CS	10	API type

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-401 A,S	Beer Column Bottoms Pump	1450	50	60	DI	10	
PC-402	Sugar Stripper Vapor Compressor	32,000 ACFM	23	3500	CI	10	
PP-403 A,S	Beer Column Reflux Pump	220	60	15	DI	10	
PP-404 A,S	Wash Return Pump	30	60	5	DI	11	
PP-405 A,S	Fusel Oil Pump	5	40	1	DI	11	
PP-406 A,S	Molecular Sieve Feed Pump	65	114	15	DI	11	
PP-407 A,S	Rectification Column Bottoms Pump	120	40	5	DI	11	
PP-408 A,S	Rectification Column Reflux Pump	260	60	15	DI	11	
PP-409 A,S	Dilute Beer Feed Pump	1450	50	60	DI	10	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 22 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Area ft²	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-402	Degasser Drum Condenser	1500	CS 100 300	CS 25/FV 300	BEM	10	
TT-403 A,B	Beer Column Reboilers	Total 20,000	CS 25/FV 400	CS 100 350	CEN	10	Vertical Thermosyphon
TT-405	Beer Column Condenser	6,000	CS 100 150	CS 15/FV 300	BEM	10	
TT-406	Beer Column Vent Condenser	7,000	CS 100 150	CS 15/FV 250	BEM	10	
TT-407	Fusel Oil Cooler	300	CS 25 250	CS 100 150	BEM	11	
TT-409	Rectification Column Reboiler	9,100	CS 25/FV 350	CS 100 350	CEN	11	Vertical Thermosyphon
TT-410	Rectification Column Condenser	3,500	CS 100 150	CS 15/FV 300	BEM	11	
TT-411	Rectification Column Vent Condenser	7,000	CS 100 150	CS 15/FV 250	BEM	11	
TT-412	Aqueous Furfural Cooler	6,000	304L 40 400	CS 100 150	BEM	10	
TT-413	Feed Preheater	20,000	304L 40 400	CS 100 400	BEM	10	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 23 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT.

Client SERI | Signature

Unit Ethanol Purification | Location Unit 400

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GZ-401	Molecular Sieve		11	Package Unit to produce 25 mm gal/yr dehydrated ethanol from 181 proof alcohol - see Kemp information

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 2 OF | SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI — Signature

Unit Furfural Recovery — Location Unit 500

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-501	Azeo Column	9'-0" / 60'-0"	25 sieve	15	300	304L	12	20' skirt
AS-501T	Lot Sieve Trays for AS-501		25			304L	12	
AS-502	Dehydration Column	4'-0" / 20'-0"	11 sieve	15	400	CS	12	10' skirt
AS-502T	Lot Sieve Trays for AS-502		11			CS	12	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 25 OF | SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-501	Furfural Decanter	7'-0" 21'-0"	H	100	250	304L	12	With internal baffle
MS-502	Solvent Decanter	10'-0" 30'-0"	H	100	300	304L	12	With internal baffle

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relavant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 26OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-501 A,S	Azeo Column Bottoms Pump	700	35	30	CI	12	
PP-502 A,S	Azeo Column Reflux Pump	120	60	10	CI	12	
PP-503 A,S	Dehydration Column Feed Pump	40	35	5	CI	12	
PP-504 A,S	Dehydration Column Bottoms Pump	30	35	5	CI	12	
PP-505 A,S	Solvent Pump	700	35	30	CI	12	
PP-506 A,S	Furfural Waste Water Pump	700	35	30	CI	12	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 27OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Area ft²	Tube Mat'l. / D.P. psig / D.T. °F	Shell Mat'l. / D.P. psig / D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TY-501	Azeo Column Preheater	23,000	304L SS / 100 / 300		Plate	12	Plate type
TY-502	Azeotrope Aftercooler	600	304L SS / 50 / 250		Plate	12	Plate type
TT-503	Azeo Column Condenser	4,000	304L SS / 50 / 300	CS / 100 / 150	BEM	12	
TT-504	Azeo Column Reboiler	11,000	304L SS / 50 / 350	CS / 150 / 350	BEM	12	
TT-505	Dehydration Column Condenser	2,000	CS / 50 / 350	CS / 100 / 150	BEM	12	
TY-506	Dehydration Column Preheater	500	CS / 50 / 350	— / —	Plate	12	Plate type
TY-507	Furfural Product Cooler	120	CS / 50 / 350	— / —	Plate	12	Plate type
TT-508	Dehydration Column Reboiler	2000	CS / 250 / 400	CS / 250 / 400	BEM	12	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 28 OF | SPE-0461-EL-5C

EQUIPMENT LIST

ACCT. M - VESSELS

Client SERI **Signature**

Unit Offsite Storage Tankage **Location** Unit 600

Item No.	Name	Dia. ft. / Lth. ft.	H / V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MT-606	Azeo Stripper Surge Tank	25'-0" / 24'-0"	V	6"WC / Atm	200	CS	13	API Type
MT-604	Fermentation Feed Tank	26'-0" / 32'-0"	V	6"WC / Atm	250	CS	13	API Type Insulated
MT-601 A,S	Ethanol Product Tank	52'-0" / 32'-0"	V	6"WC / Atm	200	CS	13	API Type Floating Roof
MT-608	Slops Tank	30'-0" / 24'-0"	V	6"WC / Atm	220	CS	13	API Type Insulated & steam traced
MT-607	Fire Water Tank	52'-0" / 32'-0"	V	6"WC / Atm	220	CS	13	API Insulated & steam traced
MT-602 A,B	Furfural Product Tank	48'-0" / 32'-0"	V	6"WC / Atm	250	CS	13	API Type Floating Roof
MT-603	Sulphuric Acid Storage	21'-0" / 24'-0"	V	6"WC / Atm	200	CS	13	API Type
MT-605	Fusel Oil Storage	21'-0" / 16'-0"	V	6"WC / Atm	250	CS	13	API Type Floating Roof
MT-609	Diesel Fuel Tank	15'-0" / 16'-0"	V	6"WC / Atm	150	CS	13	API Type Floating Roof
MT-610	Gasoline Storage Tank	30'-0" / 32'-0"	V	6"WC / Atm	150	CS	13	API Type Floating Roof

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Offsite Storage Tankage **Location** Unit 600

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-606 A/S	Azeo Stripper Feed Pump	800	60	40	DI	13	
PP-604 A/S	Fermentation Feed Pump	1550	70	100	DI	13	
PP-601 A,B,S	Ethanol Product Pump	525	30	20	CS	13	
PP-608 A,S	Slops Transfer Pump	100	40	10	CI	13	
PP-607 A,S	Fire Water Pump	600	100	60	CS	13	
PP-602 A,B,S	Furfural Export Pump	500	30	35	CS	13	
PP-603 A,S	Sulphuric Acid Transfer Pump	100	40	15	CI	13	
PP-605 A,S	Fusel Oil Export Pump	100	30	10	CI	13	
PP-609 A,S	Diesel Fuel Pump	25	50	5	CS	13	
PP-610 A,S	Gasoline Blending Pump	30	30	3	CS	13	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-IE-2-3 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 30 OF | SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Offsite Storage Tankage **Location** Unit 600

Item No.	Name	Area ft^2	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-604	Fermentation Feed Cooler	10,000	CS 100 250	CS 100 150	BEM	13	Plate type

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 31 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT.

Client SERI Signature

Unit Offsite Storage Tankage Location Unit 600

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-604	Air Vent Filter	CS	13	Depth Filter, Glass Wool Cartridge Element, 350 SCFM; ΔP max -2"WG
GF-603	Dessicant Air Filter	CS	13	Silica gel dessicant; max P 2"WG on vent air for MS-803 diameter 1ft. x length 3 ft.

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 32 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. B - Buildings

Client SERI | Signature

Unit Offsite Storage Tankage | Location Unit 600

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
B-1	Administration Building	Conc + Brick		
B-2	Maintenance Building	Corr siding on steel		
B-3	Warehouse Building	Corr siding on steel		60 ft W x 200 ft Lg x 40 ft H for drum and bag storage with winter space heating from steam pipes; 2 doors each end; small office; lunch room.
B-4	Control & Electrical Building	Conc Block		
B-5	Acid Hydrolysis Process Building	Corr siding on steel		
B-6	Fermentation Process Building	Corr siding on steel		
B-7	Fire Pump House	Corr siding on steel		
B-8	Truck Weigh Scale House	Wood		Heated by steam.
B-9	Boiler House	Corr siding on steel		Includes boilers, BFW treating, deaerators.
B-10	Gate House #1	Wood		
B-11	Gate House #2	Wood		
B-12	Well Water Pump House	Corr siding on steel		

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Environmental **Location** Unit 700

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-701	Hotwell Decanter	11'-6" 35'-0"	11	15	200	304L	14	With internal baffle.
MT-702	Mixed Solvent Tank	30'-0" 32'-0"	V	6"WG Atm	200	CS	14	API floating roof.
MT-703	Equalization Tank	-					15	
MT-704	Anaerobic Reactor	-					15	
MS-705	Reactor Surge Drum	-					15	
MS-706	Offgas K.O. Pot	-					15	
MT-707	Biotreater	50'-0" 24'-0"	V	Open top	150	CS Epoxy lined	16	API Tank Open Top
MS-708	Filter Feed Tank	16'-0" 20'-0"	V	Atm	150	CS Epoxy lined	16	
MF-709	Filtrate Sump	4'x4' x6' dp	V	Atm	Amb	Conc	16	Below ground
MS-710	LP Vent K.O. Drum	3'-0" 9'-0"	V	15	150	CS	17	With wire mesh mist eliminator

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 34OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Environmental **Location** Unit 700

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-701 A,S	First Effect Pump	1050	20	20	CD4 MCU	14	
PP-702 A,S	Second Effect Pump	600	30	15	CD4 MCU	14	
PP-703 A,S	Third Effect Pump	150	55	7½	CD4 MCU	14	
PE-704	Evaporator Vacuum System	115 lb/hr Air	Suction Press 2.5 psia	-	304L	14	With condenser 50ft^2
PP-705 A,S	Evaporator Wastewater Pump	1,250	40	40	304L	14	
PP-706 A,S	Solvent Pump	5	35	1	DI	14	
PP-707 A,S	Mixed Solvent Pump	300	40	10	DI	14	
PP-708 A,S	Reactor Feed Pump	-	-	-	-	15	
PP-709	Reactor Recycle Pump	-	-	-	-	15	
PB-710	Offgas Blower	-	-	-	-	15	
PE-711	Equalization Tank Eductor	-	-	-	-	15	
PB-712 A/S	Aeration Blowers	840 SCFM		50	CI	16	
PP-713 A/S	Sludge Pumps	650	20	15	DI	16	
PD-714 A,S	Filter Feed Pumps	85	15	25	DI	16	
PP-715	Filtrate Sump Pump	50	30	3	DI	16	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 35 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Environmental **Location** Unit 700

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-716 A/S	Final Effluent Pumps	700	40	30	DI	16	
PB-717 A,S	L.P. Vent Blower	2400 ACFM	5	25	CI	17	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 36 OF	SPE-0461-EL-5C

EQUIPMENT LIST

ACCT. T - HEAT EXCHANGERS

Client SERI | Signature

Unit Environmental | Location Unit 700

Item No.	Name	Area ft^2	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-701	First Effect Heater	26,000	CS 50/FV 350	CS 100 350	BEM	14	
TT-702	Second Effect Heater	26,000	CS 50/FV 300	CS 25/FV 300	BEM	14	
TT-703	Third Effect Heater	26,000	304L 50/FV 250	304L 25/FV 250	BEM	14	
TT-704	Evaporator Condenser	28,000	304L 100 150	304L 100/FV 250	BEM	14	
TT-705	Stillage Cooler	10,000	304L 100 150	304L 50 250	BEM	14	
TP-706	Solvent Cooler	40	CS 100 150	CS 50 250	BEM	14	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

EQUIPMENT LIST
ACCT. "G" - Special

Client SERI | Signature

Unit Environmental | Location Unit 700

Item No.	Name	Mat'l.	P & I	Duty · Description · Remarks
CE-701	First Effect Evaporator	CS	14	12'-0" dia x 18'-0" high plus cone bottom 25 psig/FV, 300°F
CE-702	Second Effect Evaporator	CS	14	15'-0" dia x 20'-0" high plus cone bottom 25 psig/FV, 250°F
CE-703	Third Effect Evaporator	304L	14	20'-0" dia x 18'-0" high plus cone bottom 25 psig/FV, 250°F
CF-704	Rotary Filter	CS	14	2,000 lb/hr, 10 sq. ft.
CU-705	Reactor Feed Heater	-	15	
CQ-706	Offgas Burner	-	15	
CV-707	Biotreater Agitators	Poly-ethylene	16	40 Kenic S type static aerator tubes 12" diam. x 16' lg.
CV-708	Secondary Clarifier	CS	16	80'-0" diam. center feed clarifier x 11'-0" sidewall with sludge rake and skimmer above grade, 2 HP motor
CV-709	Polymer Feed System	SS or plastic	16	Automated system for batch make-up, transfer to storage, & injection into process.
CV-710	Belt Filter Press	CS	16	Horizontal belt filter press 2 meters.
CA-711	Polymer Mixer	CS	16	In-line static mixer 3" ø
CA-712	Filter Feed Tank	CS	16	Side Mtd Impeller Type Agitator located on MS-708; HP-7.5
	Flame Arrestor			
	MT-704 A,B Packing License			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 3 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Utilities **Location** Unit 800

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MT-801	Process Water Tank	50'-0" 40'-0"	V	Atm	200	CS	19	API
MS-802	Blowdown Flash Drum	3'-0" 10'-0"	V	50/FV	350	CS	20	
MS-803	Hydrazine Drum	250 gals	V	10	200	316L SS	20	
MS-804	Condensate Surge Drum	10'-0" 30'-0"	H	15	250	CS	20	
MF-805	Backwash Transfer Tank	22'-0" 4'-0"	V	Atm	Amb	CS	19	
MS-806	Plant Air Receiver	5'-0" 16'-0"	V	150	150	CS	23	
MS-807	Instrument Air Receiver	5'-0" 16'-0"	V	150	150	CS	23	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 39OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI | Signature

Unit Utilities | Location Unit 800

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-802 A,S	Process Water Transfer Pumps	2400	31	75	DI	19	
PP-803 A,S	Process Water Circulating Pump	5000	60	250	DI	19	
PP-804 A,B	Backwash Feed Pumps	6000	21	125	DI	19	
PP-805 A,B	Backwash Transfer Pumps	50	21	1.5	DI	19	
PP-806 A,S	Blowdown Pump	50	25	3	DI	20	
PP-807	Hydrazine Transfer Pump	5	20	1	316SS	20	
PP-808 A,S	H.P. BFW Pump	1700	1250	2750	Chrome Steel	20	Multistage
PP-809 A,S	Deaerator Feed Pump	1700	20	40	DI	20	
PP-810 A,S	Turbine Condensate Pump	650	40	30	DI	21	
PC-811	Air Compressor	1000 SCFM	125	250	CS	23	Oil free recip with coolers and ancillaries
PP-812 A-H	Cooling Water Circ. Pumps	7500	60	350	CI	22	Motor drives qty. = 8
PP-813 A,B,S	Well Water Pumps	2000	25	50	DI	19	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 40OF | SPE-0461-EL-5C

EQUIPMENT LIST

ACCT. G

Client SERI | Signature

Unit Utilities | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-801	Sand Filter	CS	19	34'-0" dia. x 8'-0"; 18" sand, 18" anthracite
GU-803 A,B	Demineralizers		20	2 bed, skid mounted, 400 GPM capacity at 50 psig, 100 F, with intermediate degasifier, regeneration equipment, required tanks, pumps
				and auxiliaries and chemical storage for 14 days operation. Permutit or equal.
GU-804 A,S	Condensate Polisher	SS	20	Duplex bed; 1,400 GPM capacity
GU-805	Condensate Collection System		20	2,000 gal. tank with two 1,700 GPM, 70 ft. head pumps, CS, rubber lined.
GV-806	Deaerator	CS shell SS internals	20	30 psig/FV, 300 F, 1700 GPM capacity, 17,000 gals. storage. To reduce dissolved oxygen to 0.005 cc/l.
GU-807	Hydrazine Addition Unit	316L SS	20	150 gal. tank and two metering pumps, 0.1 to 5 GPH.
GU-808	Ammonia Addition Unit	Chrome Steel	20	150 gal. tank and two metering pumps, 0.1 to 5 GPH.
GU-809	Phosphate Addition Unit	316L SS	20	150 gal. tank with agitator and two metering pumps, 0.1 to 5 GPH.
GY-810	Instrument Air Dryer	CS	23	600 SCFM, dual tower, dessicant type, electric heater regeneration
GZ-811	Turbo Generator	-	21	44.5 mw See next sheet for details
GT-812	Cooling Tower	Internals vendor Std	22	60,000 GPM, inlet temp. 118 F, outlet 88 F, heat load 900 mm BTU air; New England temps: dry bulb 88F, wet bulb 74 F.

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BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. A Raytheon Company	ISSUE	DATE	SHEET 4 OF	SPE-0461-EL-5C

EQUIPMENT LIST

ACCT. G

Client SERI — Signature

Unit Utilities — Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
CZ-811	Turbogenerator		21	
	Rated steam in: 1100 psia; 874°F 522,110 lb/hr			
	steam out: 150 psig, 22,500 lb/hr			
	50 psig, 344,600 lb/hr			
	Total electrical generation 44.5 mw			
	Supply 480V, 60 Hz, 3 pH			
	120/208V, 60 Hz, 3 pH (4 wire)			
	With turbine condenser: 30,000 ft^2, 180 mm BTU/hr			
	CS/CS			
	and vacuum ejector set and controls.			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 4 OF	SPE-0461-EL-5C

EQUIPMENT LIST
ACCT. H

Client SERI | Signature

Unit Utilities | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
HB-801 A,B	Steam Boilers			18
	Steam rate:(actual)		357,500 lb/hr (each)	
	(design)		400,000 lb/hr (each)	
	Pressure:		1100 psia	
	Temp.		874°F	
	Feedwater temp.:		212°F	
	Absorbed heat load: (actual)		446 mm BTU/hr (each)	
	Efficiency:		85.0 percent	
	Total fuel available:			
	Process liquids:		63,000 lb/hr, LHV = 7100 BTU/lb	
	Process vent gas:		11,000 SCF/hr, LHV = 544 BTU/SCF	
	Lignin/tar solids:		50,000 lb/hr	
	Auxiliary startup fuel: Diesel oil			
	Each boiler to be able to take full solids flow			
	Use Flakt system for lignin and tar; common system for both boiler covers:			
	Drying			
	and			
	Particulate emission control			
	Note: (1) Each boiler produces 50% of the total steam make. This corresponds to 64% of process requirements.			
	(2) Each boiler is rated for 110% of actual steam make.			
HC-803	Common stack, concrete, 270 ft. high, 12'-0" ø			
	self supporting (allowance - to be confirmed)			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. (A Raytheon Company)	ISSUE	DATE	SHEET 4 OF	SPE-0461-EL-5C

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BADGER ENGINEERS, INC.

A Raytheon Company

CAMBRIDGE, MASS.

EQUIPMENT LIST

DESIGN CASE II

ALTERNATE CASE

25 MM GAL/YR ACID BASED WOOD TO ETHANOL PLANT

FOR

SOLAR ENERGY RESEARCH INSTITUTE

GOLDEN, COLORADO

BADGER JOB NO. E-0461

SERI S/C NO. ZX-3-03096-2

ISSUE	DATE	DESCRIPTION	CH'K'D	APP'D

CERTIFIED

ENG _____ DATE _____

_____ DATE _____

CLIENT_____ DATE _____

SHEET 1 OF

SPE-0461-EL-5D

BE-UE-3-1 (8/82)

EQUIPMENT LIST
ACCT. "G"

Client SERI | Signature

Unit Feedstock Handling (Alt. Case) | Location Unit 100

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GE-101	Wood Bucket Conveyor	CS	1	To remove chips from washing pond at 500 tons per hour (2,000 cu. yd/hr). Consider possibility of using radial stacker
GS-102	Jet Belt Conveyor	CS	1	150 tons/hr chips (612 yd^3/hr) to process (package unit).
GF-103	Chip Pile Screen	CS	1	Vibrating screen with 6 apertures; dim's 20' x 25' wide
GM-104 A,B,S	Front End Loader	-	1	Caterpillar Type 936 CAT 7.3 yd^3 bucket - one F/E Loader to manage chip pile, one to feed belt conveyor
GS-105	Magnetic Chip Cleaner	CS	1	5 kw Ding (Lexington, MA) to remove down to ½" nuts and bolts
GM-106 A,B	Yard Switching Engines	-	1	100 HP diesel
GY-107	Wood Chip Truck Unloader	-	1	100 HP, hydraulic oil oper.
GY-108	Wood Chip Truck Scale	-	1	in-ground mech. lever type
GY-109	Wood Chip Rail Car Scale	-	1	

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BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 2OF | SPE-0461-EL-5D

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Acid Hydrolysis (Alt. Case) **Location** Unit 200

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-201	Sugar Stripper	13' 6" 40' 0"	20 Sieve	15 FV	275	CS	5	25' skirt
AS-201T	Lot Sieve Trays for AS-201		20			CS	5	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 3 OF	SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI | Signature

Unit Acid Hydrolysis (Alt. Case) | Location Unit 200

Item No.	Name	Dia. ft. / Lth. ft.	H / V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-201 A,B	Slurry Vessel	4000 gal 525 cu ft conical	V	150/FV	500	316L	2	Jayco/Vrieco Conical mixer (see quotation)
MR-202 A,B,S	Hydrolysis Reactor	0'-10" 25'-0"	V	1200/FV	750	See remarks	2	Zirconium lined carbon steel
MS-203	High Pressure Flash Drum	10'-0" 16'-0"	V	200/FV	420	316L	2	With 16'6" long 30° cone bottom
MS-204	Low Pressure Flash Drum	11'-6" 22'-0"	V	50/FV	310	316L	2	
MR-206	Neutralisation Reaction Tank	9'-0" 25'-0"	V	50/FV	250	CS	3	
MS-207	Gypsum Hydroclone Feed Tank	10'-0" 30'-0"	V	50/FV	250	CS	4	
MS-209	Aqueous Furfural Drum	8'-0" 24'-0"	H	50/FV	25	304L	5	
MS-210	1st Stage Wash Tank	6'-0" 18'-0"	V	50/FV	25	304L	3	
MS-211	2nd Stage Lignin Feed Tank	6'-0" 18'-0"	V	50/FV	200	304L	3	
MS-213	Gypsum Wash Tank Tank	6'-0" 18'-0"	V	50/FV	200	CS	4	
MS-214	Gypsum Filter Feed Tank	4'-0" 12'-0"	V	50/FV	200	Rubber lined CS	4	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 4 OF | SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit 2nd Stage Hydrolysis (Alternative Case) **Location**

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MR-250	2nd Stage Hydrolysis Reactor	0'-7" / 25'-0"	V	1200 / FV	750	Zirconium Lined CS	2A	
MS-251	2nd Stage Slurry Vessel	6'-6" / 18'-0"	V	200	500	316L	2A	
MS-252	2nd Stage H.P. Flash Drum	5'-0" / 10'-0"	V	200 / FV	500	316L	2A	30° Cone Bottom
MS-253	2nd Stage LP Flash Drum	6'-0" / 18'-0"	V	50 / FV	500	316L	2A	30° Cone Bottom
MS-255	2nd Stage Lignin Wash Tank	5'-0" / 12'-0"	V	50	250	304L	2A	
MS-256	2nd Stage Lignin Centrifuge Feed Tank	5'-0" / 12'-0"	V	50	250	304L	2A	
MS-257	Lignin Sludge Tank	8'-0" / 20'-0"	V	Atm	250	304L	2A	
MS-258	Dewatering Centrifuge Feed Tank	5'-0" / 12'-0"	V	Atm	200	304L	2A	
MS-259	Sludge Dilution Vessel	6'-0" / 15'-0"	V	50	200	304L	3	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC. A Raytheon Company | ISSUE | DATE | SHEET 5 OF | SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Acid Hydrolysis (Alt. Case) **Location** Unit 200

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MB-216	Chip Feed Bin	15'-0" / 40'-0"	V	Atm.	100	CS	2	Activated Bottom Disch.
MB-217	Ground Wood Bin	20'-0" / 20'-0"	V	Atm.	250	CS	2	Activated bottom disch. ~~60° sloped btm.~~
MS-218	Lime Mix Tank	8'-0" / 8'-0"	V	25	200	CS	6	Flat top with agitator
MT-219 A,B	Lime Slurry Day Tanks	21'-0" / 24'-0"	V	Atm.	150	CS	6	API with top agitator
MB-220	Lime Storage Bin	25'-0" / 50'-0"	V	Atm.	150	CS	6	Storage silo with 21'-0" lg ~~60° cone base~~
MT-221	Sulfuric Acid Day Tank	15'-0" / 16'-0"	V	Atm.	150	CS	6	API
MT-222	Sugar Stripper Feed Tank	32'-0" / 32'-0"	V	Atm.	200	CS	5	API with 4' x 2' DP sump and ~~internal~~ baffles on inlet and outlet
MT-223	Hydrolysis Process Water Tank	14'-6" / 16'-0"	V	Atm.	200	CS	6	API Epoxy lined
MF-224	Lime Unloading Pit	20'x50' x3'	-	Atm.		Conc.	6	Below ground
MS-225	2nd Stage Wash Tank	6'-0" / 18'-0"	V	25	250	304L	3	
MS-226	3rd Stage Lignin Feed Tank	6'-0" / 18'-0"	V	25	250	304L	3	
MS-227	Dewatering Centrifuge Feed Tank	6'-0" / 18'-0"	V	25	250	304L	3	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 6 OF	SPE-0461-EL-50

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Acid Hydrolysis (Alt. Case) **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PD-201 A,B,S	Hydrolysis Feed Pump	600	860	520	Alloy 20	2	See Worthing. quotation
PP-202 A,S	Feed Water Pump	1100	340	300	CS	6	
PP-204 A,S	Lignin Slurry Pump	1150	36	40	Duriron	2	
PP-207 A,S	1st Stage Lignin Underflow Pump	570	15	15	Duriron	3	
PP-208 A,S	2nd Stage Lignin Underflow Pump	500	20	20	Duriron	3	
PP-209 A,S	Alkaline Hydrolysate Pump	1570	20	25	CD4 MCU	3	
PD-210 A,S	Acid Dosing Pump	0.1	20	0.1	Duriron	6	Gear Type
PP-211 A,S	Gypsum Hydroclone Feed Pump	1650	50	60	CD4 MCU	4	
PP-212 A to G	Gypsum Hydroclone Pumps	200	30	15	CD4 MCU	4	7 total
PP-213 A,S	Gypsum Wash Pump	100	35	10	CS	4	
PP-214 A,S	Gypsum Filter Pump	100	20	10	CD4 MCU	4	
PP-215 A,S	Sugar Stripper Feed Pump	1550	35	40	CS	5	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC. A Raytheon Company | ISSUE | DATE | SHEET 7 OF | SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Acid Hydrolysis (Alt. Case) **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-216 A,S	Lime Slurry Liquor Pump	100	40	10	CS	5	Intermittent Operation (Batch)
PP-217 A,S	Sugar Stripper Pump	1550	50	60	CS	5	
PP-218 A,S	Aqueous Furfural Pump	800	55	40	Duriron	5	
PD-219 A,S	Sulphuric Acid Feed Pump	10	275	10	Duriron	6	Gear
PP-220 A,S	Lime Mixing Pump	250	25	10	Duriron	6	
PP-221 A,B,S	Lime Slurry Pump	150	35	10	Duriron	6	
PP-223 A,S	Gypsum Filter Wash Pump	60	20	5	CS	4	
PP-224	Sump Pump	250	35	15	CS	5	Intermittent Operation
PP-225 A/S	3rd Stage Lignin Underflow Pump	500	20	20	Duriron	3	
PP-226	Sugar Stripper Reboiler Pump	300	125	40	Duriron	5	
PP-227	Hydrolyzate Reheater Pump	150	15	2	Duriron	4	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 8 OF	SPE-0461-EL-50

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit 2nd Stage Hydrolysis (Alternative Case) **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PD-250 A/S	2nd Stage Hydrolysis Feed Pump	420	634	500	Alloy 20	2A	By Worthington
PD-251 A/S	2nd Stage Acid Dosing Pump	0.1	275	0.25	Duriron	2A	Gear Type
PP-252 A/S	2nd Stage Lignin Slurry Pump	405	35	15	Duriron	2A	
PP-254 A/S	2nd Stage Lignin Wash Pump	330	35	15	CI	2A	
PP-255	2nd Stage Lignin Centrifuge Feed Pump	200	20	10	CI	2A	
PP-256	Dewatering Centrifuge Feed Pump	160	20	10	CI	2A	
PP-257	2nd Stage Slurry Pump	400	35	15	Duriron	3	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC. A Raytheon Company	ISSUE	DATE	SHEET 9 OF	SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI | Signature

Unit Acid Hydrolysis (Alt. Case) | Location Unit 200

Item No.	Name	Area ft²	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-201	Primary Feedwater Preheater	16,000	304L 200/FV 420	CS 400 400	BEM	2	
TT-202	H.P. Flash Vapor Aftercooler	4,000	304L 200/FV 420	CS 400 350	BEM	2	
TT-203	Sugar Stripper Reboiler	8,500	304L 200 420	304L 40 400	CEN	5	Vertical Thermosyphon
TT-205	Aqueous Furfural Cooler	5,100	304L 200 320	CS 100 150	BEM	2	
TT-206	Hydrolysate Cooler	11,000	CS 120 275	CS 100 200	BEM	5	
TT-207	Acid Water Heater	2,500	304L 400 500	CS 1250 600	BEM	2	
TT-209	Slurry Cooler	11,000	304L 100 300	CS 400 300	BEM	3	
TT-210	Sugar Stripper Preheater	11,000	CS 100 250	CS 120 275	BEM	5	
TT-211	Secondary Feedwater Preheater	13,000	304L 25/FV 300	CS 400 300	BEM	2	
TT-212	L.P. Flash Vapor Aftercooler	3,000	304L 100 300	CS 100 150	BEM	2	
TT-213	Hydrolyzate Preheater	12,500	CS 100/FV 300	304L 25/FV 300	BEM	4	
TT-214	Overflow Cooler	7,400	CS 100 150	CS 100 150	BEM	4	
TT-215	Slurry Vessel Vent Condenser	100	CS 150 400	CS 100 150	BEM	2	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit 2nd Stage Hydrolysis (Alternative Case) **Location**

Item No.	Name	Area ft^2	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-251	2nd Stage Slurry Cooler	1750	304L 100 300	CS 400 300	BEM	2A	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 11 OF	SPE-0461-EL-5D

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI | Signature

Unit Acid Hydrolysis (Alt. Case) | Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
CS-201 A,B,C	Chip Screen	CS	2	110,000 lb/hr, 1" raw wood chips; HP-20 Length 10'0" (approx.)
CG-202 A,B,C	Grinder	CS	2	110,000 lb/hr "through 20 mesh wood" grinds HP - 3,000 See C.E. Bauer quote.
CS-203 A,B,C	Wood Grinds Conveyor	CS	2	110,000 lb/hr wood grinds (thru 20 mesh) HP - 25 Height - 60'-0"
CA-204 A/B	High Pressure Feeder	316L	2	140,000 lb/hr wood grinds (thru 20 mesh) from atmos. press. to 150 psig; 30 HP See Ingersoll Rand quote.
CA-205 A,B	Wood Slurry Agitator	316L	2	HP-75 (approx); conical screen mixer; see Jayco Vrieco quote.
CA-207	Static Mixer	316L	2	790 gpm; (1.2% H_2SO_4 @ 350°F) Diam: 10"
CC-209 A/B	1st Stage Lignin Centrifuge	316L	3	1728 gpm See Dorr Oliver quote.
CC-210 A/B	2nd Stage Lignin Centrifuge	316L	3	1160 gpm; See Dorr Oliver quote
CA-212	1st Stage Lignin Centrifuge Feed Tank Agitator	304L	3	HP 3 Prop. type Diam 3'-0"
CA-213	Neutralization Tank Agitator	CS	3	HP-10 Propellor type Diam. = 5'-0"
CC-214 A/B	Lignin Dewatering Centrifuge	316L	3	500 GPM Feed; HP=200; Type: Screen Bowl (See Dorr Oliver quote)
CC-215	Primary Gypsum Hydroclone	Nylon	4	1650 GPM See Bauer & Dorr-Oliver Quotes

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 1 OF 3	SPE-0461-EL-5D

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI **Signature**

Unit Acid Hydrolysis (Alt. Case) **Location** Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GC-216 A to G	Gypsum Washing Hydroclones	Nylon	4	190 GPM; Total of 7 See Bauer quote or Dorr quote
GA-217	Gypsum Filter Tank Agitator	304L	4	HP - 1; Diam = 24"
GA-219	Gypsum Hydroclone Feed Tank Agitator	CS	4	20 HP; Diam = 5'-0" Prop. type
GF-220	Gypsum Rotary Filter	CS	4	50,000 lb/hr feed slurry (30% solids). To wash and produce 70% solids cake; 20 ft^2 rotary filter; includes vacuum equipment

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. A Raytheon Company	ISSUE	DATE	SHEET 13 OF	SPE-0461-EL-5D

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI Signature

Unit Acid Hydrolysis (Alt. Case) Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
CS-223	Lime Unloading Conveyor	CS	6	Intermittent Operation 200,000 lb/hr pulverised lime 120 ft. high; 50 HP; Redler type
GA-224	Lime Mix Tank Agitator	304L	6	10 HP; propellor type
CS-225	Lime Solids Feeder	CS	6	20,000 lb/hr rotary feed valve
CS-226	Lime Mixing Conveyor	CS	6	20,000 lb/hr horizontal belt type conveyor weigh feeder
GC-227	Lime Dust Cyclone	CS	6	250 ASFM Air; 15 lb/hr solids
GA-228A/B	Lime Slurry Day Tank Agitator	304L	6	25 HP Propellor type
GY-229	Oversize Wood Grind Screen	CS	2	Vibrating screen Diam - 20'0"
GA-230	Gypsum Wash Tank Agitator	CS	4	5 HP; propellor type; Diam 4'-0", length 8'-0"
CS-231 A,B	Wood Grinds Belt Feeder	CS	2	3'-0"x10'-0" LG; 170,000 lb/hr wood @ 50% moisture
GC-232A/B	3rd Stage Lignin Centrifuge	316L	3	1160 GPM See Dorr Oliver quote
GA-233	2nd Stage Lignin Feed Tank Agitator	304L	3	HP = 3 Diam 3'-0" Prop type
GA-234	3rd Stage Lignin Feed Tank Agitator	304	3	HP = 3; Diam 3'-0"; Prop type

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 1 OF	SPE-0461-EL-5D

EQUIPMENT LIST

ACCT.

Client SERI Signature

Unit 2nd Stage Acid Hydrolysis (Alt. Case) Location

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GA-250	2nd Stage Slurry Vessel Agitator	316L	2A	Prop. Type
GC-251 A/B	2nd Stage Primary Lignin Centrifuge	316L	2A	412 gpm See Dorr Oliver quotation
GC-252	2nd Stage Lignin Washing Centrifuge	316L	2A	650 gpm; see Dorr Oliver quotation.
GC-253	2nd Stage Lignin Dewatering Centrifuge	316L	2A	157 gpm
GS-254 A,B,C	2nd Stage Lignin Sludge Screw	304L	2A	Total sludge flow 130 gpm
GA-255	2nd Stage Centrifuge Feed Tank Agitator	304L	2A	2.5 HP Diam. 3'-0" Length 12' Prop. type
GA-257	Dilution Vessel Agitator	304L	3	HP - 3.0 Diam. 4'-0"
GA-258	Dewatering Centrifuge Feed Agitator	304L	2	HP - 3.0; Diam 3'-0"

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. (A Raytheon Company)	ISSUE	DATE	SHEET 1 OF	SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Utilities (Alt. Case) **Location** Unit 800

Item No.	Name	Dia. ft. / Lth. ft.	H / V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MT-801	Process Water Tank	50'-0" 40'-0"	V	Atm	200	CS	19	API
MS-802	Blowdown Flash Drum	3'-0" 10'-0"	V	50/FV	350	CS	20	
MS-803	Hydrazine Drum	250 gals	V	10	200	316L SS	20	
MS-804	Condensate Surge Drum	10'-0" 30'-0"	H	15	250	CS	20	
MF-805	Backwash Transfer Tank	22'-0" 4'-0"	V	Atm	Amb	CS	19	
MS-806	Plant Air Receiver	5'-0" 16'-0"	V	150	150	CS	23	
MS-807	Instrument Air Receiver	5'-0" 16'-0"	V	150	150	CS	23	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Utilities (Alt. Case) **Location** Unit 800

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-802 A,S	Process Water Transfer Pumps	2400	31	75	DI	19	
PP-803 A,S	Process Water Circulating Pump	5000	60	250	DI	19	
PP-804 A,B	Backwash Feed Pumps	6000	21	125	DI	19	
PP-805 A,B	Backwash Transfer Pumps	50	21	1.5	DI	19	
PP-806 A,S	Blowdown Pump	50	25	3	DI	20	
PP-807 A,S	Hydrazine Transfer Pump	5	20	1	316SS	20	
PP-808 A,S	H.P. BFW Pump	1700	1250	2750	Chrome Steel	20	Multistage
PP-809 A,S	Deaerator Feed Pump	1700	20	40	DI	20	
PP-810 A,S	Turbine Condensate Pump	650	40	30	DI	21	
PC-811	Air Compressor	1000 SCFM	125	250	CS	23	Oil free recip with coolers and
							ancillaries
PP-812 A-H	Cooling Water Circ. Pumps	7500	60	350	CI	22	Motor drives qty. = 8
PP-813 A,B,S	Well Water Pumps	2000	25	50	DI	19	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 17OF	SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. G

Client SERI | Signature

Unit Utilities (Alt. Case) | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-801	Sand Filter	CS	19	34'-0" dia. x 8'-0"; 18" sand, 18" anthracite
GU-803 A,B	Demineralizers		20	2 bed, skid mounted, 400 GPM capacity at 50 psig, 100 F, with intermediate degasifier, regeneration equipment, required tanks, pumps
				and auxiliaries and chemical storage for 14 days operation. Permutit or equal.
GU-804 A,S	Condensate Polisher	SS	20	Duplex bed; 1,400 GPM capacity
GU-805	Condensate Collection System		20	2,000 gal. tank with two 1,700 GPM, 70 ft. head pumps, CS, rubber lined.
GV-806	Deaerator	CS shell SS internals	20	30 psig/FV, 300 F, 1700 GPM capacity, 17,000 gals. storage. To reduce dissolved oxygen to 0.005 cc/l.
GU-807	Hydrazine Addition Unit	316L SS	20	150 gal. tank and two metering pumps, 0.1 to 5 GPH.
GU-808	Ammonia Addition Unit	Chrome Steel	20	150 gal. tank and two metering pumps, 0.1 to 5 GPH.
GU-809	Phosphate Addition Unit	316L SS	20	150 gal. tank with agitator and two metering pumps, 0.1 to 5 GPH.
GY-810	Instrument Air Dryer	CS	23	600 SCFM, dual tower, dessicant type, electric heater regeneration
GZ-811	Turbo Generator	-	21	20 mw See next sheet for details
GT-812	Cooling Tower	Internals vendor Std	22	60,000 GPM, inlet temp. 118 F, outlet 88 F, heat load 900 mm BTU air; New England temps: dry bulb 88F, wet bulb 74 F.

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 1 OF | SPE-0461-EL-5D

EQUIPMENT LIST

ACCT. G

Client SERI | Signature

Unit Utilities (Alt. Case) | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GZ-811	Turbogenerator		21	
	Actual steam in: 900 psia; 825°F			
	278,838 lb/hr			
	steam out: 150 psig,			
	17,201 lb/hr			
	50 psig,			
	267,259 lb/hr			
	Total electrical generation 20 mw			
	Supply 480V, 60 Hz, 3 pH			
	120/208V, 60 Hz, 3 pH (4 wire)			
	With turbine condenser: 6,500 ft^2, 38 mm BTU/hr			
	CS/CS			
	and vacuum ejector set and controls.			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC. A Raytheon Company	ISSUE	DATE	SHEET 19F	SPE-0461-EL-5D

EQUIPMENT LIST
ACCT. H

Client SERI | Signature

Unit Utilities (Alt. Case) | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
HB-801 A/B	Steam Boilers		18	
	Steam rate (actual)			246,020 lb/hr (each)
	(design)			300,000 lb/hr (each)
	Pressure			900 psia
	Temp			825°F
	Feed water temp			212°F
	Absorbed heat (actual)			302 mm BTU/hr (each)
	(design)			362 mm BTU/hr (each)
	Efficiency			85%
	Fuel Available:			
	Process liquids:			24,031 lb/hr; LHV-8,500 BTU/lb
	Lignin/tar solids:			35,148 lb/hr; LHV=12,000 BTU/lb
	Auxiliary start-up fuel:			Diesel oil
	Each boiler to be able to take full solids flow. Use Flakt system for lignin and tar, common system for both boilers; Flakt system covers drying and particulates emmission control.			
HC-803	Common stack, concrete 270 ft. high 12'-0" self supporting.			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 2OF	SPE-0461-EL-5D

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BADGER ENGINEERS, INC.

A Raytheon Company

CAMBRIDGE, MASS.

EQUIPMENT LIST

DESIGN CASE III

5 MM GAL/YR ACID BASED WOOD TO ETHANOL PLANT

FOR

SOLAR RESEARCH INSTITUTE

GOLDEN, COLORADO

BADGER JOB NO. E-0461

SERI S/C NO. 2X-3-03096-2

ISSUE	DATE	DESCRIPTION	CH'K'D	APP'D
I	6 AUG. 84	FOR FINAL REPORT DRAFT	SW	

CERTIFIED

ENG ---------- DATE ----------

---------- DATE ----------

CLIENT ---------- DATE ----------

SHEET 1 OF

SPE-0461-EL-5E

BE-UE-3-1 (8/82)

UNIT	DESCRIPTION
100	Wood Chip Handling
200	Acid Hydrolysis
300	Fermentation
400	Ethanol Purification
500	Furfural Purification
600	Offsite Tankage
700	Environmental
800	Utilities

EQUIPMENT PIECE COUNT*

EQUIPMENT ACCOUNT	ACTUAL	UNIQUE	EQUIVALENT	REMARKS
AS (Towers)	6	6		
MT	21	19		
MF	4	4		
MR	8	4		
MS/MB	39	36		
PP	169	75		
PB	7	4		
PC	4	3		
PE	2	2		
PD	13	6		
TT	35	34		
TP	2	2		
TY	8	6		
GA		16		
GF	12	10		
G (Balance)	68	41		
H	3	2		
JC	-	-		
Totals	419	270		
B (Bldg)	12	12		

BE-UE-3-2 (Rev. 3/83)

EQUIPMENT LIST
ACCT. "G"

Client SERI **Signature**

Unit Feedstock Handling **Location** Unit 100

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GE-101	Wood Bucket Conveyor	CS	1	To remove chips from washing pond at 100 tons per hour (400 cu. yd/hr.) Consider possibility of using radial stacker.
GS-102	Jet Belt Conveyor	CS	1	30 tons/hr chips (120 yd^3/hr) to process (package unit).
GF-103	Chip Pile Screen	CS	1	Vibrating screen with 6" apertures; dimensions 9' x 12' wide.
GM-104 A,S	Front End Loader	-	1	Caterpillar Type 936 CAT 7.3 yd^3 bucket - one F/E
GS-105	Magnetic Chip Cleaner	CS	1	5 kw Ding (Lexington, MA) to remove down to ½" nuts and bolts
GM-106 A	Yard Switching Engines	-	1	100 HP diesel
GY-107	Wood Chip Truck Unloader	-	1	100 HP, hydraulic oil oper.
GY-108	Wood Chip Truck Scale	-	1	In-ground mech. lever type
GY-109	Wood Chip Rail Car Scale	-	1	

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

BADGER ENGINEERS, INC. | ISSUE | DATE | SHEET 4 OF | SPE-0461-EL-5E

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Feedstock Handling **Location** Unit 100

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-101	Flume Pump	2000	5	10	CS	1	To wash chips and drain washing pit

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 5 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-210	Sugar Stripper	6' 0" 40' 0"	20 Sieve	15 FV	275	CS	5	25' skirt
AS-201T	Lot Sieve Trays for AS-201		20			CS	5	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 6 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-201 A	Slurry Vessel	1600 gal conical	V	150 FV	500	316L	2	Jayco/Vrieco Conical mixer ~~(see quotation)~~
MR-202 A,S	Hydrolysis Reactor	0'-6" 24'-0"	V	1200 FV	750	See remarks	2	Zirconium lined carbon steel
MS-203	High Pressure Flash Drum	6'-0" 12'-0"	V	200 FV	420	316L	2	With 7'-0" long 30° cone bottom
MS-204	Low Pressure Flash Drum	7'-0" 12'-0"	V	50 FV	310	316L	2	
MR-206	Neutralisation Reaction Tank	5'-0" 16'-0"	V	50 FV	250	CS	3	
MS-207	Gypsum Hydroclone Feed Tank	6'-0" 16'-0"	V	50 FV	250	CS	4	
MS-209	Aqueous Furfural Drum	5'-0" 12'-0"	H	50 FV	25	304L	5	
MS-210	1st Stage Wash Tank	3'-6" 12'-0"	V	50 FV	25	304L	3	
MS-211	2nd Stage Lignin Feed Tank	3'-6" 12'-0"	V	50 FV	200	304L	3	
MS-212	Lignin Sludge Tank	4'-0" 12'-0"	V	Atmos	200	304L	3	with agitator 60° cone bottom
MS-213	Gypsum Wash Tank Tank	3'-6" 12'-0"	V	50 FV	200	CS	4	
MS-214	Gypsum Filter Feed Tank	2'-6" 8'-0"	V	50 FV	200	Rubber lined CS	4	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 7 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI | Signature

Unit Acid Hydrolysis | Location Unit 200

Item No.	Name	Dia. ft. / Lth. ft.	H / V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MB-126	Chip Feed Bin	9'-0" / 24'-0"	V	Atm.	100	CS	2	Activated Bottom Disch.
MB-217	Ground Wood Bin	12'-0" / 12'-0"	V	Atm.	250	CS	2	Activated bottom disch. ~~60° sloped btm.~~
MS-218	Lime Mix Tank	5'-0" / 8'-0"	V	25	200	CS	6	Flat top with agitator
MT-219 A,B	Lime Slurry Day Tanks	12'-0" / 12'-0"	V	Atm.	150	CS	6	API with top agitator
MB-220	Lime Storage Bin	15'-0" / 28'-0"	V	Atm.	150	CS	6	Storage silo with 21'-0" lg ~~60° cone base~~
MT-221	Sulfuric Acid Day Tank	9'-0" / 12'-0"	V	Atm.	150	CS	6	API
MT-222	Sugar Stripper Feed Tank	19'-0" / 20'-0"	V	Atm.	200	CS	5	API with 4'x2' DP sump and ~~internal~~ baffles on inlet and outlet
MT-223	Hydrolysis Process Water Tank	8'-6" / 9'-6"	V	Atm.	200	CS	6	API Epoxy lined
MF-224	Lime Unloading Pit	20'x30' x3'	-	Atm.		Conc.	6	Below ground
MS-225	2nd Stage Wash Tank	4'-0" / 12'-0"	V	25	250	304L	3	
MS-226	3rd Stage Lignin Feed Tank	4'-0" / 12'-0"	V	25	250	304L	3	
MS-227	Dewatering Centrifuge Feed Tank	4'-0" / 12'-0"	V	25	250	304L	3	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PD-201 A,S	Hydrolysis Feed Pump	350	860	300	Alloy 20	2	See Worthington quotation
PP-202 A,S	Feed Water Pump	220	340	75	CS	6	
PP-204 A,S	Lignin Slurry Pump	400	36	15	Duriron	2	
PP-207 A,S	Lignin Wash Pump	120	15	2.5	Duriron	3	
PP-208 A,S	Lignin Centrifuge Pump	100	20	5	Duriron	3	
PP-209 A,S	Alkaline Hydrolysate Pump	320	20	7.5	CD4 MCU	3	
PD-210 A,S	Acid Dosing Pump	0.05	20	0.05	Duriron	6	Gear Type
PP-211 A,S	Gypsum Hydroclone Feed Pump	330	50	15	CD4 MCU	4	
PP-212 A to G	Gypsum Hydroclone Pumps	40	30	2.5	CD4 MCU	4	7 total
PP-213 A,S	Gypsum Wash Pump	20	35	2	CS	4	
PP-214 A,S	Gypsum Filter Pump	20	20	1.5	CD4 MCU	4	
PP-215 A,S	Sugar Stripper Feed Pump	310	35	10	CS	5	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 9 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-216 A,S	Lime Slurry Liquor Pump	20	40	2.5	CS	5	Intermittent Operation (Batch)
PP-217 A,S	Sugar Stripper Pump	310	50	15	CS	5	
PP-218 A,S	Aqueous Furfural Pump	160	55	10	Duriron	5	
PD-219 A,S	Sulphuric Acid Feed Pump	2	275	5	Duriron	6	Gear
PP-220 A,S	Lime Mixing Pump	50	25	2.5	Duriron	6	
PP-221 A,B,S	Lime Slurry Pump	30	35	2.5	Duriron	6	
PP-223 A,S	Gypsum Filter Wash Pump	12	20	1.5	CS	4	
PP-224	Sump Pump	50	35	3	CS	5	Intermittent Operation
PP-225	3rd Stage Lignin Underflow Pump	100	20	5	Duriron	3	25-30% lignin slurry
PP-226	Sugar Stripper Reboiler Pump	60	125	10	Duriron	5	
PP-227	Hydrolyzate Reheater Pump	30	15	1	Duriron	4	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 10OF	SPE-0461-EL-5E

BE-UE-2-3 (8/82)

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Area ft²	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-201	Primary Feedwater Preheater	3,200	304L 200/FV 420	CS 400 400	BEM	2	
TT-202	H.P. Flash Vapor Aftercooler	800	304L 200/FV 420	CS 400 350	BEM	2	
TT-203	Sugar Stripper Reboiler	1,700	304L 200 420	304L 40 400	CEN	5	Vertical Thermosyphon
TT-205	Aqueous Furfural Cooler	1,020	304L 200 320	CS 100 150	BEM	2	
TT-206	Hydrolysate Cooler	2,200	CS 120 275	CS 100 200	BEM	5	
TT-207	Acid Water Heater	500	304L 400 500	CS 1250 600	BEM	2	
TT-209	Slurry Cooler	2200	304L 100 300	CS 400 300	BEM	3	
TT-210	Sugar Stripper Preheater	2200	CS 100 250	CS 120 275	BEM	5	
TT-211	Secondary Feedwater Preheater	2600	304L 25/FV 300	CS 400 300	BEM	2	
TT-212	L.P. Flash Vapor Aftercooler	600	304L 100 300	CS 100 150	BEM	2	
TT-213	Hydrolyzate Reheater	2,500	304L 100/FV 300	CS 25/FV 300	BEM	4	
TT-214	Overflow Cooler	1,500	CS 100 150	CS 100 150	BEM	4	
TT-215	Slurry Vessel Vent Condenser	20	CS 150 400	CS 100 150	BEM	2	
*Consider use of plate type exchanger if cheaper.							

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 11 OF	SPE-0461-EL-5E

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI **Signature**

Unit Acid Hydrolysis **Location** Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GS-201	Chip Screen	CS	2	70,000 lb/hr, 1" raw wood chips HP=20 Diam. 10'0" Length 10'0" (approx.)
GG-202	Grinder	CS	2	70,000 lb/hr "through 20 mesh wood" grinds HP = 2,000; See C.E. Bauer quote.
GS-203	Wood Grinds Conveyor	CS	2	70,000 lb/hr wood grinds (thru 20 mesh) HP = 25; Height - 60'-0"; diam. 3'0"
GA-204	High Pressure Feeder	316L	2	84,000 lb/hr wood grinds (thru 20 mesh) from atmos. press. to 150 psig; 20 HP; See Ingersoll Rand quote.
GA-205	Wood Slurry Agitator	316L	2	HP (approx) 50; conical screen mixer; see Jayco/Vrieco quote.
GA-207	Static Mixer	316L	2	200 gpm (1.2% H_2SO_4 @ 350°F) Diam: 6"
GC-209 A/B	Primary Lignin Centrifuge	316L	3	See Dorr-Oliver quote.
GC-210	Lignin Washing Centrifuge	316L	3	See Dorr-Oliver quote.
GS-211 A,B,C	Lignin Sludge Screws	304L	3	19000 lb/hr moist lignin sludge; HP-5; GPM 50 Length 100 feet (Allowance).
GA-212	Lignin Centrifuge Feed Tank Agitator	304L	3	HP 1; Prop. type Diam 2'-0"
GA-213	Neutralization Tank Agitator	CS	3	HP-2.5; Propellor type; Diam. = 3'-0"
GC-214	Lignin Centrifuge	316L	3	See Dorr-Oliver quotation.
GC-215	Primary Gypsum Hydroclone	Nylon	4	330 GPM See Bauer & Dorr-Oliver Quotes

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 1 OF	SPE-0461-EL-5E

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI | Signature

Unit Acid Hydrolysis | Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GC-216 A to G	Gypsum Washing Hydroclones	Nylon	4	30 GPM Total of 7 See Bauer quote or Dorr quote
GA-217	Gypsum Filter Tank Agitator	304L	4	HP - 0.25; Diam = 1'6"
GA-219	Gypsum Hydroclone Feed Tank Agitator	CS	4	5 HP; Diam = 3'-0"; Prop. type
GF-220	Gypsum Rotary Filter	CS	4	10,000 lb/hr feed slurry (30% solids) to wash and produce 70% solids cake 5 ft^2 rotary filter; includes vacuum equipment
GA-222	Lignin Sludge Tank Agitator	316L	3	10 HP; helical or prop type; diam = 3'-0"
GC-232A/B	3rd Stage Lignin Centrifuge	316L	3	
GA-233	2nd Stage Lignin Feed Tank Agitator	304L	3	HP - 3; Diam 2'-0" Prop type
GA-234	3rd Stage Lignin Feed Tank Agitator	304L	3	HP-3 Diam 3'-0" Prop type

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 1 OF	SPE-0461-EL-5E

EQUIPMENT LIST

ACCT. G - Misc. Equip.

Client SERI Signature

Unit Acid Hydrolysis Location Unit 200

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GS-223	Lime Unloading Conveyor	CS	6	Intermittent Operation 40,000 lb/hr pulverised lime 70 ft. high; 10 HP; Redler type
GA-224	Lime Mix Tank Agitator	304L	6	2.5 HP; propellor type
GS-225	Lime Solids Feeder	CS	6	4000 lb/hr rotary feed valve
GS-226	Lime Mixing Conveyor	CS	6	4000 lb/hr horizontal belt type conveyor (weigh feeder)
GC-227	Lime Dust Cyclone	CS	6	50 ACFM Air; 3 lb/hr solids
GA-228A/B	Lime Slurry Day Tank Agitator	304L	6	5 HP; Propellor type
GY-229	Oversize Wood Grind Screen	CS	2	Vibrating screen; Diam - 10'0"
GA-230	Gypsum Wash Tank Agitator	CS	4	1 HP; propellor type Diam 2'-6", length 5'-0"
GS-231 A	Wood Grinds Belt Feeder	CS	2	3'-0"x10'-0" LG 70,000 lb/hr wood @ 50% moisture

NOTE: Above data (except for item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 1 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-301	Scrubber	3'-6" 23'-0"	Packed	1.5	110	CS	8	
		Packed height 16'-5" 1" Plastic Raschig Rings Packing volume 5.0 m^3						

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC. (A Raytheon Company)	ISSUE	DATE	SHEET 15 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MR-301	#1 Fermenter	12'-6" 45'-0"	V	1.5	105	CS	7	Internal Draft-tube (see sketch)
MR-302 A,B	#2 Fermenter	12'-6" 45'-0"	V	1.5	105	CS	7	Internal Draft-tube (see sketch)
MS-303	IMY Regeneration Tank	10'-0" 20'-0"	V	50	105	CS	8	With jacket (see sketch)
MS-304	Air Receiver	3'-6" 8'-0"	V	75	150	CS	7	(see sketch)
MS-305	PBM Tank	5'-0" 8'-0"	V	Atmos + H_2O full	150	CS	7	(see sketch)
MF-306	Blowdown Pit	50 m^3		Atmos + full H_2O		Conc	7	In-ground
MS-311	Resin Tank	2'-6" 2'-6"	V	Atmos + H_2O full	125	304L	9	
MS-312	Yeast Liquid Tank	1'-3" 1'-3"	V	Atmos + H_2O full	125	304L	9	
MS-313	Alginate Tank	1'-6" 1'-6"	V	Atmos + H_2O full	125	304L	9	With jacket designed to 35 psig +125°F (see sketch)
MS-314	CA Tank	3'-6" 4'-0"	V	Atmos + H_2O full	105	Epoxy Coated CS	9	
MF-315	IMY Storage Pit	20'x20' x6' deep	V			Conc	9	Inground

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 16 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-301 A/S	#1 Broth Recycle Pump	520	50	25	CI	7	
PP-302 A,S	#2 Broth Recycle Pump	440	50	20	CI	7	
PP-303 A,S	Broth Transfer Pump	180	35	7.5	CI	8	
PP-304 A,S	IMY Transfer Pump	180	35	7.5	CI	7	
PP-305 A,S	Chemical Feed Pump	70	50	5	CI	7	
PP-306 A,S	Scrubber Pump	50	35	5	CI	8	
PD-307 A,S	PBM Pump	1	50	0.5	PVC	7	Reciprocating
PC-308 A,S	Air Compressor	70 SCFM	50	15	CI	7	Oil Free Reciprocating
PB-309 A,S	Recycle Blower	170 SCFM	50	32	CI	8	Nash/root Blower
PP-311 A,S	Polymer Pump	2	25	0.5	304SS	9	
PP-312 A,S	Yeast Pump	2	25	0.5	304SS	9	
PD-313 A,S	Feed Pump	0.05	25	0.1	304SS	9	
PP-314 A,S	IMY Feed Pump	20	35	5	304SS	9	
PP-315 A,S	CA - Pump	0.5	35	0.5	304SS	9	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 17 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Area ft²	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TY-302	#1 Broth Cooler	2000	Plate 304L	Frame 304L	Plate & Frame	7	NBR Gaskets
TY-303	#2 Broth Cooler	1300	Plate 304L	Frame 304L	Plate & Frame	7	NBR Gaskets
TP-304	Air Heater	1	CS	CS	Double Pipe	7	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

EQUIPMENT LIST
ACCT. "G"

Client SERI **Signature**

Unit Fermentation **Location** Unit 300

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-301	Air Prefilter	PVA	7	Glass Wool Packed; 70 SCFM Design Pressure 50 psig
GF-302	Air Filter	PVA	7	Depth Filter; 70 SCFM Design pressure = 50 psig
GF-303 A	#1 Auto Strainer	304L SS	7	Rotary Brush Type; 520 GPM; Design Pressure 60 psig
GF-304 A	#2 Auto Strainer	304L SS	7	Rotary Brush Type; 440 GPM; Design Pressure 60 psig
GA-305	PBM Tank Agitator	CS	7	HP 1; Propellor type
GA-311	Line Mixer	304L SS	9	Mechanical in-line mixer 0.1 HP 0.1 GPM
GZ-312	Yeast Immobilising Unit	304L SS	9	Package Unit 0.1 GPM 10 HP JGC Cost Quote: $50,000
GY-313	Chiller Unit		9	16,000 BTU/hr 5 HP Brine circulation supply temp. 0°C Package unit
GA-314	Resin Tank Agitator	304L SS	9	0.1 HP; Propellor type
GA-315	Yeast Liquid Tank Agitator	304L SS	9	0.1 HP; Propellor type
GA-316	Alginate Tank	304L SS	9	0.1 HP; Propellor type
GA-317	CA Tank Agitator	304L SS	9	1 HP; Propellor type
GY-318	Emergency Chiller Unit		7	0.25 mm BTU/hr; Package unit; 50 HP
GL-319	Lab Equipment		-	For Fermentation unit see attached sheets.
Lab equipment same for 5 MM gal		as for 25 MM gal.		

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 1 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-401	Beer Column	5'-6" / 32'-0"	16 sieve	15 / FV	300	CS	10	20 ft. skirt
AS-401T	Lot Sieve Trays for AS-401		16			CS	-	
AS-402	Rectification Column	4'-6" / 40'-0"	24 sieve	15 / FV	300	CS	11	20 ft. skirt
AS-402T	Lot Sieve Trays for AS-402		24			CS	-	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 2 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-401	Degasser Drum	3'-6" 12'-0"	V	15 FV	300	CS	10	
MS-402	Beer Column Reflux Drum	2'-0" 8'-0"	H	50 FV	250	CS	10	
MS-403	Fusel Oil Decanter	2'-0" 8'-0"	H	25 FV	150	CS	11	with baffle
MT-404	Molecular Sieve Feed Tank	12'-0" 12'-0"	V	Atm.	250	CS	11	API
MS-405	Rectification Column Reflux Drum	3'-6" 12'-0"	H	50 FV	250	CS	11	
MT-406	Dilute Beer Feed Tank	15'-0" 20'-0"	V	6"WG Atm.	200	CS	10	API type

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC. (A Raytheon Company)	ISSUE	DATE	SHEET 21OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-401 A,S	Beer Column Bottoms Pump	290	50	15	DI	10	
PC-402	Sugar Stripper Vapor Compressor	6400 ACFM	23	1000	CI	10	
PP-403 A,S	Beer Column Reflux Pump	50	60	5	DI	10	
PP-404 A,S	Wash Return Pump	6	60	2.5	DI	11	
PP-405 A,S	Fusel Oil Pump	1	40	0.25	DI	11	
PP-406 A,S	Molecular Sieve Feed Pump	15	114	10	DI	11	
PP-407 A,S	Rectification Column Bottoms Pump	25	40	2.5	DI	11	
PP-408 A,S	Rectification Column Reflux Pump	50	60	5.0	DI	11	
PP-409 A,S	Dilute Beer Feed Pump	290	50	15	DI	10	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

EQUIPMENT LIST
ACCT. T · HEAT EXCHANGERS

Client SERI **Signature**

Unit Ethanol Purification **Location** Unit 400

Item No.	Name	Area ft^2	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-402	Degasser Drum Condenser	300	CS 100 300	CS 25/FV 300	BEM	10	
TT-403	Beer Column Reboilers	4,000	CS 25/FV 400	CS 100 350	CEN	10	Vertical Thermosyphon
TT-405	Beer Column Condenser	1200	CS 100 150	CS 15/FV 300	BEM	10	
TT-406	Beer Column Vent Condenser	1,400	CS 100 150	CS 15/FV 250	BEM	10	
TT-407	Fusel Oil Cooler	60	CS 25 250	CS 100 150	BEM	11	
TT-409	Rectification Column Reboiler	2000	CS 25/FV 350	CS 100 350	CEN	11	Vertical Thermosyphon
TT-410	Rectification Column Condenser	700	CS 100 150	CS 15/FV 300	BEM	11	
TT-411	Rectification Column Vent Condenser	1400	CS 100 150	CS 15/FV 250	BEM	11	
TT-412	Aqueous Furfural Cooler	1200	304L 40 400	CS 100 150	BEM	10	
TT-413	Feed Preheater	4000	304L 40 400	CS 100 400	BEM	100	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

EQUIPMENT LIST

ACCT.

Client SERI | Signature

Unit Ethanol Purification | Location Unit 400

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
CZ-401	Molecular Sieve		11	Package Unit to produce 5.0 mm gal/yr dehydrated ethanol from 181 proof alcohol - see Kemp information

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 2 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. A - TOWERS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Dia. ft. / Ht. ft.	No. Trays	Design Press. psig.	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
AS-501	Azeo Column	4'-0" / 45'-0"	25 sieve	15	300	304L	12	20' skirt
AS-501T	Lot Sieve Trays for AS-501		25			304L	12	
AS-502	Dehydration Column	2'-0" / 18'-0"	11 sieve	15	400	CS	12	10' skirt
AS-502T	Lot Sieve Trays for AS-502		11			CS	12	

* Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-1 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 25 OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-501	Furfural Decanter	4'-0" 12'-0"	H	100	250	304L	12	With internal baffle
MS-502	Solvent Decanter	6'-0" 16'-0"	H	100	300	304L	12	With internal baffle

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 26OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-501 A,S	Azeo Column Bottoms Pump	140	35	7.5	CI	12	
PP-502 A,S	Azeo Column Reflux Pump	25	60	5	CI	12	
PP-503 A,S	Dehydration Column Feed Pump	10	35	2.5	CI	12	
PP-504 A,S	Dehydration Column Bottoms Pump	6	35	1	CI	12	
PP-505 A,S	Solvent Pump	140	35	7.5	CI	12	
PP-506 A,S	Furfural Waste Water Pump	140	35	7.5	CI	12	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 27OF	SPE-0461-EL-5E

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI **Signature**

Unit Furfural Recovery **Location** Unit 500

Item No.	Name	Area ft²	Tube Mat'l. / D.P. psig / D.T. °F	Shell Mat'l. / D.P. psig / D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TY-501	Azeo Column Preheater	5,000	304L SS / 100 / 300		Plate	12	Plate type
TY-502	Azeotrope Aftercooler	120	304L SS / 50 / 250		Plate	12	Plate type
TT-503	Azeo Column Condenser	800	304L SS / 50 / 300	CS / 100 / 150	BEM	12	
TT-504	Azeo Column Reboiler	2200	304L SS / 50 / 350	CS / 150 / 350	BEM	12	
TT-505	Dehydration Column Condenser	400	CS / 50 / 350	CS / 100 / 150	BEM	12	
TY-506	Dehydration Column Preheater	100	CS / 50 / 350	— / —	Plate	12	Plate type
TY-507	Furfural Product Cooler	25	CS / 50 / 350	— / —	Plate	12	Plate type
TT-508	Dehydration Column Reboiler	400	CS / 250 / 400	CS / 250 / 400	BEM	12	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevent specification/data sheets shall be used.

BE-UE-2-4 (8/82)

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Offsite Storage Tankage **Location** Unit 600

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MT-606	Azeo Stripper Surge Tank	15'-0" 16'-0"	V	6"WG Atm	200	CS	13	API Type
MT-604	Fermentation Feed Tank	21'-3" 16'-0"	V	6"WG Atm	250	CS	13	API Type Insulated
MT-601 A,B	Ethanol Product Tank	30'-0" 24'-0"	V	6"WG Atm	200	CS	13	API Type Floating Roof
MT-608	Slops Tank	21'-3" 16'-0"	V	6"WG Atm	220	CS	13	API Type Insulated & ~~steam traced~~
MT-607	Fire Water Tank	30'-0" 24'-0"	V	6"WG Atm	220	CS	13	API Insulated & ~~steam traced~~
MT-602 A,B	Furfural Product Tank	30'-0" 24'-0"	V	6"WG Atm	250	CS	13	API Type Floating Roof
MT-603	Sulphuric Acid Storage	15'-0" 16'-0"	V	6"WG Atm	200	CS	13	API Type
MT-605	Fusel Oil Storage	15'-0" 16'-0"	V	6"WG Atm	250	CS	13	API Type Floating Roof
MT-609	Diesel Fuel Tank	6'-0" 16'-0"	V	6"WG Atm	150	CS	13	API
MT-610	Gasoline Storage Tank	15'-0" 16'-0"	V	6"WG Atm	150	CS	13	API Type Floating Roof

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-2 (8/82)

EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Offsite Storage Tankage **Location** Unit 600

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-606 A/S	Azeo Stripper Feed Pump	160	60	15	DI	13	
PP-604 A/S	Fermentation Feed Pump	310	70	20	DI	13	
PP-601 A,B,S	Ethanol Product Pump	105	30	5	CS	13	
PP-608 A,S	Slops Transfer Pump	20	40	2	CI	13	
PP-607 A,S	Fire Water Pump	120	100	15	CS	13	
PP-602 A,B,S	Furfural Export Pump	100	30	5	CS	13	
PP-603 A,S	Sulphuric Acid Transfer	20	40	2.5	CI	13	
PP-605 A,S	Fusel Oil Export Pump	20	30	2.0	CI	13	
PP-609 A,S	Diesel Fuel Pump	25	50	1.5	CS	13	
PP-610 A,S	Gasoline Blending Pump	6	30	1.0	CS	13	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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BE-UE-2-3 (8/82)

EQUIPMENT LIST
ACCT. T - HEAT EXCHANGERS

Client SERI | Signature

Unit Offsite Storage Tankage | Location Unit 600

Item No.	Name	Area ft^2	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TY-604	Fermentation Feed Cooler	2,000	CS 100 250	CS 100 150		13	Plate type

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-4 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 31 OF	SPE-0461-EL-5E

EQUIPMENT LIST

ACCT.

Client SERI | Signature

Unit Offsite Storage Tankage | Location Unit 600

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-604	Air Vent Filter	CS	13	Depth Filter, Glass Wool Cartridge Element, 70 SCFM P max -2"WG
GF-603	Dessicant Air Filter	CS	13	Silica gel dessicant max P 2"WG on vent air forms - 803 diameter 0.5" x length 2'

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

BADGER ENGINEERS, INC.	ISSUE	DATE	SHEET 33 OF	SPE-0461-EL-5E

EQUIPMENT LIST

ACCT. B - Buildings

Client SERI | Signature

Unit Offsite Storage Tankage | Location Unit 600

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
B-1	Administration Building	Conc + Brick		
B-2	Maintenance Building	Corr siding on steel		
B-3	Warehouse Building	Corr siding on steel		40 ft W x 100 ft Lg x 30 ft H for drum and bag storage with winter space heating from steam pipes; 2 doors each end; small office; lunch room.
B-4	Control & Electrical Building	Conc Block		
B-5	Acid Hydrolysis Process Building	Corr siding on steel		
B-6	Fermentation Process Building	Corr siding on steel		
B-7	Fire Pump House	Corr siding on steel		
B-8	Truck Weigh Scale House	Wood		Heated by steam.
B-9	Boiler House	Corr siding on steel		Includes boilers, BFW treating, deaerators.
B-10	Gate House #1	Wood		
B-11	Gate House #2	Wood		
B-12	Well Water Pump House	Corr siding on steel		

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Environmental **Location** Unit 700

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MS-701	Hotwell Decanter	6'-6" 20'-0"	11	15	200	304L	14	With internal baffle.
MT-702	Mixed Solvent Tank	21'-3" 16'-0"	V	6"WG Atm	200	CS	14	API floating roof.
MT-703	Equalization Tank	-					15	
MT-704	Anaerobic Reactor	-					15	
MS-705	Reactor Surge Drum	-					15	
MS-706	Offgas K.O. Pot	-					15	
MT-707	Biotreater	40'-0" 24'-0"	V	Open top	150	CS Epoxy lined	16	API Tank Open Top
MS-708	Filter Feed Tank	10'-0" 20'-0"	V	Atm	150	CS Epoxy lined	16	
MF-709	Filtrate Sump	3'x3' x4' dp	V	Atm	Amb	Conc	16	Below ground
MS-710	LP Vent K.O. Drum	2'-0" 6'-0"	V	15	150	CS	17	With wire mesh mist eliminator

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Environmental **Location** Unit 700

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-701 A,S	First Effect Pump	210	20	5	CD4 MCU	14	
PP-702 A,S	Second Effect Pump	120	30	5	CD4 MCU	14	
PP-703 A,S	Third Effect Pump	30	55	2	CD4 MCU	14	
PE-704	Evaporator Vacuum System	50 lb/hr Air	Suction Press 2.5 psia	-	304L	14	With condenser 20ft^2
PP-705 A,S	Evaporator Wastewater Pump	250	40	10	304L	14	
PP-706 A,S	Solvent Pump	1	35	0.25	DI	14	
PP-707 A,S	Mixed Solvent Pump	60	40	5	DI	14	
PP-708 A,S	Reactor Feed Pump	-	-	-	-	15	
PP-709	Reactor Recycle Pump	-	-	-	-	15	
PB-710	Offgas Blower	-	-	-	-	15	
PE-711	Equalization Tank Eductor	-	-	-	-	15	
PB-712 A/S	Aeration Blowers	168 SCFM		20	CI	16	
PP-713 A/S	Sludge Pumps	130	20	5	DI	16	
PD-714 A,S	Filter Feed Pumps	20	15	1	DI	16	
PP-715	Filtrate Sump Pump	10	30	1	DI	16	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes.
For this purpose the data on the relevant specification/data sheets shall be used.

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EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Environmental **Location** Unit 700

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-716	Final Effluent Pumps	140	40	7.5	DI	16	
PB-717 A,S	L.P. Vent Blower	480 ACFM	5	7.5	CI	17	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

BE-UE-2-3 (8/82)

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EQUIPMENT LIST

ACCT. T - HEAT EXCHANGERS

Client SERI | Signature

Unit Environmental | Location Unit 700

Item No.	Name	Area ft²	Tube Mat'l. D.P. psig D.T. °F	Shell Mat'l. D.P. psig D.T. °F	Type	P & I	Remarks *(WT. KIPS.)
TT-701	First Effect Heater	5,200	CS 50/FV 350	CS 100 350	BEM	14	
TT-702	Second Effect Heater	5,200	CS 50/FV 300	CS 25/FV 300	BEM	14	
TT-703	Third Effect Heater	5,200	304L 50/FV 250	304L 25/FV 250	BEM	14	
TT-704	Evaporator Condenser	5,600	304L 100 150	304L 100/FV 250	BEM	14	
TT-705	Stillage Cooler	2,000	304L 100 150	304L 50 250	BEM	14	
TP-706	Solvent Cooler	8	CS 100 150	CS 50 200	BEM	14	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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EQUIPMENT LIST
ACCT. "G" - Special

Client SERI | Signature

Unit Environmental | Location Unit 700

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GE-701	First Effect Evaporator	CS	14	5'-6" dia x 8'-6" high plus cone bottom 25 psig/FV, 300°F
GE-702	Second Effect Evaporator	CS	14	8'-0" dia x 12'-0" high plus cone bottom 25 psig/FV, 250°F
GE-703	Third Effect Evaporator	304L	14	10'-0" dia x 9'-0" high plus cone bottom 25 psig/FV, 250°F
GF-704	Rotary Filter	CS	14	400 lb/hr, 2 sq. ft.
GU-705	Reactor Feed Heater	-	15	
GQ-706	Offgas Burner	-	15	
GV-707	Biotreater Aerators	Poly-ethylene	16	40 Kenic S type static aerator tubes 6" diam. x 12' lg
GV-708	Secondary Clarifier	CS	16	50'-0" diam. center feed clarifier x 7'-0" sidewall with sludge rake and skimmer above grade, 0.5 HP motor
GV-709	Polymer Feed System	SS or plastic	16	Automated system for batch make-up, transfer to storage, & injection into process.
GV-710	Belt Filter Press	CS	16	Horizontal belt filter press 1 meter.
GA-711	Polymer Mixer	CS	16	In-line static mixer 1.5" ø
GA-712	Filter Feed Tank	CS	16	Side Mtd Impeller Type Agitator located on MS-708; HP-2.0
	Flame Arrestor			
	MT-704 A,B Packing License			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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BE-UE-2-5 (8/82)

EQUIPMENT LIST
ACCT. M - VESSELS

Client SERI **Signature**

Unit Utilities **Location** Unit 800

Item No.	Name	Dia. ft. / Lth. ft.	H V	Design Press. psig	Design Temp. °F	Mat'l.	P & I	Remarks *(WT. KIPS.)
MT-801	Process Water Tank	30'-0" 24'-0"	V	Atm	200	CS	19	API
MS-802	Blowdown Flash Drum	2'-0" 6'-0"	V	50/FV	350	CS	20	
MS-803	Hydrazine Drum	50 gals	V	10	200	316L SS	20	
MS-804	Condensate Surge Drum	7'-0" 20'-0"	H	15	250	CS	20	
MF-805	Backwash Transfer Tank	13'-0" 3'-0"	V	Atm	Amb	CS	19	
MS-806	Plant Air Receiver	3'-0" 9'-0"	V	150	150	CS	23	
MS-807	Instrument Air Receiver	3'-0" 9'-0"	V	150	150	CS	23	

*Estimated erection weight. (Excluding insulation and attachments)

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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EQUIPMENT LIST
ACCT. P - PUMPS

Client SERI **Signature**

Unit Utilities **Location** Unit 800

Item No.	Name	Capacity gpm	Δp psi	Motor h.p.	Mat'l.	P & I	Remarks *(WT. LBS.)
PP-802 A,S	Process Water Transfer Pumps	480	31	15	DI	19	
PP-803 A,S	Process Water Circulating Pump	1000	60	50	DI	19	
PP-804 A	Backwash Feed Pumps	2400	21	35	DI	19	
PP-805 A	Backwash Transfer Pumps	20	21	1	DI	19	
PP-806 A,S	Blowdown Pump	10	25	1	DI	20	
PP-807	Hydrazine Transfer Pump	1	20	0.25	316SS	20	
PP-808 A,S	H.P. BFW Pump	340	1700	400	Chrome Steel	20	Multistage
PP-809 A,S	Deaerator Feed Pump	250	20	50	DI	20	
PP-810 A,S	Turbine Condensate Pump	130	40	10	DI	21	
PC-811	Air Compressor	200 SCFM	125	100	CS	23	Oil free recip with coolers and
							ancillaries
PP-812 A,B,S	Cooling Water Circ. Pumps	6000	60	250	CI	22	Motor drives qty. = 8
PP-813 A,B,S	Well Water Pumps	1000	25	20	DI	19	

*Including driver and baseplate

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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EQUIPMENT LIST

ACCT. G

Client SERI | Signature

Unit Utilities | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GF-801	Sand Filter	CS	19	15'-6" dia. x 6'-0"; 12" sand, 12" anthracite
GU-803 A,B	Demineralizers		20	2 bed, skid mounted, 100 GPM capacity at 50 psig, 100 F, with intermediate degasifier, regeneration equipment, required tanks, pumps
				and auxiliaries and chemical storage for 14 days operation. Permutit or equal.
GU-804 A,S	Condensate Polisher	55	20	Duplex bed; 300 GPM capacity
GU-805	Condensate Collection System		20	500 gal. tank with two 350 GPM, 70 ft. head pumps, CS, rubber lined.
GV-806	Deaerator	CS shell SS internals	20	30 psig/FV, 300 F, 350 GPM capacity, 3,500 gals. storage. To reduce dissolved oxygen to 0.005 cc/l.
GU-807	Hydrazine Addition Unit	316L SS	20	30 gal. tank and two metering pumps, 0.02 to 1 GPH.
GU-808	Ammonia Addition Unit	Chrome Steel	20	30 gal. tank and two metering pumps, 0.02 to 1 GPH.
GU-809	Phosphate Addition Unit	316L SS	20	30 gal. tank with agitator and two metering pumps, 0.02 to 1 GPH.
GY-810	Instrument Air Dryer	CS	23	150 SCFM, dual tower, dessicant type, electric heater regeneration

NOTE Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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ACCT. G

Client SERI | Signature

Unit Utilities | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
GZ-811	Turbo Generator	-	21	8.9 mw
	Rated steam in:	1100 psia; 825°F		
	(actual)	104,422 lb/hr		
	(design)	120,000 lb/hr		
	steam out:	150 psig, 4,500 lb/hr		
		50 psig, 75,800 lb/hr		
	Total electrical generation 8.9 mw			
	Supply 480V, 60 Hz, 3 pH			
	120/208V, 60 Hz, 3 pH (4 wire)			
	With turbine condenser:	6,000 ft^2, 36 mm BTU/hr CS/CS		
	and vacuum ejector set and controls.			
CT-812	Cooling Tower	Internals vendor	22	12,000 GPM, inlet temp. 118 F, outlet 88 F, heat load 180 mm BTU air; New England temps:
		Std		dry bulb 88F, wet bulb 74 F.

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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EQUIPMENT LIST

ACCT. H

Client SERI | Signature

Unit Utilities | Location Unit 800

Item No.	Name	Mat'l.	P & I	Duty - Description - Remarks
HB-801 A,B	Steam Boilers			18
	Steam rate: (actual)		71,500 lb/hr	
	(design)		80,000 lb/hr	
	Pressure:		1100 psia	
	Temp.		874°F	
	Feedwater temp.:		212°F	
	Total absorbed heat load:		110 mm BTU/hr	
	Efficiency:		85.0 percent	
	Total fuel available:			
	Process liquids:		12,600 lb/hr, LHV = 8096 BTU/lb	
	Process vent gas:		2200 SCF/hr, LHV = 544 BTU/SCF	
	Lignin/tar solids:		10,000 lb/hr	
	Auxiliary startup fuel: Diesel oil			
	Each boiler to be able to take full solids flow			
	Use Flakt system for lignin and tar common system for both boiler covers.			
	Drying			
	Burning			
HC-803	Particulate emission control			
	Common stack, concrete, 150 ft. high, 6'-0" ø			
	self supporting (allowance - to be confirmed)			

NOTE: Above data (except for Item No. and Name) shall not be used for design purposes. For this purpose the data on the relevant specification/data sheets shall be used.

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