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DE90 013346

INTEGRAL MONITORED RETRIEVABLE STORAGE (MRS) FACILITY

CONCEPTUAL DESIGN REPORT

VOLUME IV BOOK VI — CALCULATIONS

Prepared for

UNITED STATES DEPARTMENT OF ENERGY
Richland Operations Office

Report No. MRS 11
Contract No. DE-AC06-84RL 10436
September 1985

THE RALPH M. PARSONS COMPANY OF DELAWARE
Westinghouse Electric Corporation
Golder Associates

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RECEIVING AND HANDLING FACILITY CALCULATIONS
FOR MATERIAL HANDLING EQUIPMENT

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SUBJECT

BOOK WHB-001

PAGE 1.

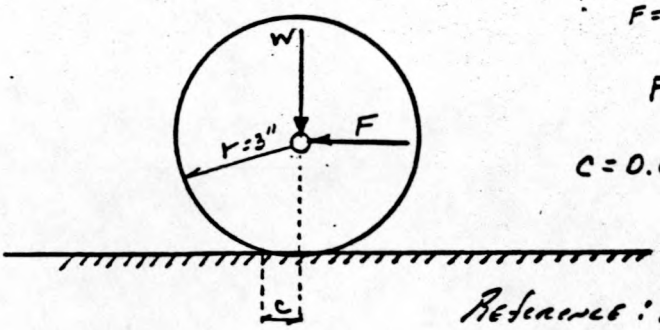
DATE 5/8/85

Transfer Cart Calculations

DWG H-3-56885

Assume wheel $\phi = 6''$
STEEL on STEEL wheels
TRANSPORT A 55gal drum
@ 800 lbf MAX WEIGHT

W = WEIGHT (lbf)
r = radius (in)
c = coefficient of rolling friction (in)
F = FORCE @ CTR (lbf)



$$F = \frac{cW}{r} = \frac{(0.020\,in)(3250\,lbf)}{3\,in} \cong \underline{\underline{22\,lbf}}$$

c = 0.020 in steel on steel

Reference: Engineers Manual
Hudson, 2nd Edition pg 106

Torque Reqd to Move Cart w/Full Drum

1.) Cart Component Weight Breakdown

A) Cart Platform ≅ 400 lb
B.) Motor ≅ 100 lbf
C.) Gear Drive ≅ 200
D.) wheels & shafting ≅ 125 lbf

TOTAL = 825 lbf

2.) Filled Drum max est weight = 800 lbf

Total Σ_{1+2} = 1625 lbf w/FS of 2 = $\underline{3250\,lbf}$

3.) Torque = 22 lbf × 3 in = 66 lbf-in

NOTE Engineer: [signature] Checked By: Eric P. Fratangelo 6/20/85

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2B

SUBJECT	BOOK WHD-001
Transfer Cart Calculations	PAGE 2
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4.) Assume speed of 3 MPH

$$V = \frac{3 \times 5280}{60} = 264 \text{ FT/MIN}$$

5.) $$\text{RPM REQD} = \frac{264}{\frac{\pi D}{12}} = \frac{264}{\frac{\pi 6}{12}} = 168 \text{ RPM}$$

6.) $$\text{Rough HP REQD} = \frac{T \times N}{63{,}000} = \frac{66 \times 168}{63{,}000} = 0.176 \text{ HP}$$

FOR Rolling Friction

Gear Motor Selection Philadelphia in-line speed reduct w/output speed of 168 RPM Select Single Reduction @ 720 RPM INPUT SERVICE FACTOR = 1.0, UNIT SIZE is 70 RATIO = 4.13:1. Based on cart speed a motor size of 1.77 is reqd to deliver the required speed reduction of 720 input to 168 output & is the motor size selected. Additionally, a brake will be used to accurately aid in cart deceleration and positioning an electromechanical brake will be selected.

NOTE ENG: W H Blanchard CHECKED BY: Eric P. Fratangelo 6/20/85

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SUBJECT DWG H-3-56889

HOPPER Infeed Chute Opening Size

BOOK WMB-001
PAGE 3
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LARGEST PWR = B & W @ 8.536 sq } ENVELOPE
BWR = GE @ 5.438 sq } DIMENSIONS

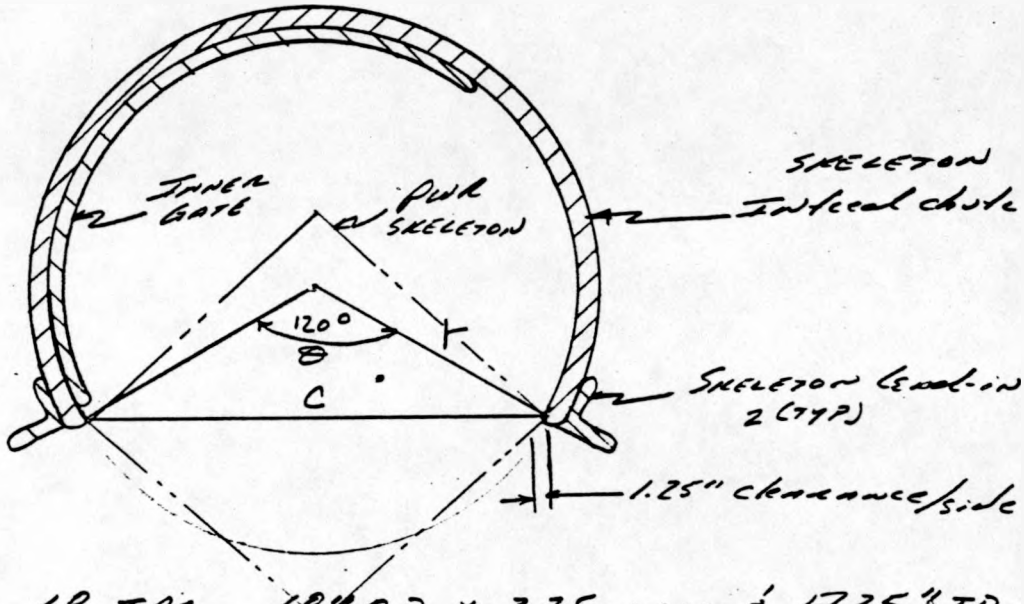
Diagonal of PWR = (1.414)(8.536) = 12.06"

Clearance of ~1.25"/side ∴ C = 12.06" + 2.5" = 14.5"

Need Radius REQD = r

& $r = \frac{C}{2 \sin \frac{\theta}{2}} = \frac{14.5}{2 \sin(\frac{120}{2})} = 8.37"$

& NEED dia of ~16.75



Choose 18 IPS, 18" OD x .375 wall & 17.25" ID STANDARD PIPE SIZE

NOTE: Dimension "C" Represents worst case PWR diagonal envelope dimension. Calculation doesn't include bowing or skeleton twist for rough size of In-feed hopper.

NOTE ENG: W H Blanc CHECKED BY: Eric P. Statangelo 6/20/85

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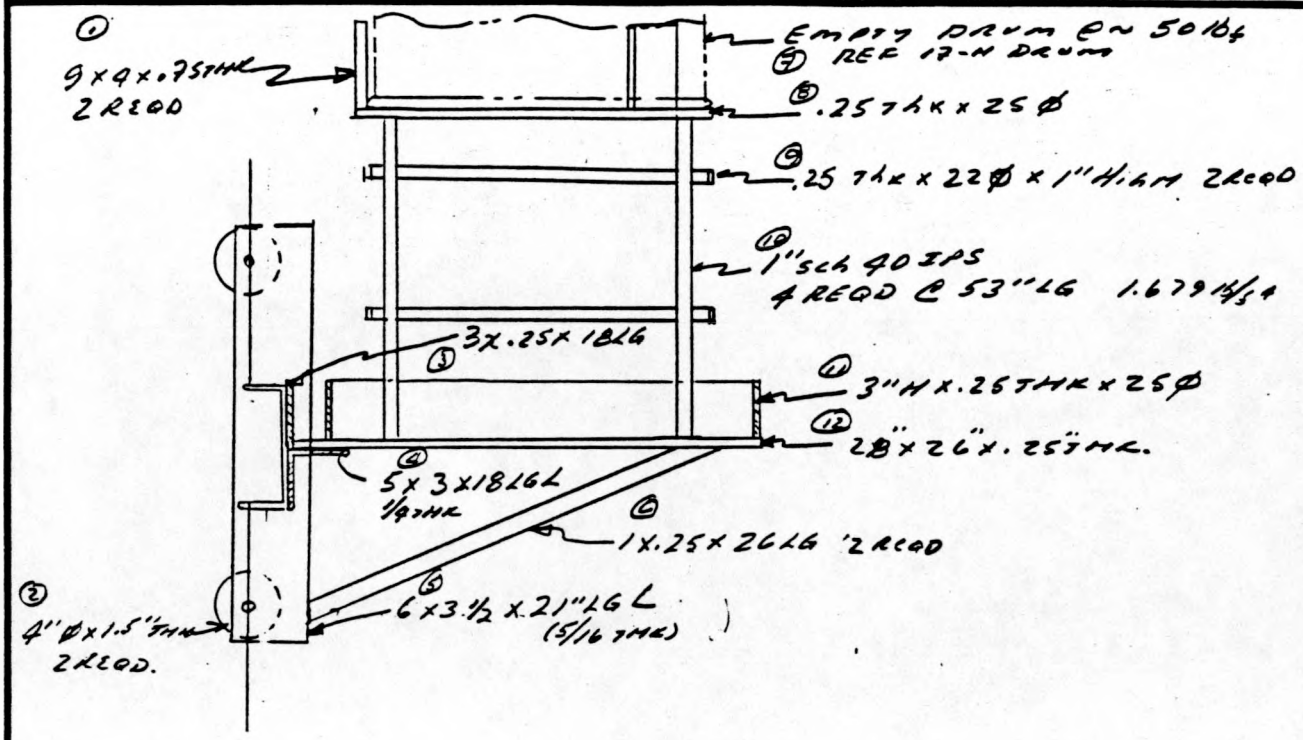
SUBJECT DWG H-3-56288

BOOK WMB-001
PAGE 4
DATE 4/30/85

Clean Drum Elevator Calculations



Estimated Weight Calculation w/ Drum

Assume $\gamma_{steel} = .283\ lb_f/in^3$

1.) $9 \times 4 \times .75 \times 2 \times .283 = 15.3$
2.) $\frac{\pi (4)^2}{4} \times 1.5 \times 2 \times .283 = 10.7$
3.) $3 \times .25 \times 18 \times .283 = 3.8$
4.) $6.6 \times \frac{18}{12} = 9.9$
5.) $9.8 \times \frac{21}{12} = 17.2$
6.) $1 \times .25 \times 26 \times 2 \times .283 = 3.7$
7.) - Drum @ Est wt = 50
8.) $\frac{\pi (25)^2}{4} \times .25 \times .283 = 34.7$
9.) - $22 \times \pi \times .25 \times 1 \times 2 \times .283 = 9.8$
10.) $1.7 \times \frac{53}{12} \times 4 = 30$
11.) $25 \times \pi \times .25 \times 3 \times .283 = 16.7$
12.) $28 \times 26 \times .25 \times .283 = 51.5$

$\Sigma = 253.3\ lb_f$

NOTE
Engineer: W. H. Klumpp Checked By: Eric P. Fratangelo 6/20/85

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SUBJECT

Clean Drum Elevator Calculations

BOOK WMB-001
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Use of a hydraulic cyl. as a standard item comes in a 2" Bore. The effective square area is 3.0649 in² (mea carnegie; Ref Tol-o-matic cable cyl. catalog, pg 5) At the lowest maximum continuous pressure rating of 200 psi this represents a Force of 613.0 lb.

$$F.S. = \frac{613.0}{253.3} = \underline{\underline{2.4}}$$

Choose model 200-2-AT w/ automatic TENSIONER

FORCE AT VARIOUS PRESSURES

BORE	EFFECTIVE AREA IN SQ. IN.	LBS. OF FORCE 25 PSI	50 PSI	60 PSI	80 PSI	90 PSI	100 PSI	125 PSI	150 PSI	200 PSI
½"	.196	4.9	9.7	11.6	15.5	17.5	19.4	–	–	–
¾"	.435	10.9	21.8	26.1	34.8	39.2	43.5	–	–	–
1"	.7785	19.5	38.9	46.7	62.3	70.1	77.9	–	–	–
1½"	1.7395	43.5	87.0	104.4	139.2	156.6	174.0	–	–	–
2"	3.0925	77.3	154.6	185.6	247.4	278.3	309.6	386.6	463.9	618.5
2½"	4.8596	121.5	243.0	291.6	388.8	437.4	486.0	607.4	728.9	971.9
3"	6.9919	174.8	349.6	419.5	559.4	629.3	699.2	874.0	1048.8	1398.4
4"	12.4897	312.2	624.5	749.4	999.2	1124.1	1249.0	1405.1	1873.5	2497.94
6"	28.0780	702.0	1403.9	1684.7	2246.2	2527.0	2800	3510	4212	5615.6
8"	49.8726	1246.8	2493.6	2992.4	3989.8	4488.5	4987	6234	7480	9974
		150 PSI	200 PSI	250 PSI	300 PSI	350 PSI	400 PSI	450 PSI	500 PSI	
2" Hyd.	3.0649	459.7	~~[illegible]~~ 613.0	766.2	919.5	1072.7	1226.0	1379.2	1532.4	

MAXIMUM CONTINUOUS PRESSURE RATING

DIAMETER OF CYLINDER	½"	¾"	1"	1½"	2"	2½"	3"	4"	6"	8"
PSI (HYDRAULIC OR PNEUMATIC)	100	100	100	100	200 & 500	200	200	200	200	200

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NOTE ENGINEER: W.H. Blair CHECKED BY: Eric P. Fratangelo 6/20/85

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SUBJECT

Clean Drum Elevator Calculations

BOOK WHB-001

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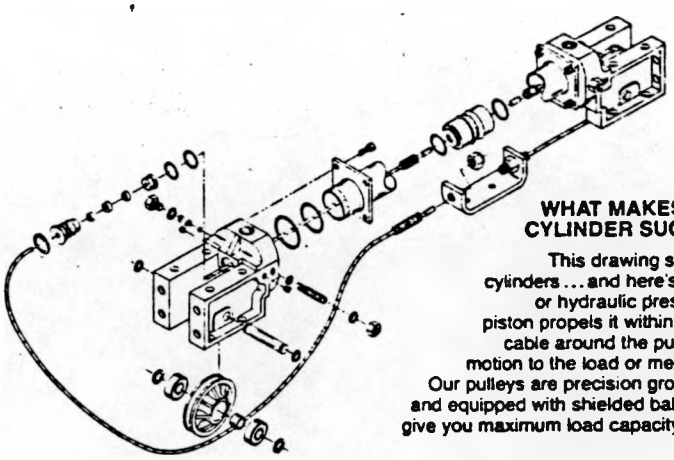
DATE 9/30/85

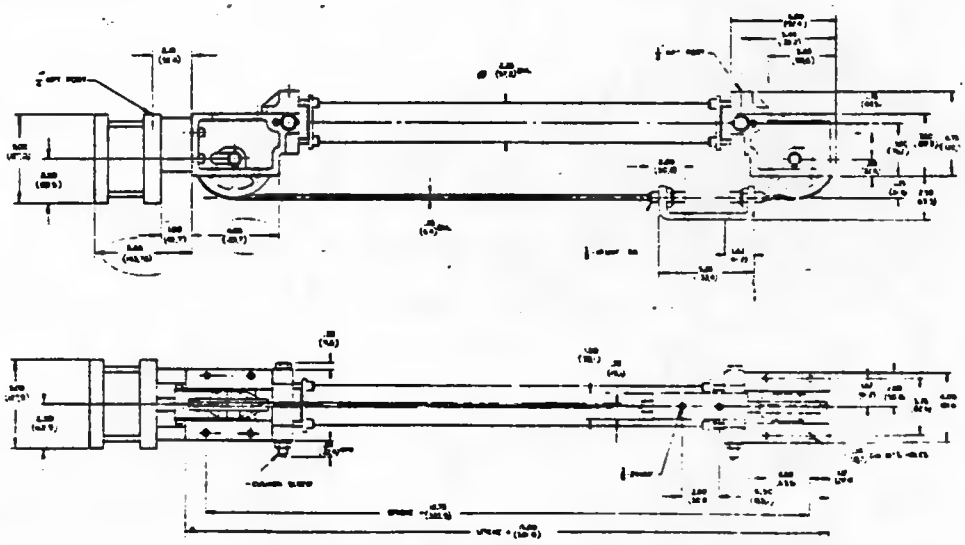


WHAT MAKES THE TOL-O-MATIC CABLE CYLINDER SUCH A SMOOTH OPERATOR?

This drawing shows what goes inside our cable cylinders ... and here's what goes on inside: pneumatic or hydraulic pressure applied to either side of the piston propels it within the cylinder. The piston pulls the cable around the pulley, delivering a smooth, forceful motion to the load or mechanism attached to the bracket. Our pulleys are precision grooved to fit the radius of the cable and equipped with shielded ball bearings* to reduce friction and give you maximum load capacity. The Tol-O-Matic cable cylinder: It's a smooth operator.

*½", ¾" and 1" cylinders have needle bearings.

200-2-AT



The Encapsulated Gland Seal is protected under U.S. Patent 4121840

NOTE ENGINEER: W H Blanier CHECKED BY: Eric P. Fratangelo

DATE: 6/20/85

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SUBJECT DWG - H-3-56888

Drum Elevator Hydraulic Supply

BOOK WHB-C01
PAGE 7
DATE 6/18/85

REF DWG H-3-56888

How many G.P.M is Reqd to move the cable cyl. piston at the rate of 3 inches per second?

Ref. Tol-o-matic Cable cyl catalog
2" Ø Bore, Hyd Cyl
Effective square area = 3.0649 (includes loss due to cable)
Operating pressure = 500psi
Force @ 500psi = 1532.4 lbf
Cyl = 500-2-AT

Parker Fluid power, Design Engineer's Handbook
Bulletin 0224-B1, Section I

$$VOL\ (G.P.M.) = \frac{A \times L \times 60}{231 \times \text{time in sec.}}$$

Where A = 2" Ø Piston = 3.0649 in²
L = Length = 3 in
231 = # of cubic inch/gal.
time in sec. = 1 sec
60 = 60 sec/min

$$\therefore G.P.M. = \frac{(3.0649\,in^2)(3\,in)(60\,sec/min)}{(231\,in^3/gal)(1\,sec)}$$

$$= \underline{2.4\ G.P.M.}$$

Pump should be gear pump because of constant volume reqmt of the elevator. Low pressure 600 vs ~5000 psi application. Simplicity of design. Low cost relative to power output.

NOTE Eng W.H. Blumer 6/18/85 Checked by Eric O. Trutangelo 6/24/85

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SUBJECT	BOOK WMB-001
Drum Elevator Hydraulic Supply	PAGE 8
	DATE 6/18/85

Fixed Gear Pumps, Flow range from 0.58 to 34 G.P.M.
Pressure to 3000 psi

$1 HP = 550 \frac{ft \cdot lb}{sec}$

$$\text{Input HP} = \left(2.4 \frac{GAL}{MIN}\right)\left(500 \frac{lb}{in^2}\right)\left(\frac{231 in^3}{GAL}\right)\left(\frac{1 ft}{12 in}\right)\left(\frac{1 min}{60 sec}\right)\left(\frac{1 HP - sec}{550 ft - lb}\right)$$

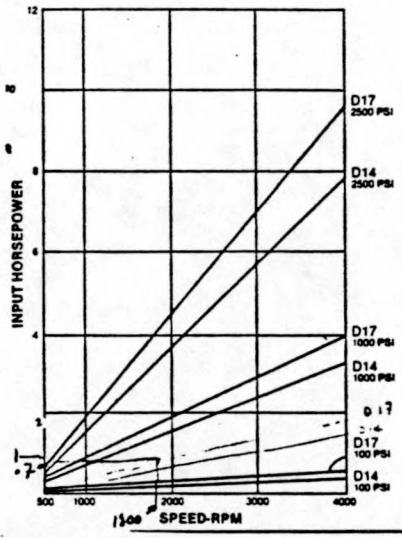
$= 0.7$ HP Calculated, Select 1 HP input

Hydraulic Performance Data

Parker Hydraulic Pumps — **Pumps - Fixed Gear "D" Series**

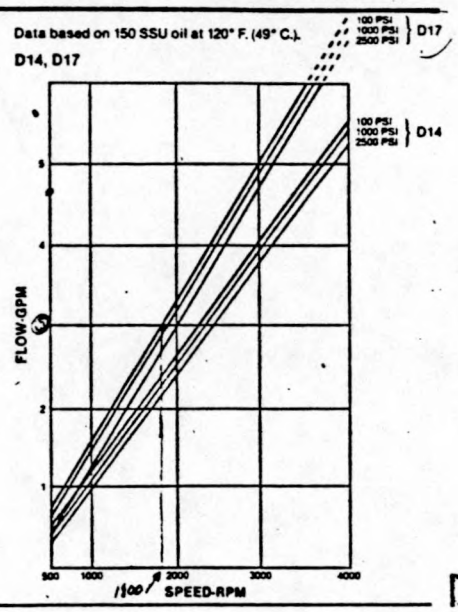
Performance Data Continued

D14, D17



Data based on 150 SSU oil at 120° F. (49° C.).

D14, D17



Performance Data Agrees w/ calculated Input Reqm'ts, for D17 series.

NOTE Eng. W H Blanier 6/18/85 Checked by: Eric P. Fritzinger 6/24/85

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SUBJECT

Drum Elevator Hydraulic Supply

BOOK WHB-001

PAGE 9

DATE 6/18/85

Motor Requirements

1 HP, TEFC, 56C, Nema Service Factors

230/460

3 Phase

60 Hz

1725 R.P.M.

FLA @ 460 V = 1.8

Approx Weight lb = 29

NOTE Eng N. H. Bomar 6/18/85 Checked by: E. P. Fretangeli 6/24/85

WTSD-0046

SUBJECT: Consolidation Power Report's

BOOK: WTS-001
PAGE: 10
DATE: 6/19/85

Consolidation Equipment

DWG	Motor Description	Quantity	HP	VOLT	Phase	HZ	Full Load Volt-Amp
H-3-54909	Robot Prg	4	N/A	220/440	3	60	28,000
	Translational Dr.	4	1.5	230	3	60	4784
H-3-54911	Downender Dr	4	1.5	230	3	60	4,784
H-3-54912	Horiz. Comb Dr	4	1/6	115	1	60	2,024
	BWR Nozzle Clamp Dr	28	1/6	115	1	60	14,168
	BWR Spring Dr	28	1/6	115	1	60	14,168
H-3-54913	Rod Extract. Dr.	8	3	230	3	60	17,664
	BWR Horiz Comb Dr	128	1/6	115	1	60	65,768
H-3-54914	Genrl. Assy	N/A	N/A	N/A	N/A	N/A	N/A
H-3-54915	Laser X-Dr	4	0.75	230	3	60	2,576
	Laser Y-Dr	4	0.25	115	1	60	2,668
	Laser Z-Dr	4	0.25	115	1	60	2,668
	Laser Θ-Dr	4	1/3	115	1	60	3,312
	Laser Φ-Dr	4	1/3	115	1	60	3,312
	Focusing Mirror Dr	4	–	24 DC	–	–	768
	Focusing Mirror Dr	4	–	24 DC	–	–	768
	Focusing Mirror Dr	4	–	24 DC	–	–	768
H-3-54917	IFRU Upender Dr	4	1.5	230	3	60	4,784
	IFRU Carriage Dr	4	1.5	230	3	60	4,784
H-3-54918	Module Lift Rig	N/A	N/A	N/A	N/A	N/A	N/A

NOTES

1.) ALL VOLT in A.C. unless otherwise specified

2.) Based on FULL LOAD current RATINGS @ given volt. Ref National Elect. Code Article 430, Table 430-149 & 150.

3.) HP for Robot not given, Info from MFG on Xfm Regulator's & voltage Regulator's for system.

WMB 6/18/85

24 VDC Pwr Supp.

NOTE: Eng. Mgr. 6/19/85 Checked by: Eric P. Pratangelo 6/24/85

WTSD-0046

SUBJECT

Secondary Waste Process Equip Pwr. Req'ts

BOOK WHB-001

PAGE 11

DATE 6/19/85

SECONDARY WASTE

DWG	MOTOR DESCRIPTION	QUANTITY	H.P.	VOLT	PHASE	HZ	FULL LOAD VOLT-AMP
H-3-56884	S.W. J.B. Rotary Dr.	2	1.5	230 AC	3	60	2392
	Drum Grap. Assy Dr.	2	1	115 AC	1	60	1656
	Drum Grap Arm Dr.	2	0.5	115 AC	1	60	920
H-3-56888	Drum Elevator Hyd. Dr.	2	1.0	230 AC	3	60	1656
H-3-56885	S.W. Drum Trans. Cart Dr.	4	1.0	230 AC	3	60	3312
H-3-56889	Shredder Dr.	8	40.0	440 AC	3	60	191360
	Drum Lid Dr.	4	3.0	230 AC	3	60	8832
	In-feed Chute Dr.	4	0.25	115 AC	1	60	2668
H-3-56886	S.W. Shield Valve Dr.	4	0.5	24 DC			768
H-3-56887	Drum Slider	—	—	—	—	—	
H-3-56883	Drum L/O Manual	—	—	—	—	—	

NOTE Eng: N.H. Rhiner 6/19/85 Checked by: Eric P. Fratangelo 6/24/85

WTSD-0046

SUBJECT

Consol. & Sec. Waste Pwr Reqmts (Systems)

BOOK WMB-001

PAGE 12

DATE 6/19/85

Disassembly Equipment

- Robotics (32.784 kva)
- Downender (4.784 kva)
- Laser Cutting (14.536 kva AC) + (2.304 DC)
- Clamping Module's (30.36 kva)

82.464 kva AC

2.304 kva DC

Consolidation Equipment

- Gripper Head & Push Mech. (17.664 kva)
- Horizontal & Vertical Combs (64.768 kva)
- Vertical Combs N/A
- Spool lowering Device N/A
- Upper & Lower Foaming Dies N/A

82.432 kva AC

Secondary Waste in cell Shredder

- Shredder w/chutes (194.028 kva)
- Drum lidding equip. (8.832 kva)

202.86

Decon Cell

- Jib crane & Gantrik (4.968 kva)
- Drum Cart (3.312 kva)
- Drum slide & Guidance sys. (0 kva)
- Shield valve (0.768 kva DC)

8.28 kva AC
0.768 kva DC

Drum Storage/Loading Area

- Drum Carrier Hydraulic Pwr supply (1.656 kva)

1.656 kva AC

Inner Fuel & Recovery Upender

- Carriage Drive (4.784 kva)
- Upender Table (4.784 kva)

9.568 kva AC

WMB
6/18/85

NOTE Eng: W H Rhodes 6/19/85 Checked by: Eric P. Fruterzels 6/24/85

WTSD-0046

SUBJECT MRS

POWER REQUIREMENTS
MOTOR ANALYSIS CALC.

BOOK PAM-001
PAGE 1
DATE 6/18/85

REF. DWG. NO.
H-3-56884.

REF CAT.
DUFF-NORTON pp. 52, 57

POWER => P = VI IN WATTS

- P = POWER (watts)
  V = VOLTS
  I = AMPS

CONVERSION FACTOR
1 H.P. ≅ 746 WATTS

GRAPPLE ARM DRIVE

V = 115
I = 2.30 A
FROM DUFF NORTON

P = (115v)(2.30) = 264.5 WATTS

H.P. 264.5 ~~WATTS~~ x $\frac{1 \text{ H.P}}{746 \text{ ~~WATTS~~}}$ = .345 HP

SELECT ½ H.P. MOTOR 115 V, AC, 60 CYC, 1 ϕ

GRAPPLE ASSY DRIVE

V = 115
I = 5.5 A.
FROM DUFF NORTON

P = VI
P = (115V)(5.5A) = 632.5W

H.P = 632.5W x $\frac{1 \text{ H.P}}{746 \text{ W}}$ = .85 H.P

SELECT 1 H.P. MOTOR 115V, AC. 60CYC. 1 ϕ

H-3-S-6886
SHIELD VALVE DRIVE

V = 24
I = 8A.
FROM ELECTRIC LINEAR ACTUATORS.

P = VI . P = (24)(8) = 192W

H.P. 192 W x $\frac{1 \text{ H.P.}}{746 \text{ W}}$ = .257

Select 0.5 HP, 24VDC MOTOR, 8A full Load

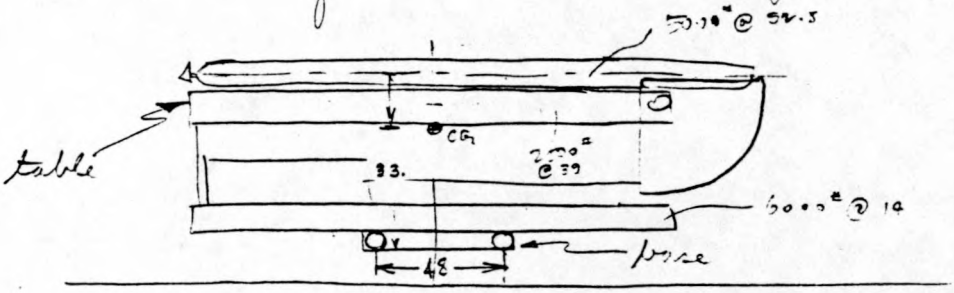
ENG: Paul A. McGuire 6/18/85 Checked by W H Robert 6/18/85

NOTE

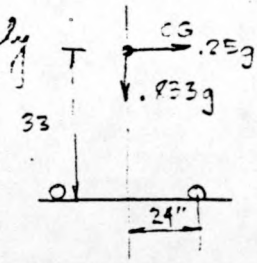
WTSD-0046

SUBJECT Spent Fuel Canister Upender Stability Calculation	BOOK EPF006
	PAGE 1
MRS	DATE 4/17/85

The upender depicted on drawing H-3-54906 will be balanced so that the center of gravity is between the axles when the table is perpendicular to the base. Since only the weight of the loaded canister is known (~5000 lbs) and the other components can only be estimated, the height of the CG is calculated at 33" above the floor using these estimations shown below. (as opposed to lower which is probably more likely) If the upender is in a 90° rotated position and an earthquake occurs, will upender tip?



A seismic event with accelerations of 1/6 g and 1/4 g vertically and horizontally respectively will cause instability. (B.F.D.) Worst case is if ground moves down simultaneously



NOTE Calcs. by: Eric P. Fratangelo 4/20/85 Checked by: [illegible] 4/19/85

WTSD-0046

SUBJECT Operator Stability Calc.

MCC

BOOK EPF006

PAGE 2

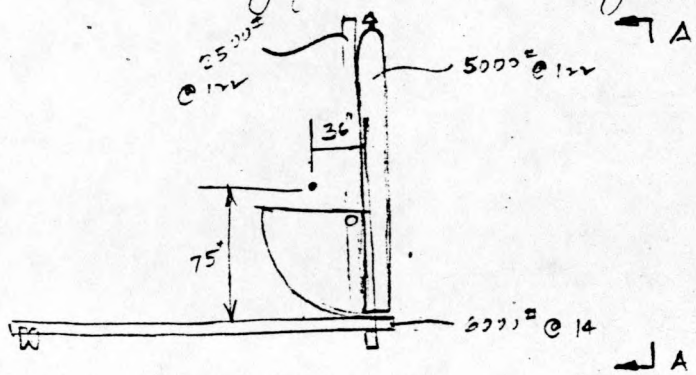
DATE 4/17/85

tipping moment restoring moment

$(.25g)(33\ IN) \doteq (.833g)(24\ IN)$

Ratio $\frac{RESTOR.}{TIP.} = \frac{19.99}{8.25} = 2.42$

In the upended position, the table will always be aligned with the base. Configuration is as follows.



Determining the location of the C.G.: 75" up and 36" from wheel

Doing earthquake, comparing moments in pictured plane.

(tipping restoring)

$(.25)(75) \doteq (.833)(36)$

$18.75 \doteq 29.9$ Ratio = 1.6

Comparing moments in A-A plane

tipping

$(.25)(75) \doteq (.833)(24)$ Ratio = 1.06

$18.75 \quad 19.9$ very close to unstable

Since the 1.06 ratio of $\frac{restoring}{tipping}$ moments is so close to one, the operator will need to be secured at upended level

NOTE Calcs by Eric P. Katsanglo 6/20/85 Checked by: [illegible] 6/20/85

WTSD-0046

SUBJECT	BOOK EPF006
NFSC Transfer System – Platform Beam Size Cart Weight	PAGE 3
	DATE 4/30/85

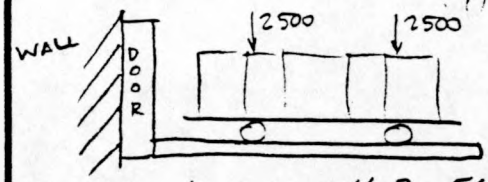
Cart Weight:

Platform weight: ~ 10 #/IN

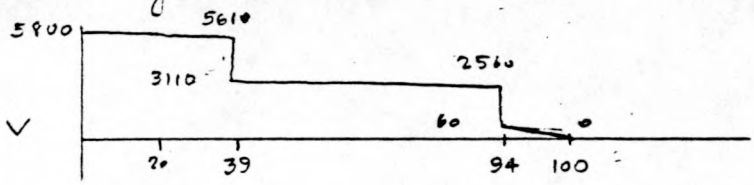
Reel axle	=	300
Simple axle	=	200
Frame	≈	700
Tray	≈	600
		1800

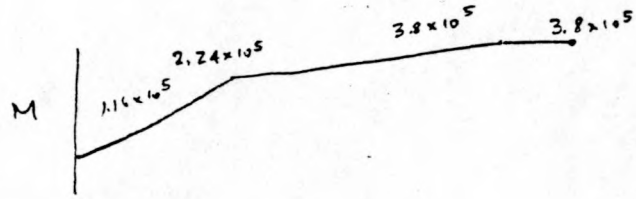
5 barrels @ 600# = 3000

Assume total weight = 5000



see dwg. H-3-56896





$\sigma = \frac{M}{Z}$

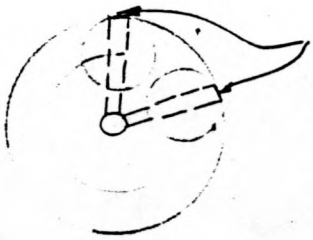
$\frac{36000}{2} = 18{,}000 = \frac{380{,}000}{Z} =$ ⇒ 2 beams of $Z \geq 11$ IN³

S.F.

NOTE Calcs. by Eric P. Fratangelo 6/20/85 Checked by: [illegible] 6/19/85

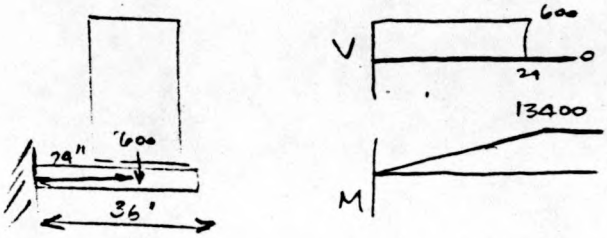
WTSD-0046

SUBJECT For NFBC Cart Tray - Size of Support Beams	BOOK EPF006
	PAGE 4
	DATE 5/8/85



Tube steel is underneath plate.

It will be analyzed as a cantilevered beam and sized to support the drum on its own. Therefore the plate will not be relied upon for strength but will actually tie the structure together only



$\sigma = \frac{M}{Z} = \frac{13,500}{Z} = 18,000$ ↑ F.S. of 2 $Z = .75$ use 2×2" box beam ≥ 1/4 thick

NOTE Calcs. by: Eric P. Fratangelo 6/20/85 / Checked by [illegible] 6/19/85

WTSD-0046

SUBJECT	BOOK EPF006
NFBC Cart - Size Drive Motor and Axle	PAGE 5
	DATE 5/13/85

Cart is same as that described on the previous two pages.

Approx. weight = 5000#

Rolling friction is calculated from Marks Handbook p 3-28.

$P = (k/r)\,L$ $\quad$ k = friction factor
r = wheel radius (in) (could be 3 - 6 in radius)
k/r = coeffi of fric.

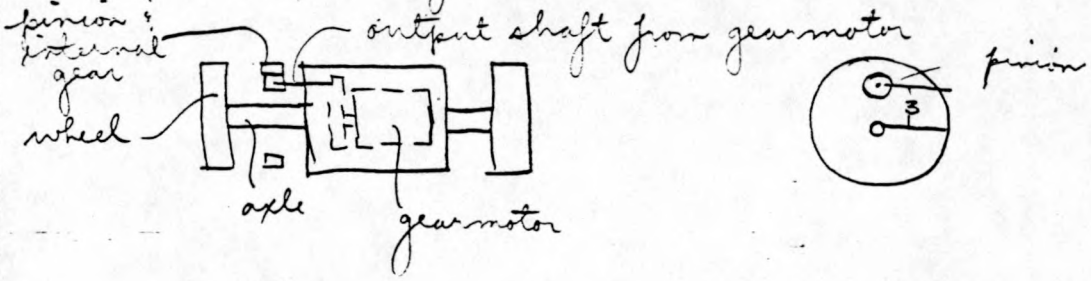
k = .01 for coated / rusty steel on steel
r = 3 (very conservative) gives max. torque required
$k/r \approx .004$

P = (.004)(5000) = 20 LB rolling friction force accounts for 4 wheels

so assume 6 IN rad for worst case

T = (20)(6) = 120 IN-LB

For axle design (to be described later), torque from gearmotor is calculated as follows



to get 120 IN-LB on shaft, pinion shaft must provide

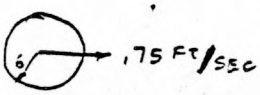
120/3 = 40 LBS force @ 1½" pinion = 60 IN·LBS torque

NOTE Calcs. by: Eric P. Fratangelo 6/20/85 Checked by: W. M. Bothwell 6/19/85

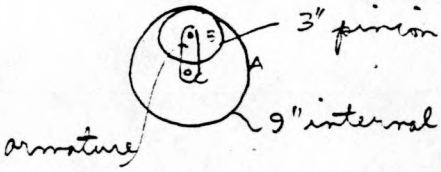
WTSD-0046

SUBJECT	BOOK EPF006
NFBC Cart - Size of Drive Motor	PAGE 6
	DATE 5/13/85

For cart speed of 1/2 mile/hr or less ≈ .75 ft/sec.



$v = r\omega$, $\omega = \frac{.75\ ft}{.5\ sec} \frac{rev}{2\pi\ rad} \frac{60\ sec}{min} = 14.32\ RPM$



Use method from Martin Kinematics

A	B	C
1	1	1
-1	-3	0
0	-2	1

For each armature revolution, which is the same as the wheel revs., pinion rotates twice; pinion and thus motor rpm is (2)(14.32) ≈ 30 RPM

120 IN LB torque @ 30 RPM w/ safety factor of 2

Breakaway torque is overcome by starting torque of motor. Verified by conversation w/ Bala Nair.

NOTE Calcs. by: Eric P. Fratangelo 6/20/85 Checked by [illegible] 6/19/85

WTSD-0046

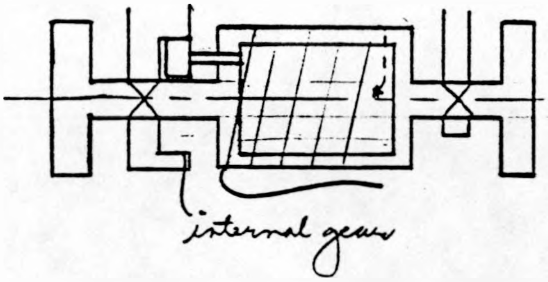
SUBJECT Drum Transfer Cart Motor Design

BOOK EPF006

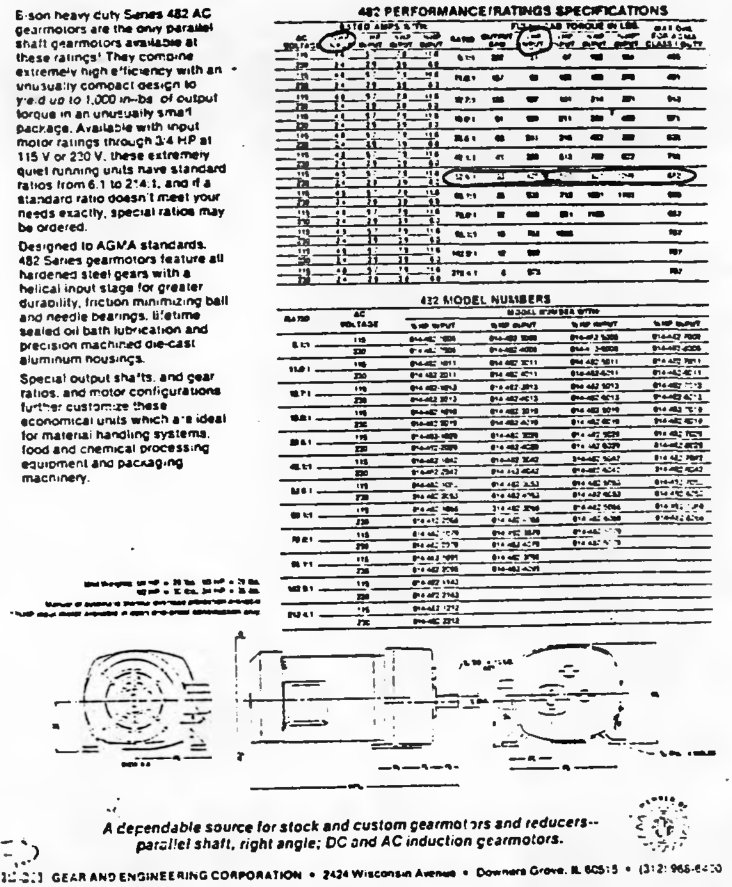
PAGE 7

DATE 5/20/85

Design reel/motor/wheel assy. that is one unit. Eliminates connectors and slip rings.



- motor, shaft, gear
- bearing, supports, internal gear
- power supply
- cable reel, axle, wheel assy


Elison heavy duty Series 482 AC gearmotors are the only parallel shaft gearmotors available at these ratings! They combine extremely high efficiency with an unusually compact design to yield up to 1,000 in–lbs. of output torque in an unusually small package. Available with input motor ratings through 3/4 HP at 115 V or 230 V, these extremely quiet running units have standard ratios from 6.1 to 214:1, and if a standard ratio doesn't meet your needs exactly, special ratios may be ordered.

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G.O. or CHARGE NO. _____ PROJECT MODIFIED MRS STUDY

SUBJECT TASK 2B.1 Concept Development - WASTE RECEIPT & OPER TIMES

A study to investigate design changes to the MRS facility has been initiated to integrate the consolidation and repository waste overpack. Per IOC #308 from W.D. Woods to File dated 12/20/84 this study will consist of two phases:

- TASK 2B.1 Modified R&H FACILITY Preliminary Concept Development
- TASK 2B.2 Modified MRS FACILITY DESIGN

Copies of the scope of these two phases are included for reference. These descriptions are based on the preliminary review of the scope and may not represent the final scope. However, the basic information presented will be used for evaluating the waste receipt and operating requirements (times, operations, number of cells and crane requirements). In addition, the process times used in evaluating the present MRS design will be used in this study. The process times are from APPENDIX F of the MRS Design

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G.O. or CHARGE NO. _____ PROJECT MMRS

SUBJECT Task 23.1 Concept Development - Waste Receipt & Oper. Times

Report (Waste Receipt and Handling Characteristics of the MRS FACILITY).

TASK 23.1

MODIFIED RECEIVING & HANDLING FACILITY

PRELIMINARY CONCEPT DEVELOPMENT

Activities to be performed by the Contractor shall include preliminary layouts, front end engineering and design document preparation to form a baseline for the follow on production design efforts. The work shall include the following activities:

- Prepare building arrangements and trade-offs to establish modified building configuration
- Prepare material and process flow diagrams with material balances and operation times to support building arrangement development
- Develop preliminary handling concepts for repository overpack and loadout cell
- Conduct thermal and criticality analysis to support lag storage configuration.
- Revise Basis for Design in accordance with modified requirements

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G.O. or CHARGE NO. _____ PROJECT MMRS

SUBJECT Task 2B.1 Concept Development - Waste Receipt & Oper. Times

TASK 2B.2

MODIFIED MRS FACILITY DESIGN

The technical requirements of the Modified MRS Facility are as stated below.

The base case Modified MRS Facility shall be designed to receive and ship or store a minimum of 3600 metric tons of uranium (MTU) per year primarily as spent fuel and a small amount of (20 MTU/yr equivalent) as HLW. It will have a base case in-building, open cycle vault, lag storage capacity of 300 metric tons of consolidated fuel in canisters, plus sealed storage cask storage capacity of 15,000 MTU of spent fuel and a small amount (100 MTU equivalent) of HLW. Design shall assume a spent fuel mix of 60% PWR/40% BWR by weight, based on 0.462 MTU per PWR assembly and 0.186 MTU per BWR assembly. It must also be capable of retrieval, overpack as required, and shipment of at least 3600 MTU or equivalent per year of spent fuel and waste. Receiving and shipping will be concurrent at these rates.

Surge capacity shall be included in the design of receiving, handling, and storing systems to obviate the impacts of credible offsite and onsite disruptions of spent fuel, waste, and material flows.

Hot cell space shall be included to accommodate overpack equipment capable of sealing consolidated fuel canisters in a repository type overpack. The equipment is not included in the design scope at this time.

The Modified MRS Facility must also satisfy the following requirements:

- licensed by the Nuclear Regulatory Commission (NRC) per 10 CFR 72 or other appropriate regulations (20-year license, renewable)
- capable of receiving at least 12,400 fuel assemblies (60 wt% PWR/40 wt% BWR) or any combination of spent fuel, HLW and RHTRU equivalent to 3600 MTU per year of spent fuel, including up to the equivalent of 1500 MTU per year as HLW and RHTRU
- capable of receiving cask shipments by both rail and truck, 50/50 split
- capable of receiving and shipping spent fuel and HLW in shipping casks weighing up to 125 tons and transportable metal storage casks (dual purpose casks)
- capable of receiving, inspecting, and external decontaminating sealed transportable metal storage (dual purpose) casks and transferring them to the storage facility
- capable of loading and unloading shipping casks and containers; decontaminating shipping cask exteriors, shipping containers and vehicles; and treating wash water and other wastes for disposal

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SUBJECT Task 23.1 Concept Development - Waste Receipt & Oper. Times

- capable of safely storing for offsite disposal all low-level radioactive wastes resulting from operations at the facility while handling spent fuel, HLW and TRU
- capable of handling fuel assemblies up to 15 feet 0 inches long with cross sections up to 9 inches by 9 inches
- capable of handling canisters up to 16 feet 0 inches long containing intact fuel assemblies
- capable of maintaining spent fuel cladding surface temperatures in storage below 375°C in an inert gas environment
- capable of handling canisters of HLW, compacted fuel hulls and RHTRU, up to 15-feet long and from 0.5- to 2.5-feet in diameter and weighing as much as 16,000 pounds
- capable of maintaining HLW container surface temperature below 375°C when stored in air, and borosilicate glass canterline temperature below 500°C
- capable of performing the following operations on spent fuel prior to shipping:
  - examine and identify fuel
  - place fuel assemblies in canisters, backfill with inert gas, seal-weld, leak test, decontaminate, and label canisters
  - disassemble fuel assemblies, consolidate fuel rods in canisters, fill canister with inert gas, seal-weld, leak-test, decontaminate, and label canisters

    overpack defective canisters received from offsite
  - compact fuel assembly hardware, place in canisters, seal-weld, leak-test, decontaminate, and label canisters
  - place canisters of spent fuel in lag storage awaiting shipping
  - place canister of spent fuel in sealed storage casks for extended onsite storage
  - retrieve consolidated fuel canisters from lag storage and/or sealed storage casks and load into shipping casks for shipment offsite
- capable of receiving, identifying, decontaminating, and checking for leakage of canisters of HLW, overpacking defective canisters and labeling canisters as required

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SUBJECT Task 2B.1 Concept Development - Waste Receipt & Oper. Times

Modified MRS Facility Design
Page 3

- capable of receiving, inspecting, identifying, overpacking or repairing, decontaminating, labeling, and storing packages of RHTRU
- capable of routine monitoring and/or inspecting both the stored waste package and the storage system to ensure the safety of the public, operating personnel, the environment and the facility
- capable of being decommissioned

From APPENDIX F:

Based on best estimates of all efficiencies that might be obtained in the MRS FACILITY, estimates of lost production time on a per-cell-basis are shown below:

Loss of worker productivity @ 1 hour/shift	1,095 hours/year
Maintenance (scheduled and unscheduled) and minor decontamination @ 1.5 days/week	1,872 hours/year
Major decontamination @ 20 days/year	480 hours/year
Tool changeout @ 2 days/month	576 hours/year
	4,023 hours/year

Based on suggested operation times of 3 shifts per day and 365 days per year. The total available hrs per cell is 8760 hrs. Subtracting the lost time for the year per cell, the remaining 4737 hours or ~ 54% are available for fuel

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SUBJECT Task 23.1 Concept Development - Waste Receipt & Operations

processing. Since the basic design of the cells is to remain the same, the processing times for consolidation and encapsulation will remain consistent with APPENDIX F and repeated here for clarity. The truck and rail cask unloading times are also included on Table F-1.

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G.O. or CHARGE NO. _____ PROJECT MMRS

SUBJECT Waste Receipt & Oper. Times – Assumptions

TABLE F-1

ESTIMATED PROCESS TIMES FOR SHIPPING CASKS

	Rail Casks Hrs.	Rail Casks Mins.	Truck Casks Hrs.	Truck Casks Mins.
I. RECEIVING				
A. Position cask transport vehicle for cask off-loading		15		10
B. Remove cask tie downs, impact limiters, and personnel barriers	1	0		45
C. Complete preparations for cask off-loading		30		20
D. Position cask lifting yoke - rotate cask to vertical and place on cask cart		35		35
II. UNLOADING				
A. Remove cask valve covers - install gas sampling/venting system - take gas samples and vent cask - remove outer cask cover (if necessary) - install shield/contamination barrier adapter - untorque inner closure bolts	2	0	1	35
B. Move cask (on cart) into unloading cell; engage contamination barrier, close shadow shield and shield door		20		20
C. Remove cell entry port shield plugs and remove cask inner closure		40		30
D. Unload cask				
Spent fuel				
20^m/PWR fuel assembly	4	0		40
15^m/BWR fuel assembly	8	0	1	15
15^m/HLW canister		45*		15**

*Assumes 3 HLW canisters per rail cask.
**Assumes 1 HLW canister per truck cask.

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(F4030) 92

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G.O. or CHARGE NO. _____ PROJECT MARS

SUBJECT Waste Receipt & Oper. Times – Assumptions

TABLE F-1

ESTIMATED PROCESS TIMES FOR SHIPPING CASKS (Continued)

	Rail Casks Hrs.	Rail Casks Mins.	Truck Casks Hrs.	Truck Casks Mins.
III. DISCHARGE				
A. Inspect cask - replace inner closure - replace entry port shield plugs	1	15		45
B. Open shadow shield and shield door - disengage contamination barrier - move cask into decon area		20		20
C. Complete inner closure installation - remove shield/barrier adapter - survey for contamination - decon if necessary. Replace outer cover (if necessary)	2	30	2	0
D. Move cask to transport vehicle and rotate to horizontal - remove lifting yoke		35		35
E. Install cask tie downs impact limiters, personnel barriers, etc.	1	0		45
F. Complete preparations for cask and transporter discharge		30		20

TABLE F-2

ESTIMATED PROCESS TIMES FOR FUEL ROD CONSOLIDATION

	PWR* Hrs.	PWR* Mins.	BWR* Hrs.	BWR* Mins.
1. Load fuel assemblies (if fuel assemblies are in lag storage)		45	1	45
2. Disassemble fuel	2	30	5	25
3. Consolidate fuel rods	1	10	1	35
4. Load fuel rods in canister		15		15

*Process times are based on consolidating and loading fuel rods from three PWR fuel assemblies or seven BWR fuel assemblies into a storage canister.

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SUBJECT Waste Receipt & Oper. Times - Assumptions

TABLE F-3

ESTIMATED PROCESS TIMES FOR ENCAPSULATION OF SPENT FUEL

		Hrs.	Mins.
1.	Rotate canister and place in evacuation chamber		5
2.	Evacuate canister and backfill with inert gas - weld closure lid		20
3.	Decontaminate and inspect (leak check and ultrasonic exam of weld)	1	35
4.	Survey canister for contamination - move to lag storage cask, to concrete cask, or to transfer shield (drywell concept)		25

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SUBJECT Waste Receipt & Dep. Times - Assumptions

The base case throughput requirements and assumptions for the Modified MRS FACILITY are:

- Receive and store at least 3600 MTU per year as spent fuel (at least 12400 assemblies) or any combination of spent fuel, HLW or RHTRU.

- Receive an equivalent of up to 1500 MTU per year of HLW or RHTRU which can be part of 3600 MTU.

- Assume that spent fuel received will consist of 60% PWR-type fuel assemblies and 40% BWR-type fuel assemblies. The percentages are based on weight of contained uranium.

- On the average, a PWR-type fuel assembly will contain .462 MTU and a BWR-type fuel assembly will contain .186 MTU.

- Assume that 50% (by weight) of spent fuel and equivalent waste will be received in truck casks and 50% will be received in

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SUBJECT Waste Receipt & Dispatch Times – Assumptions

rail car.

- Assume that truck cask will contain either two (2) PWR fuel assemblies or five (5) BWR fuel assemblies.
- Assume that rail casks will contain either twelve (12) PWR fuel assemblies or 32 BWR fuel assemblies.
- Assume that the facility will be operated three shifts per day for 365 days per year.

Features of the MRS Receiving and Handling Building that have an impact on throughput rate are summarized below:

- The shipping cask receiving and inspection area is serviced by a single bridge crane with a 150 ton capacity. Lower capacity lifts, such as transport vehicle personnel barriers and cask impact limiter, are performed with self-propelled handling equipment.

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SUBJECT Waste Receipt & Oper. Times – Assumptions

- Each of the process cells is provided with two entry ports and one exit port. Only one entry port in each cell may be open at any time.

- A minimum of three shielded cells are provided for processing waste forms. One cell is dedicated primarily to processing PWR spent fuel, the second cell is dedicated to processing BWR spent fuel and the third cell is provided as a backup for the other two cells. The third cell is also used to process the RHTRU and HLW. All three cells are capable of consolidating either PWR or BWR fuel assemblies.

  Additional cells will be required to handle the increased throughput for this study. Initially, it will assumed that 2 additional (1 PWR and 1 BWR) will be required.

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SUBJECT Waste Receipt & Oper. Times – Assumptions

- Each process cell entry port is served by a rail-mounted cart that is used to move the shipping cask from the Receiving and Inspection Area and to position it below the entry port for unloading.

- Consolidation operations will be performed in parallel on either three PWR fuel assemblies or seven BWR fuel assemblies.

- Spent fuel storage canisters will contain one of the following:

  - fuel rods from three PWR fuel assemblies
  - fuel rods from seven BWR fuel assemblies
  - one intact PWR fuel assembly
  - two intact BWR fuel assemblies

- Spent Fuel, HLW, RH TRU, and on-site generated waste that could possibly contain spent fuel residue or TRU will be stored in either concrete casks or drywells.

- Each concrete cask will contain one of the following:

  - Twelve canisters of consolidated spent fuel

  - Twelve canisters of intact spent fuel
    Note: Intact and consolidated spent fuel canisters could be stored in the same concrete cask if necessary.

  - Five HLW (Base Case) canisters

  - Fifteen 55-gallon drums containing non-fuel waste generated by the consolidation process

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SUBJECT Waste Receipt & Oper. Times - Assumptions

- Each drywell will contain one of the following:

  - One canister of consolidated or intact spent fuel
  - One HLW canister
  - Five 55-gallon drums of secondary waste.

- Either thirty-five or forty-five (depending on specific activity) 55-gallon drums containing on-site generated waste such as first stage HEPA filters.

Estimated times for receiving, unloading and discharging truck and rail casks are presented in Table F-1. The operations are assumed to begin with release of the cask and transportation vehicle from the washdown area of the facility and to terminate with the cask remounted on the transportation vehicle ready for discharge from the Receiving and Inspection Area.

Table F-2 presents estimated times for consolidation of PWR and BWR fuel assemblies. In developing diagrams to demonstrate the timed interaction of the various operational steps, the given times to load fuel assemblies into the consolidation equipment were, in some cases, combined with the times for cask unloading operations.

Table F-3 presents estimated times for encapsulation of the spent fuel, inspection and decontamination of the storage canister, and placement of the canister in lag storage or directly into a concrete cask. For the dry well storage concept, the canister is loaded either into lag storage or directly into the transfer shield.

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G.O. or CHARGE NO. _____ PROJECT MNRS

SUBJECT Waste Receipt & Open Times - analysis

For this study, it was assumed that all PWR and BWR spent fuel would be received as intact fuel assemblies (no pre-consolidation) and that all fuel assemblies received would be consolidated prior to storage.

For the base case, it will be assumed the throughput requirement is 3600 MTU per year, of which 2160 MTU (60%) is PWR fuel assemblies and 1440 MTU (40%) is BWR fuel assemblies.

$$\therefore \text{PWR assemblies to be processed/yr} = 2160 \frac{MTU}{yr} \times \frac{\text{PWR assy}}{.462\ MTU} = \underline{\underline{4676}}$$

$$\text{BWR assemblies to be processed/yr} = 1440 \frac{MTU}{yr} \times \frac{\text{BWR assy}}{.186\ MTU} = \underline{\underline{7740}}$$

A total of 12416 fuel assemblies would be processed through the shielded cells.

Based on the efficiency of the process cells, which requires 4023 hrs/cell of lost time the remainder of 4737 hrs/cell is available for processing.

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SUBJECT Waste Receipt & Oper Times — Analysis

Therefore, the number of cells required will be based on the available time, the amount of spent fuel assemblies for processing and the time required for consolidation.

Available hours of processing per cell is 4737 hrs per year. This represents ~54% of the total year. Operation efficiencies in the order of 49% to 53%, will represent a range of operation which is consistent with the original design of the MRS facility.

The time required for consolidation is dependent on the type of fuel being processed and by the type of shipping container (truck or rail cask). Copies of Figures F-1 and F-2 are included to describe the unloading, consolidation and load of storage cask when using truck casks or rail casks. The production rate for PWR storage canisters is on the average 5 hours and 40 minutes. For BWR storage canisters, the production rate is 9 hours.

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checked by: Jeff Mitchell 5-3-85

Waste Receipt & Dispos. Time - Analysis

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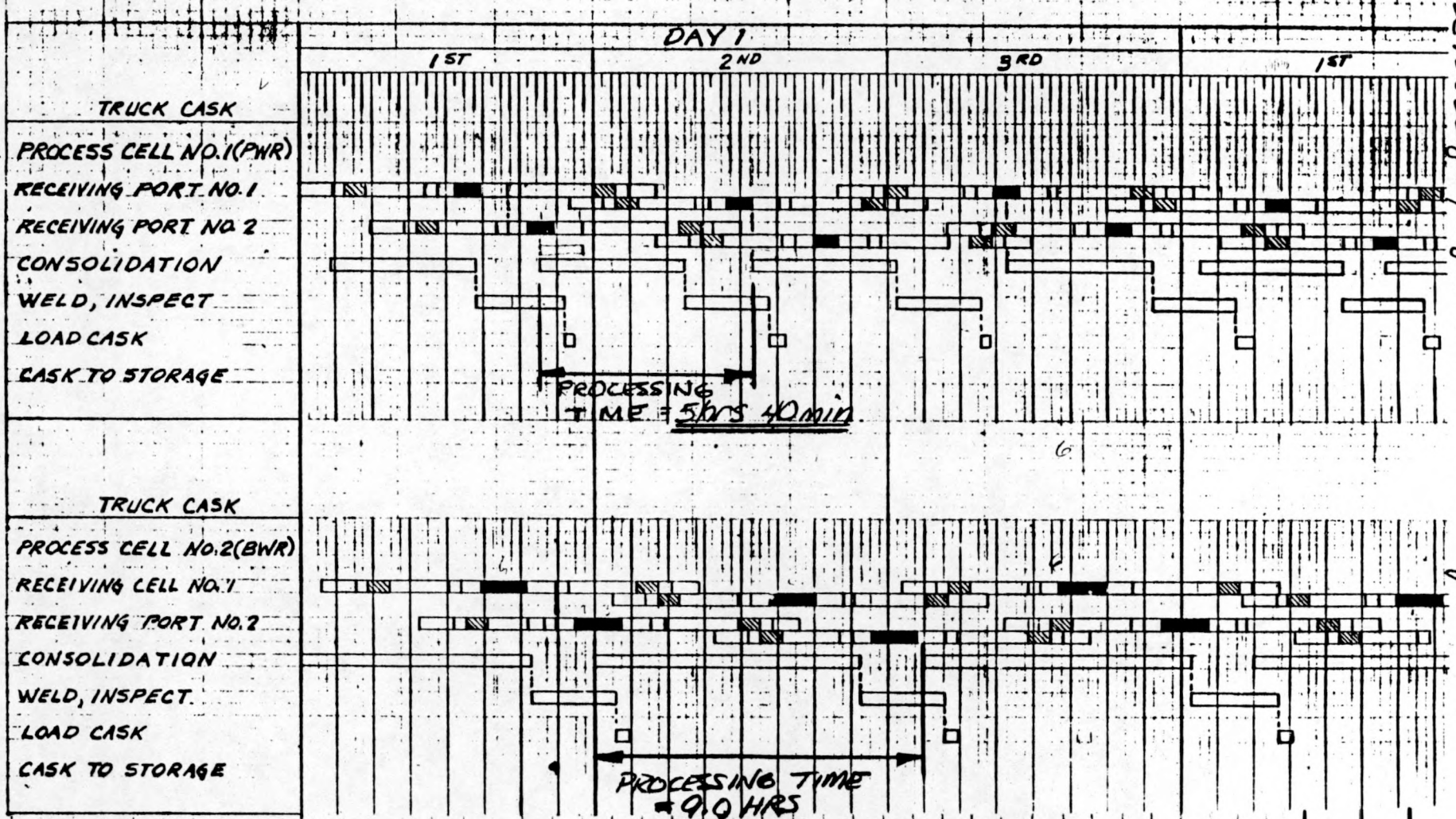

LEGEND
- 150 TON CRANE USE
- CASK UNLOADING

FIGURE F-1 CELL PROCESS TIME LINE BASED ON TRUCK CASKS

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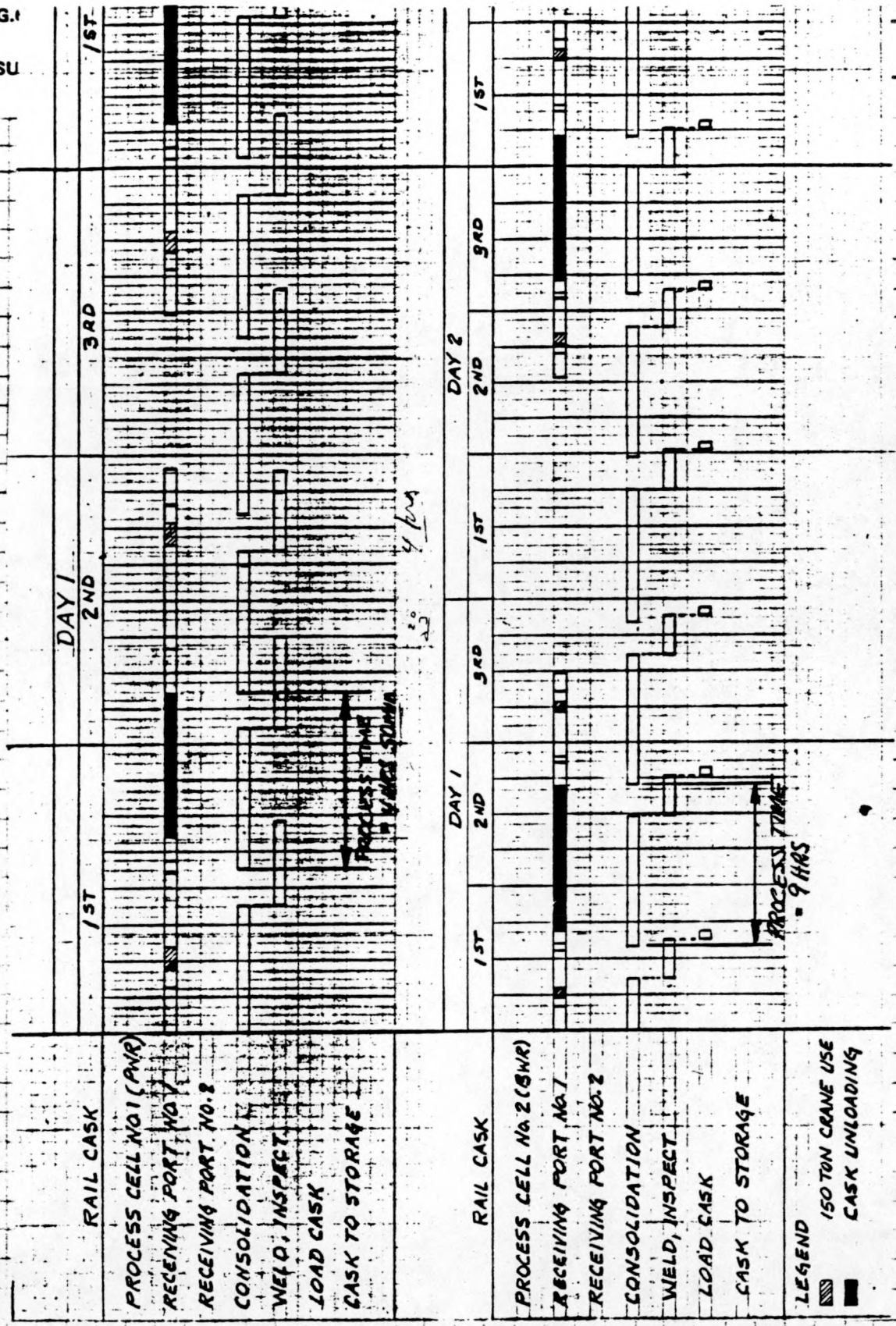
Checked by [illegible] 5-3-85

Waste Receipt & Oper. Times - Analyses



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SUBJECT Waste Receipt & Disposal Times - Analyses

As shown on Figure F-1, the PWR canister production rates are limited by approximate utilization of cask carts, while BWR canister production rates are limited by the consolidation process times plus time for loading fuel assemblies into the disassembly upender.

Figure F-2 shows production rates achievable when all spent fuel is received in rail casks containing either 12 PWR fuel assemblies or 32 BWR fuel assemblies. For this case, the maximum production rate for PWR storage canisters is 4 hours and 50 minutes, while the production rate for BWR storage canisters remains the same as for truck cask shipments - 9 hours. Both PWR and BWR canister production rates are limited by the consolidation process times plus time for loading fuel assemblies into the disassembly upender.

BASED ON FIGURES F-1 AND F-2 AND INFORMATION PROVIDED THREE CASES WILL BE EVALUATED TO DETERMINE THE NUMBER OF CELL REQUIRED AND EFFICIENCY OF EACH CELL. THE THREE CASES ARE DESCRIBED BELOW:

CASE 1: NO BWR FUEL RECEIVED IN TRUCK CASKS

CASE 2: ALL BWR FUEL RECEIVED IN TRUCK CASKS

CASE 3: BOTH BWR AND PWR FUEL RECEIVED IN A MIX OF 50% VIA TRUCK AND 50% VIA RAIL.

NOTE: IN ALL CASES THE 3600 MTU THROUGHPUT IS MADE UP OF SPENT FUEL ASSEMBLY AND DOES NOT INCLUDE THE EFFECT OF HLW & RHTRU.

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SUBJECT Waste Receipt & Oper Times - Analysis

Table 1 summarizes the information relative to the required annual receiving rates and canister production rates for these three cases. It should be noted that two other extreme cases - no PWR fuel received in trucks casks and all PWR fuel received in trucks casks are not consistent with the 50% truck/rail split.

In determining the throughput capacity of the MRS conceptual design, it was assumed that the facility is operational for three shifts per day, 365 days per year, or a total of 8,760 hours per year. The definition of efficiency, as used in this study, represents the processing hours as a percentage of total available operating hours (8760 hours per year) required to meet the base case through-put requirements for the facility.

Using the canister processing rates developed from Figures F-1 and F-2, the cell efficiencies that must be maintained to achieve the annual ~~3600 MTU~~ throughput of spent fuel for each of the cases identified in Table 1 are discussed below.

Case 1

A total of 1559 PWR and 1106 BWR canisters of consolidated spent fuel must be processed annually, assuming the spent fuel is the only waste form.

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SUBJECT Waste Receipt & Disposal Times - Analysis

TABLE 1

SUMMARY OF ANNUAL RECEIVING AND CANISTER PRODUCTION RATES

CASE	FUEL TYPE	QUANTITY (MTU/YR)	CASK TYPE	NO. OF CASK (PER YR)	NO. OF FUEL ASSY PER YEAR	NO. OF CANISTERS PER YEAR
1	PWR	1799.9	TRUCK	1948	3896	1298.6
	PWR	360.3	RAIL	65	780	260.0
	BWR	1440.4	RAIL	242	7744	1106.2
2	PWR	360.3	RAIL	65	780	260.0
	PWR	1799.9	TRUCK	1948	3896	1298.6
	BWR	1439.6	TRUCK	1548	7740	1105.7
3	PWR	1080.1	TRUCK	1169	2338	779.3
	PWR	1081.1	RAIL	195	2340	780.0
	BWR	719.8	TRUCK	774	3870	552.8
	BWR	720.2	RAIL	121	3872	553.14

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Processing this quantity of canisters of spent fuel will require an efficiency of 53% for each of four cells. The distribution of canisters and the processing times are shown on Table 2. The 53% efficiency is an upper limit and does not permit for any unusual distruption of the processing of spent fuel. This 53% efficiency is an upper based on the production losses described on page 29 of this TR Book. Cell 2 which is primarily a PWR spent fuel production cell must process at least 76 canisters of BWR since two cells dedicated to BWR fuel are inadequate to handle the BWR fuel at efficiencies less than 50%. The higher efficiency requirements of each of the four cells can be alleviated by processing some of the BWR fuel in a fifth cell. Due to the similarities in processing time between BWR truck/rail shipments, the effect of processing BWR fuel in a 5th cell is defined in Case 2.

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SUBJECT Waste Receipt & Dispos. Times — Analysis

TABLE 2

SUMMARY OF CELL PRODUCTION RATES

CASE	FUEL TYPE	CASK TYPE	No. OF CANISTERS PER YEAR	CELL No. / FUEL	CANISTERS PROCESSED	PROCESS TIME (HRS)	CELL No. & EFFICIENCY (%)
1	PWR	TRUCK	1298.6	1 PWR	820	5.66	1 - 53%
	PWR	RAIL	260.0	2 PWR	478.6	5.66	2 - 53.1%
					260.0	4.83	
					76.2 (BWR)	9.00	
	BWR	RAIL	1106.2	3 BWR	515.0	9.00	3 - 53%
				4 BWR	515.0	9.00	4 - 53%
2	PWR	RAIL	260.0	1 PWR	260.0	4.83	1 - 50%
				1 PWR	551.0	5.66	
	PWR	TRUCK	1298.6	2 PWR	747.6	5.66	2 - 48.3%
	BWR	TRUCK	1105.7	3 BWR	490.0	9.00	3 - 50.3%
				4 BWR	490.0	9.00	4 - 50.3%
				5 BWR	125.7	9.00	5 - 1131.3 HRS or 12.9%

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SUBJECT Waste Receipt & Process Times – Analysis

TABLE 2

SUMMARY OF CELL PRODUCTION RATES (CONT'D)

CASE	FUEL TYPE	CASK TYPE	NO. OF CANISTERS PER YEAR	CELL NO/ FUEL	CANISTERS PROCESSED	PROCESS TIME (HRS)	CELL No. & EFFICIENCY %
3	PWR	TRUCK	779.3	1 PWR	750	5.66	1 - 48.5
				2 PWR	29.3	5.66	2 - 44.9
	PWR	RAIL	780.0	2 PWR	780.0	4.83	
	BWR	TRUCK	552.8	3 BWR	490.0	9.0	3 - 50.3
				4 BWR	62.8	9.0	4 - 50.6
	BWR	RAIL	553.14	4 BWR	430.0	9.0	
				5 BWR	123.14	9.0	5 - 12.65% (1108.3 HRS)
4	PWR	TRUCK	779.3	1 PWR	779.3	5.66	1 - 53.4
	PWR	RAIL	780.0	1 PWR	54.4	4.83	
				2 PWR	725.6	4.83	2 - 52.8
				2 BWR	125.0	9.00	
	BWR	TRUCK	552.8	3 BWR	490.0	9.00	3 - 50.3
	BWR	RAIL	553.14	4 BWR	490.9	9.00	4 - 50.4

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Case 2

As in Case 1, all the BWR fuel (1106 canisters) can not be processed in two cells of the R&H building. This would require an efficiency in the two BWR cells of 57% which is currently beyond the anticipated standard efficiency of 54% limit.

In order to lower the efficiencies in all processing cells, the use of the 5th processing cell to handle the BWR fuel results in an average efficiency of 49.7% for the four primary cells. This requires that the 5th cell process 125.7 canisters at 1131 hours of operation. This results in an efficiency of 12.9% for the fifth cell, but provides the capability to process HLW and RHTRU in the fifth cell concurrently or serially. The fifth cell will also permit some concurrent outgoing shipping while the other 4 cells are in full production. This adds to the overall efficiency of the MRS facility.

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Case 3

This base case represents a true 50% split of truck/rail shipments of PWR and BWR fuel for processing. The results of this case are defined on Table 2 (Pg 48 of this TR Book). The best efficiencies are achieved via this case in which an average of 48.6% for each of the four main cells. This case is similar to Case 2 with the distribution of 123.4 canisters of BWR fuel to the 5th cell. However, the delivery of 50% of the PWR fuel via rail speeds up the processing time, permitting sharing of the PWR truck shipments from cell 1. Redistribution of BWR fuel to cell 5 requires at least 1108 hours of production from cell 5 with an overall efficiency of utilization of 12.6%.

Case 4

This case represents the 50/50 split of truck/rail deliveries and using only four process cells instead of five cells. These numbers (see pg. 48) indicate good efficiencies which are achievable and consistent with the possible design configuration.

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SUBJECT Waste Receipt & Dyer Times — Analysis

The overall cell efficiencies for the required throughput of 3600 MTU are based upon the assumption that the MRS facility is capable of off-loading the fuel and preparation of casks on a timely basis. The truck/rail casks unloading times listed on Table F-1 and FIGURE F-1 and F-2 indicate the 150 ton crane is used 70 minutes for each truck/rail shipment. Summarizing, the number of crane accesses is shown below to determine the feasibility of using one crane. Case 2 indicates that two cranes (or two bridges on the same rails) is necessary with an utilization of 107%. Even though case 2 may be an extreme case the usage of greater than 50% of the time suggests a second crane may be necessary. These figures do not incorporate the usage for cell 5 either for normal production of spent fuel or for processing of HLW or RHTRU. Crane maintenance also has not been included

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SUBJECT Waste Receiving & Export Times – Analysis

Table 3
Summary of 150 Ton Crane Usage
(Based on 70 min/access)

Case	Cell No. AND FUEL TYPE	Cask TYPE (TRUCK OR RAIL)	No. OF ACCESSES PER DAY	ACCESS TIME TOTAL (MIN)	UTILIZATION EFFICIENCY % (BASED ON 1440 MIN)
1	1 PWR	T	6	980	68%
	2 PWR	T/R	6		
	3 BWR	R	1		
	4 BWR	R	1		
2	1 PWR	T	6	1540	107%
	2 PWR	T	6		
	3 BWR	T	5		
	4 BWR	T	5		
3	1 PWR	T	6	945	65.6%
	2 PWR	R	1.5		
	3 BWR	T	5		
	4 BWR	R	1		

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SUBJECT Waste Receipt & Dock Times – Analysis

in this evaluation. The high utilization of the crane during case 2 suggests that if all 4 main process cells are operation, crane delay will reduce productivity of all cells. This case also suggests that all truck casks will probably jam up the incoming wash down and unloading area. Figure F-1 indicates that for only two cells unloading with trucks, between 4 to 5 trucks will be moving or parked in front of cells 1 and 2 and possibly limiting access to cells 3 and 4 assuming the entrance and exit are at opposite ends.

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SUBJECT Secondary Waste-Processing Time Evaluation

Processing Variations and Options with a Fifth Cell

Generally, four main processing cells are required (2 for BWR, 1 for PWR and 1 for PWR/BWR mix) with a higher efficiency ~53%. This is also based on all spent fuel assemblies comprising 3600 MTU throughput. Part of the Modified MRS evaluation is to include the processing/storage of up to 1500 MTU of HLW and RHTRU.

From the Conceptual Basis For Design Volume 1 of 2, section 2.5.2 Basis for Design Para. B 3 (Throughput rates), the following number of canisters must be received at the MRS per year:

(4) The HLW and RHTRU equivalent to 1,500 MTU of spent fuel is assumed to be received as follows:

HLW canisters (1' dia x 10' long):	705
RHTRU canisters (2' dia x 10' long):	555
RHTRU drums:	699

Also, the Basis for Design states that the spent fuel, HLW and RHTRU will all be shipped based on 50% truck casks and 50% rail casks.

In addition to receiving this quantity of HLW and

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SUBJECT Secondary Waste Processing Time Evaluation

RHTRU the facility must be able to process (in Cell 5), secondary waste streams and on-site generated waste.

Based on information presented in the BASIS for Design, the secondary waste system will volume reduce the waste from PWR and BWR and place the waste into 55 gal drums at the following rates:

- 10 PWR assemblies / drum
- 6 BWR* assemblies (with channels) / drum

*Note: this may be conservative because not all BWR's will have channels.

From Table 1, of pg. 45

$$4678 \text{ PWR} \times \frac{1 \text{ DRUM}}{10 \text{ PWR ASSY}} = 467.8 \text{ Drums or } 468 \text{ Drums}$$

$$7742 \text{ BWR} \times \frac{1 \text{ Drum}}{6 \text{ BWR ASSY}} = 1290.3 \text{ Drums or } 1291 \text{ Drums}$$

TOTAL = 1759 DRUMS of Secondary Waste

Assuming these are generated according to the same rate as the production cells, the drum must be processed via the following rate:

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SUBJECT Secondary Waste Processing Time Evaluation

Table 1.5-1 - Reference Casks and Containers

Material	Shipping Mode	Shipping Container	Assemblies/Canisters per Shipment
Spent fuel	Truck	NLI-1/2[a]	2 PWR or 5 BWR[a]
	Rail	TN-12	12 PWR or 32 BWR
High-level wastes	Truck	NLI-1/2	1 canister
	Rail	TN-12	5 to 8 canisters
RHTRU special canister	Truck	HLW-T[b]	1 canister
	Rail[c]	HLW-R[b]	5 canisters
RHTRU drums < 5 R/hr	Truck	CNS 14-170[d]	14 drums
	Rail[c]	CNS 14-170[d]	42 drums
RHTRU drums > 5 R/hr	Truck	CNS 7-100[d]	7 drums
	Rail[c]	CNS 7-100[d]	21 drums
CHTRU wastes	Truck	TRUPACT	36 drums or 2 boxes
	Rail[e]	TRUPACT	72 drums or 4 boxes

[a]Not yet approved for this loading. Assume new cask configuration will be similar to existing configuration.
[b]Not yet built.
[c]Assumes three shipping containers transported per railcar.
[d]Only for use for material of low specific activity.
[e]Assumes two truck TRUPACT versions transported per railcar.

Obtained from Basis for Design, November 1984.

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SUBJECT Secondary Waste Processing Time Evaluation

Average utilization of 4 process cells is 51.7%. This translates to 4531.1 hrs of yearly operation. Therefore, 1759 drums will be produced in 4531.1 hrs for a rate of .388 DRUM/hrs or 2.576 hrs to produce 1 drum).

From Table 4, (see pg. 59) the processing of secondary waste drums will not cause a delay in the off loading of the drums since the processing time is less than the drum generation rate. It is also anticipated that this activity would occur in parallel with placement of canisters of consolidated fuel into the repository package and applying the closure weld. Note: These operations can be parallel if and only if the cell, in general, is kept clean as in the B side of the other production cells. If it is determined via a study that this may not be the case, one of the following options must be invoked:

- Decon the cell prior to processing the secondary waste drums.

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SUBJECT Secondary Waste Processing Time Evaluation

Table 4

Secondary Waste Process Time Estimate

(Process time only in cell 5)

A. Lift drum from transfer elevator to inspection station	.25 hr
B. INSPECT DRUM FOR LEAKAGE AND/OR DAMAGE	.25 hr
C. TRANSFER TO DECON STATION	.10 hr
D. DECON DRUM EXTERIOR USING FREON WASH AND AIR BLOW DRY	.50 hr
E. TRANSFER TO SWIPE STATION	.10 hr
F. SWIPE DRUM AND LABEL	1.0 hr
G. TRANSFER TO DRUM CAGE IN LAG STORAGE	.25 hr
TOTAL TIME	2.45 hr

These times are based on the cell crane being used only to place the drum at the inspection station and transfer to lag storage and/or cask. Other transfers would occur via a power driven drum transfer system with individual drum wash down decon station.

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SUBJECT Secondary Waste Processing Time Evaluation

- Develop a separated area within the cell to inspect and decon the drums with its' own bag storage.

- Develop containment structures around the welding stations (e.g. repository welder and overpack welder).

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SUBJECT Concrete Cask and Dry Well Emplacement Times

In order to assess integration of the production rates in the receiving and handling building process cells with those of the storage facilities, estimated times for processing concrete casks and for drywell emplacement of canisters or other waste forms are given in Tables F-5 and F-6. Comparing the processing rates for consolidated spent fuel canisters with either the processing times for concrete casks or the emplacement times for drywells, it is apparent that storage operations will not limit through put of the facility. At the maximum consolidation canister production rate of 4 hour and 50 minutes, which can be achieved when PWR spent fuel is received in rail casks, it will take at least 58 hours to generate sufficient canisters (12) to fill a concrete cask. This can be compared with the estimated time of 5 hours and 45 minutes required for concrete cask processing, transport and placement.

These tables (see pg. 62) indicate that for the drywell configuration that one drywell transporter per cell is all that is required for the original MRS design. The effect on the modified MRS throughput of 3600 MTU with a linear concept would pose no major impact. However, of 3600 MTU must be processed out of the facility and a mirror image R&H building design was developed the number of silo type port required must be evaluated.

From Table 2 pg. 48 of this book.

Total Number of canister = 3600 MTU = 2665 canisters per year.

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SUBJECT Concrete Cask & DryWell Emplacement Times

TABLE F-5

ESTIMATED PROCESS TIMES FOR CONCRETE CASKS

	Hrs.	Mins.
Prepare cask for storage	3	10
Move cask to storage area		30
Place cask on storage pad		35
Move transporter to cask manufacturing Facility - Load Empty Cask - Return Transporter and Cask to Receiving and Handling Building	1	00
Position Cask Under Exit Port - Engage Contamination Barrier - Close Shadow Shield		15
Remove Shield Plugs from Exit Port - Remove Shield Plug from Cask		15
Total	5	45

TABLE F-6

ESTIMATED TIMES FOR DRYWELL EMPLACEMENTS

	Hrs.	Mins.
Replace Exit Port Shield Plug - Retract Contamination Barrier - Open Shadow Shield and Door - Prepare Transfer Cask for Transporting to Storage Area		15
Transport Transfer Shield (with Storage canister) to Drywell Storage Area		20
Align Transfer Shield with Drywell Liner - Place Storage Canister in Drywell - Place Shield Plug in Drywell Liner		30
Transport Empty Transfer Shield to R&H Building - Load Shield Plug		25
Position Transfer Shield Under Exit Port - Engage Contamination Barrier - Close Shadow Shield and Door - Remove Shield Plugs from Exit Port		20
Total	1	50

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SUBJECT Concrete Cask & Drywell Emplacement Times

Assuming a 53% utilization of a dedicated 5th cell to ship out the drywell canisters, the number of canisters per day requirement is as follows:

$.53 \times 8760 \text{ hrs/year} = 4643 \text{ hrs/year available}$

Assume 2 hrs/drywell canister retrieval

$\therefore \quad 4643 \text{ hrs/year} \times \frac{\text{drywell}}{2 \text{ hrs}} = 2321.5 \frac{\text{drywells}}{\text{yr}}$

can be retrieved using a single transporter

$\therefore$ for 3600 MTU shipping 2665 canisters/year must be achieved

$\therefore$ Two drywell transporters used would be more than adequate to handle the load. Therefore two ports are necessary to transfer dry well canisters back through cell #5 (central cell).

Note: If the Modified MRS Repository Overpack is to be filled directly using drywells; 4 - 12.75" DIA canisters are required per overpack. If the canisters are to be loaded directly from the dry wells to the repository overpack, than 4 ports may be required to manage

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SUBJECT Concrete Dock & Drywell Emplacement Times

the 3600 MTU output.

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G.O. or CHARGE NO. SB-1239-07-001 PROJECT MMRS

SUBJECT Number of Truck Rail Concurrent Shipments

Purpose: Determine the number of possible truck/rail shipments per day required to meet the 3600 MTU throughput and a possible 3600 MTU output via repository casks and/or rail casks.

Assumptions:

- Figures F-1 and F-2 are correct for the 1800 MTU/year value and the use of four cells to handle the 3600 MTU/YR throughput. Also the washdown area flow rate does not inhibit the delivery rate to the process cell.

- For the base case, the 50/50 rail/truck delivery split permits a situation in which two cells have rails and two cells have truck shipments.

- From Pg. 63 of this TR Book - RH-JWW-01, the number of repository overpacks to be shipped out per day is 3.444. This is based on a 53% availability of all five cells.

(Note: 2665 canisters/yr × 1 repos. overpack / 4 canisters = 666.25 overpack/yr

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SUBJECT Number of Truck/Rail Concurrent Shipments

Based on 3.444 repository overpacks per day this requires a maximum production rate of

$3.444 \frac{\text{overpacks}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hrs}} = .1435 \frac{\text{overpack}}{\text{hr}}$ or $6.968 \frac{\text{hrs}}{\text{overpack}}$.

Current estimate of the welding time is less than 4 hours per overpack.

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G.O. or CHARGE NO. SB-1239-07-001 PROJECT MMRS 28.1

SUBJECT Process Time to Evaluate Canister Weld Station Reduction

Purpose: Develop the process time study for the mirror image MRS configuration with lag storage located at Floor 2. Evaluate weld station access and process time in normal and failure mode scenario.

Assumptions: • The plan layout view of the Modified MRS R&H Facility is shown on pg 71 of this TR Book. The four process cells (1 thru 4) are oriented in the mirror image with a common back wall on the "B" side.

• Each process cell "A" side is serviced by a 20 ton powermast crane. The "B" side of the cells 1 & 2 is a common area, serviced by two cranes (one at end near weld station and one near repository overpack end). Note these cranes traverse 90° to the cranes in the "A" side.

• The "B" sides of cells 1 & 2 and 3 & 4 share a common wall (single wall and air plenum wall).

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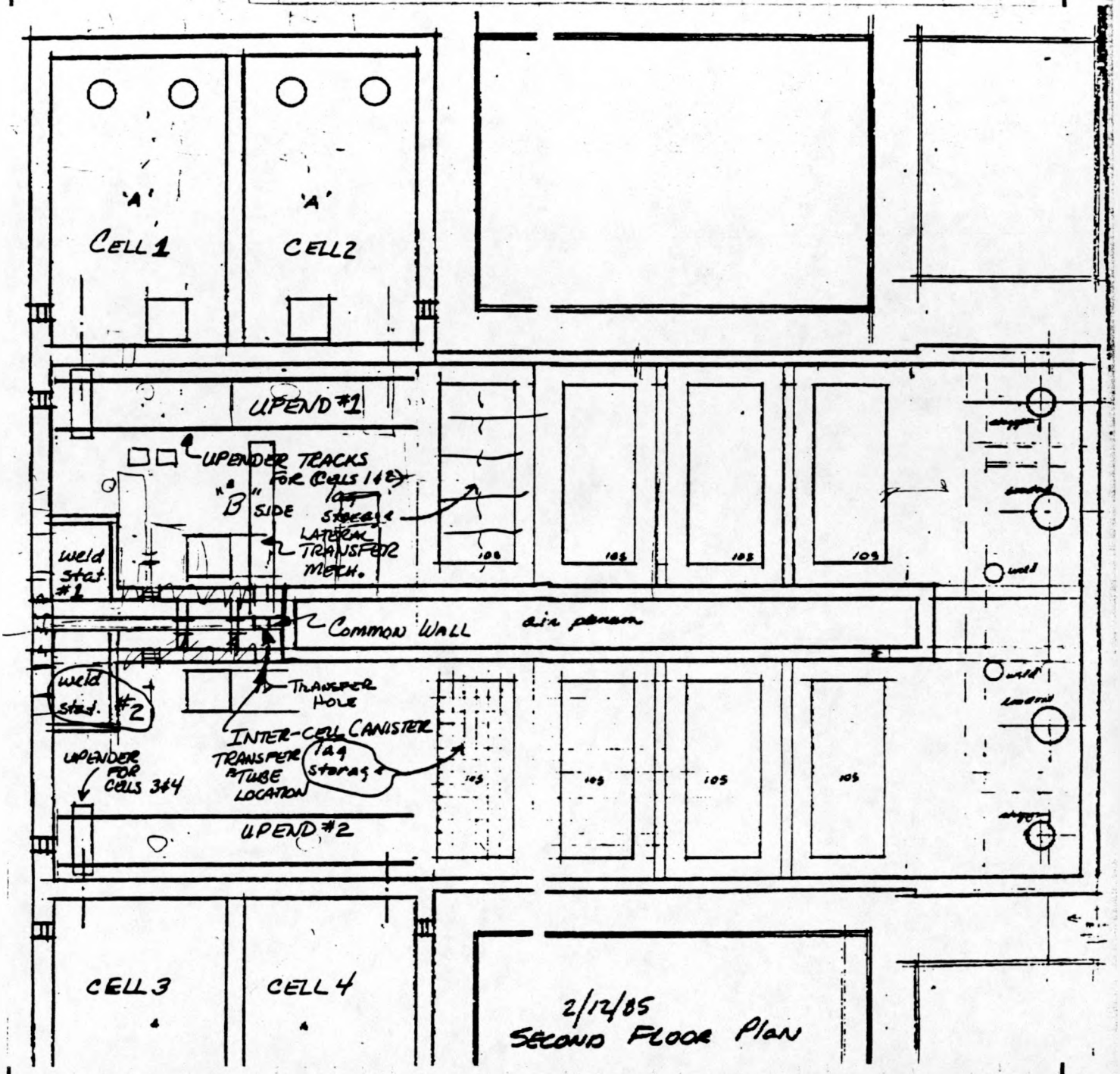
SUBJECT Process Time to Evacuate Canisters Weld Sta Reduction



Plan Layout to be evaluated as Received from L.P. POLLONO on 2/13/85.

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SUBJECT Process Time to Evaluate Canister Weld Station Reduction

- The through-put for base case of 3600 MTU/yr for the four main process cells using a 60/40 PWR/BWR split and delivered using a 50/50 split of truck/rail shipments.

- For the base case two option could occur during a year or a combination of the two:

A) Canisters Welded Max (Ref: BASIS FOR DESIGN & IOC-353)

PWR	Consolidated	1402.8
"	INTACT	467.6
BWR	Consolidated	995.2
"	INTACT	387.0
	TOTAL	3252.6 Canisters/yr.

B) Canisters welded (No INTACT - ALL CONSOLIDATED)

Cell No.	Canisters	
1	833.7	PWR
2	850.6	PWR
3	490.0	BWR
4	490.9	BWR
TOTAL	2665.2 canisters/yr.	

The basis for the intact number of canisters is based on data assumed in BASIS FOR DESIGN 3.5.2.B Storage Requirements 2. Storage Retrieval Rates

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SUBJECT Process Time to Evaluate Canister Weld Station Reduction

with 5% of Total MTU non-consolidatable and 5% of the higher-burnup or shorter life. (The second 5% is too hot to store in concrete casks.)

- Using data from APPENDIX F of the MRS Design Report the following represents the time values for the canister upender.

CANISTER UPENDER / WELDING PROCESS TIME ESTIMATE FOR:	CONSOLIDATED FUEL hr min	INTACT FUEL hr min
A. Install clean canister into canister upender while vertical.	- 30	- 30
B. Downend, rotate table, translate to fuel bundle receiving station and position canister.	- 15	- 15
C. Receive fuel bundle from consolidation machine	- 15	- 15 (intact fuel)
D. Retract from position, translate to rotation position, rotate canister and translate to weld position	- 15	- 15
E. Slide canister into weld position and weld	- 20	- 20
F. Decouple from welder, slide canister in decon. chamber, decontaminate and ultrasonically inspect	1 35	1 35
G. Repeat step B in reverse order	- 15	- 15
H. Unload canister to lag storage	- 15	- 15
TOTAL UPENDER USAGE =	3 hrs 40 min	3 hrs 40 min

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SUBJECT Process Time to Evaluate Canister Weld Stn. Reduction

- Assume from the sketch that only one canister opener is used for each of cell 1&2 and cell 3&4.
- Assume that the welder location is the same as that normally found on cell 1 (adjacent to an outside wall for access.
- Assume a inter-cell lateral transfer mechanism is available for each of the two "B" side locations.
- Based on process times described for the canister opener, the time required to weld intact fuel assembly is the same to weld process the consolidated fuel.

Discussion: Four scenarios will be evaluated for this study.

1. Basic cell configuration as defined but with 4 welders available.
2. Basic cell configuration as defined but with 2 welders [1 for cells 1&2 (WS#1) and 1 for cells 3&4 (WS#2)].

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G.O. or CHARGE NO. _____ PROJECT MMRS 2B.1

SUBJECT Process Time to Evaluate Canister Weld Station Reduction

3. Same as case 2 except one welder defined for cell 3 & 4 is down for repair and all welded is performed on welder 1 (located on "B" side for cells 1 & 2).

4. Same as case 2 except the welders are moved to a location between cells 1 & 2 and cells 3 & 4 to permit better cell access. In addition, a second upender is placed on the traverse track to permit better access to the welder. A service corridor would be required for maintenance of the welders.

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CHECKED BY [illegible] 7-13-85

G.O. or CHARGE NO. _____ PROJECT MMRS 2B.1

SUBJECT Process Time to Evaluate Canister Weld Station Reduction

ANALYSIS:

The Canister Upender / Welding Process Time Estimate Table on pg 73 of this TR Book indicates that the upender is occupied for a total of 3 hrs and 40 minutes per canister. This is true when processing intact spent fuel assemblies or consolidated fuel rods.

A previous time estimate indicates 3.85 hrs to disassemble and consolidate 3 PWR assemblies into one canister. The same time to process 7 BWR assemblies is 7.25 hrs/canister.

Case 1

For the case of one welder per cell, the 3.66 hrs time estimate to weld and release a canister of fuel is less time than the consolidation process time. Therefore, the canister welding processing time will not slow down the overall production time.

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CHECKED BY J/ Mitchell 7-3-85

G.O. or CHARGE NO. _____ PROJECT MMRS 2B.1

SUBJECT Process Time to Evaluate Canister Weld Station Reduction

INTACT FUEL PROCESSING TIME ESTIMATE	PWR hr min	BWR* hr min
A. Visually examine to verify fuel type (determine to intact process)	- 30	- 50
B. Secure assembly on Intact & Recovery Upender	- 5	- 5
C. Rotate to horizontal	- 3	- 3
D. Open transfer tube valve	- 5	- 5
E. Push intact fuel element into canister.	- 10	- 10
TOTAL TIME	0-53	1 13
For calculation Purposes use	1 hr	1 hr 15 min

* Note: Two BWR assemblies required before loading into canister.

Based on the above table, the intact fuel processing has a relatively short processing time. The canister upender/welding process would limit the throughput rate. A brief review of the time layout indicates the upender/welding operation controls the intact fuel assembly processing. Assuming a 50/50 split of intact elements in each of the processing

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CHECKED BY: [illegible] 3-8-85

G.O. or CHARGE NO. _____ PROJECT MMRS 2B.1

SUBJECT Process Times & Evaluate Canister Weld Station Reduction

cells based on fuel type, the cell efficiency percentages increase from an average of 51.7% to 55.5% with a maximum of 58.8% in cell 2.

Case 2

For the case with the basic Modified MRS design with one upender per two process cells and the one welder per cell located on a outside wall (on cell 1 and cell 3 sides), the process time is limited by the canister upender.

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CHECKED BY Jeff Mitchell 7 3-85

G.O. or CHARGE NO. _____ PROJECT M MAS 2B.1

SUBJECT Process Time to Evaluate Canister Weld Sta Reduction

Case 3

Assuming the same conditions as Case 2, except that one of the welding station is down for service, the overall canister production will be significantly reduced. For fuel canisters to transfer from the single canister upender #2 (UPEND #2) to the weld station LS #1, the filled canister (without lid) must be transfer through the inter-cell transfer tube (see sketch on pg. 71). This action will be performed by a new piece of equipment defined as the lateral transfer mechanism. The following table lists the estimated time required to perform this activity. Assume that UPEND #1 is empty and ready for transfer without delays. Also, prior to step A, the intact fuel assembly or consolidated fuel have been just be pushed into the canister.

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G.O. or CHARGE NO. _____ PROJECT MMRC 2B.1

SUBJECT Process Time to Evaluate Canister Weld Station Reduction

Lateral Transfer Mech. Time Estimate

	Consolidated Fuel hr	Consolidated Fuel min	Inner Fuel hrs	Inner Fuel min
A. Retract from position (Cell 3), translate to center of two cells, rotate upender, and install protective plug	–	15	–	15
B. Slide canister from canister upender #2 onto LTM#2.	–	2	–	2
C. Open LT port plug between "B" sides	–	2	–	2
D. Slide canister from LTM#2 onto LTM#1	–	2	–	2
E. Close LT port	–	2	–	2
F. Slide canister from LTM#1 onto UPEND #1	–	2	–	2
G. Rotate canister on UPEND#1, translate to weld staging position	–	10	–	10
H. Perform steps E, F, G and H from Canister Upender time study pg. 73 (Note: Canister from cell 3 is placed in Cell 1 & 2 lag storage.	2	25	2	25
TOTAL	3 hr	0 min	3 hr	0 min

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CHECKED BY [illegible] 2-3-85

G.O. or CHARGE NO. _____ PROJECT M MRS 2B.1

SUBJECT Process Times to Evaluate Canister Weld Station Reduction

Case 4 – Lateral Transfer From Upender to Auxiliary Weld Station Located near Repository Overpack.

Assumptions:

- BOTH UPENDERS WORKING WITH CELLS 1 & 2 ARE OPERATING.
- ONLY ONE WELDER IS DOWN FOR REPAIR.
- ALL WELDING AND INSPECTION EXIST AT AUXILIARY WELD STATION
- UPENDER EXISTS AT AUXILIARY WELD STATION FOR TRANSFER OF CANISTER TO WELDER AND PASS CANISTER THROUGH WALL.
- SPECIAL TOOLING IS NECESSARY TO HANDLE AND CLOSE OPEN CANISTER OF SPENT FUEL.
- NO DIFFERENCE IN HANDLING AND WELDING CONSOLIDATED OR INTACT FUEL ASSEMBLIES.

Crane Travel Times	Time to Process hrs	min
A. Retract from receipt position (Cell 1), translate to center of two cells, rotate upender.	–	15
B. GRAPPLE THE CANISTER WITH SPECIAL TOOLING AND RELEASE CLAMPS ON UPENDER #1-A	–	10
C. LIFT CANISTER WITH FUEL AND TRANSFER TO AUXILIARY UPENDER NEAR REPOSITORY OVERPACK @ 90 FPM 2.36 min	–	10
D. UNGRAPPLE CANISTER INTO AUXILIARY UPENDER AND CLAMP ONTO UPENDER	–	5
E. TRANSLATE BACK TO CELL 1 END AND CHANGE OUT TOOLING TO PICKUP GRAPPLE	–	5
TOTAL	–	45 min

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CHECKED BY J.P. Mitchell 7-3-85

G.O. or CHARGE NO. SB-1239-08-009 or .017 PROJECT INTEGRATED MRS

SUBJECT Repository Overpack Weight and Size Calculations

Assumed Weights: 1) Canister of consolidated fuel in 12.75" OD canister = 5100#
(Conservative)

2) Canister of overpacked consolidated fuel in 14.00" OD canister
610# + 5100# = 5710#
(Ref. Pg 7 of TR-Book RH-JWW-01)

Assumptions: R.O - Material Carbon Steel

1) Side wall thickness = 5.50"
2) Top & Bottom Heads = 9.00" thick
} See pg. 68 of TR Book RH-01 dated 4/16/85

3) 2" Deep full penetration weld at Bottom (full circumference)

4) 2" Deep weld at top head using Electron Beam weld.

Contents weights: Case 1 - 4-12.75" OD Canisters
= 4@5100 = 20400#

Cage to support Canisters is assumed to equal 600#

Total content weight = 21000#

Case 2 - 2-12.75" OD Canister
2@5100# = 10200#
1-14.00" OD Canister
1@5710# = 5710
Cage = 600#

Total = 16510#

SIGNATURE J W Wilter DATE 4/16/85 TRB NO. RH-JWW-01 PAGE 93

CHECKED BY: Jeff Mitchell 7-3-85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Repository Overpack Weight & Size Calculations

$$W_T = [(\text{Vol Cylind}) + (\text{Vol Heads}) + (\text{Vol Pintle})] \times \text{Density}$$

$$W_T = \left[\left[\frac{\pi}{4}(D_o^2 - D_i^2)\cdot(IL + 2HT)\right] + \left[\frac{\pi}{4} D_i^2 \cdot 2HT\right] + \left[\frac{\pi}{4}(10.5)^2 \times 4 + 6\left(\frac{\pi}{4}(4)^2\right)\right]\right] \times .283 = 170729.74 \times .283 = 48316.5$$

W_T including misc lags = 48400#

where IL = inside length
HT = head thickness

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CHECKED BY Jeff Mitchell 7-3-85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT ~~Repository Overpack Weight & Sizing Calculations~~

Weld Area Required to lift or support R.O full.

Assume Contents = 21000#

Assume R.O empty Wt = 52000# (actual is 48400#)

73000#

Tw allow for CS = 16500psi

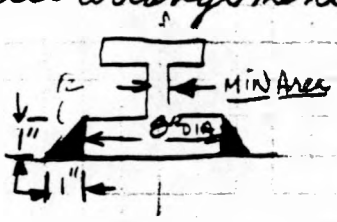
Assume Impact lift factor of 2 on Load.

Assume factor of safety of 4 on overload.

or total of SF = 6.0

$\sigma_{all} = \frac{P}{A} \therefore$ Area req $= \frac{73000(6)}{16500.0} = 26.54 in^2$

For Pintle arrangement of base diameter of 8".



Area = .765 W · 2π(4") =
where w = 1"

Area = .765 (1)(2π)(4) = 19.22 in²

(less than allowable area of 26.54 in²)

Area of minimum pintle section:

Area = π(3)² = 28.27 in² Min. Area-diameter = 6"

∴ Pintle weld area must be increased at least 10" and increase throat size from 1"x1" to 1.5"x1.5".

Area weld = .765(1.5)(2π)(5) = 36.049 in² → Permits 73% weld efficiency

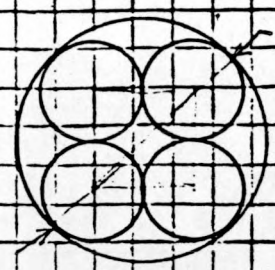
SIGNATURE J.W. Willis DATE 4/19/85 TRB NO. RH-TWW-01 PAGE 95

CHECKED BY J. Mitchell 2-3-85

G.O. or CHARGE NO. 5B 123908 009 PROJECT MRS

SUBJECT SALT OVERPACK FOR MRS PACKAGES

MRS CANISTER IS 12.75 OD - USE 14.75 OD FOR ENVELOPE IN SHIPPING CASK



$d = 14.75\sqrt{2} + 14.75 = 14.75(1+\sqrt{2})$

$d = 35.609$ say 36.00

for components under external pressure see ASME BPVC, § III ¶ NB 3133

L = 165"

Let $D_o = d + T$ where $T = 4.6$ ∴ $D_o = 45.2$

$D_o/T = \frac{45.2}{4.6} = 9.826$ $L/D_o = 165/45.2 = 3.65$

∴ A = .014 (Fig VII-1100-1)

Then, from fig III-1101-2 B = 16500 @ 400°F

$P_a = \frac{4B}{3\,D_o/T} = \frac{4 \times 16500}{3 \times 9.826} = 2239$ design pressure is 22.33 psi (TME + 001)

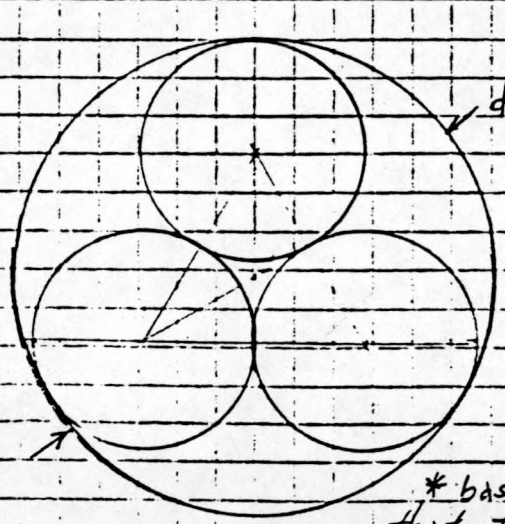
so this is OK

corrosion allowance should be 2.3 cm (0.905")

therefore req'd t = 4.6 + .905 = 5.505" use 5.50"

so OD = 36 + 11 = 47" (OVERPACK 119.4 cm)

so, for shipping cask (PRDA-5 type w/ 3 SALT OP) for inner cyl, D = OD + 2 = 47 + 2 = 49



$d_c = 2\left(\frac{D}{2\cos 30} + \frac{D}{2}\right) = D\left(1 + \frac{1}{\cos 30}\right)$

$= 49\left(1 + \frac{1}{.866}\right) =$

$d_c = 105.58$"

$t_{steel} = 6.5$"* so OD = 118.58

Bises $t_b = 3.00$ w/ .5" stl outside

OVERPACK LENGTH 165 + 2×9 = 183 + pintle say 190

SHIPPING CASK HEADS 10" THK, for structure

OD OVER BISES

118.58 + 2×(.5 + 3 + .5) = 126.58" TOO BIG

* based on PRDA info that total t (steel) must be ~ 11.0" (6.5 + 4.6 = 11.1)

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CHECKED BY: Jeff [illegible] 7-3-85

G.O. or CHARGE NO. SB1239-08-009 PROJECT MRS

SUBJECT Weight of Cask from P.61

full canister : 304L pipe @ 12" sch 40 @ 156 long
w/ 1" THK HEADS

wt : $[(12.75^2 - 12^2) \times 156 + 12.75^2 \times 2]\pi/4 \times .289$ = 731 #

fuel rods from 3PWR assume (17×12) $3 \times 264 \times 5.5$# 4356 #

Σ 5087 #
say 5100 #

canister
$[(47^2 - 36^2) \times 165 + 47^2 \times 18]\pi/4 \times .283$ = 42321 say 42325
plus 4 CANISTERS @ 5100 20400
62725 #

SHIPPING CASK :
STN. STL : $[(118.6^2 - 106^2)190 + 118.6^2 \times 20]\pi/4 \times .289$ = 185900 185900
BISCO $[(125.5^2 - 118.6^2)211 + 125.5^2 \times 6]\pi/4 \times .064$ = 20341 say 20350
SHELLS (BISCO) $[(119.6^2 - 119.0^2)210 + (116.5^2 - 115.5^2)217 + 119^2 \times .5 + 116 \times 1]\pi/4 \times .289$ = 23335 say 23350
229600
PLUS 3 full canisters @ 62725 188175
417775
ALSO TOO HEAVY (208.89T)
TOO MUCH
working limit is 150T or 300000 #

Overpack is sized to hold 3 canisters.

$d_{OP} = 19.75\left(1 + \frac{1}{\cos 30}\right) = 31.78"$ say 32"; at this diameter the thickness may be reduced to 4.05" plus corrosion allowance of .905" for a total t of 5.00". Thus the OD$_{OP}$ = 32 + 2 × 5 = 42" / Head thickness is 8 + 1 = 9". On the basis the SHIPPING CASK ID = $d_{SC} = 44\left(1 + \frac{1}{\cos 30}\right) = 94.8$ say 95"
+ OD of CRES = 95 + 2(5.5) = 106"
OD Biscot clad say = 106 + 2(4) = 114" OK

SIGNATURE SBHall DATE 11 Apr 85 TRB NO. GH01 PAGE 62

CHECKED BY Jeff Mitchell 7-3-85

G.O. or CHARGE NO. SB1239-08-009 PROJECT MRS

SUBJECT Weights & Physical Sizes of Casks

Weight of shipping cask (Pre Lid)

3 canisters @ 5100 — 15300

overpacks $[(42^2-32^2)\times165+42^2\times18]\pi/4\times.283 = 34196$ say — 34200

49500

SHIPPING CASK

STN STL $[(106^2-95^2)190+106^2\times20]\pi/4\times.289 = 146359$ say — 146400

BISCO $[(113^2+107^2)211+113^2\times6]\pi/4\times.064 = 17850$ — 17850

SHELLS (BISCO) $[(107^2-106.5^2)191+107^2\times.5+(114^2-113^2)212+114^2]\pi/4\times.289 = 19860$ — 19800

189050

plus 3 FULL OVERPACKS @ 49500 each — 148500

332550

166T (at limit) (too much)

1st option 36 assem in 388000# contains 10777#/assem

2nd option 27 assem in 332550# — 12316#/assem

ONWI design (see TME 001, p 124)

wt 38800#

OD: 33.3" t: 10cm = 4" ID: 25.3

Length 175"* t: 18.3 = 7.2"

* NO PINTLE

shipping cask for 3 ONWI overpacks:

$d = 35.3\left(1+\frac{1}{\cos 30}\right) = 76.06$ say 76.00

$t = 10.5 - 4 = 6.5$ OD = 76 + 13 = 89

wt: $[(89^2-76^2)185+89^2\times20]\pi/4\times.289 = 126029$ say — 126050

BISCO $[(96^2-90^2)206+96^2\times6]\pi/4\times.064 = 14335$ say — 14350

SHELLS $[(90^2-88.5^2)206+(97^2-96^2)\times212+90.5^2/2+97^2]\pi/4\times.289 = 16538$ say — 16550

156950

plus 3 ONWI CANISTERS 3×38800 — 116400

273350

THIS DESIGN 36 ASSEM : 7592#/assembly

136.7T

+10% for each wt for pallets, etc 156950×1.1 + 116400

Cages = 289045, say 289000

OK

SIGNATURE [illegible] DATE 11 Apr 85 TRB NO. GH01 PAGE 63

CHECKED BY: Jeff [illegible] 7-3-85

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G.O. or CHARGE NO. SB1239-08-008 PROJECT MRS

SUBJECT CABLE WEIGHT FOR CRANES

The numbers & sizes of cables for the MRS cranes have NOT been ascertained. However an estimate is as follows according to Charlie McCullough.

- PAR Manipulator — 1 cable 36 conductor (1.25" DIA) — Power
  5 cables [6 cond. ea] (1.0" DIA) — Resolver
  assume 7/8 ϕ
- Bridge
- Trolley
- Turntable
- Power Mast Hoist
- Manipulator Hoist

  } 1 cable ~17 conductor (0.75) — Power control

- CCTV controls } 1 cable (0.82)
- " video }

- Instrumentation (1.7)
  - Load cells
  - Limit switches "
  - 2 cables 6 cond. ea
  - 20 " 4 " " — 212 cx pair

2400 V, 3ϕ power distributed to crane on the power rail.

CRANE CABLE ESTIMATES

6 x cable - ϕ

SIGNATURE Gary V B Hall DATE 25 Apr 85 TRB NO. GH 01 PAGE 66

CHECKED BY Jeff Mitchell 7-3-85

G.O. or CHARGE NO. SB1239.08-008 PROJECT MRS

SUBJECT CABLE WEIGHT FOR CRANES

There is insufficient definition to calculate the weight of these wires, so we will assume that they weigh 1/2 as much as if they were solid. $\rho_{cu} = 0.323\ \#/in^3$

$wt = .5\left(1.75^2 + 1.25^2 + 0.82^2 + .75^2 + 5 \times .375^2\right)\pi/4 \times .323 \times 12 = 9.984\ \#/ft$

say $10\ \#/ft$

4.75 #/ft
2.84 #/ft

assume 1/2 of each diameter is air for bracing is PVC

also assume $\rho_{pvc} = 1.25$* $= \frac{62.4 \times 1.25}{12^3} = 0.095\ \#/in^3$

$wt = 5.693\ \#/ft$ say $6\ \#/ft$

Minimum bend radius ~ 6d = 6 × 1.7 = 10.2"

*Handbook of Tables for Applied Engineering Science, CRC, Edn. 1-84,

SIGNATURE DVB Hall DATE 25 Apr 85 TRB NO. GH01 PAGE 67

CHECKED BY: Jeff Mitchell 7-3-85

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G.O. or CHARGE NO. SB-08-008 PROJECT MRS - TASK 2B

SUBJECT SIZING OF CRANE POWER WIRING -

REPRODUCED BELOW IS A PAGE FROM A P&H CATALOG:

P&H INDUSTRIAL DUTY CRANES

CAPACITIES AND RECOMMENDED SPEEDS

Cap.	Hoist		Trolley		20 to 60 Ft. Bridge Spans Wide Flange Girders				60 to 100 Ft. Bridge Spans Box Girders			
					Floor Controlled		Cab Controlled		Floor Controlled		Cab Controlled	
Tons	Speed Range fpm	Total Motor hp	Speed Range fpm	Total Motor hp	Speed in fpm	Total Motor hp	Speed in fpm	Total Motor hp	Speed in fpm	Total Motor hp	Speed in fpm	Total Motor hp
5	80	30	120	2	180	3 to 6	270	6 to 8	180	6 to 8	270-365	8 to 20
7½	55	30	120	2	180	4 to 6	270	6 to 8	180	6 to 8	300-365	10 to 20
10	44	30	120	2	180	4 to 6	270-300	8 to 10	180	8 to 10	300-365	10 to 20
15	39	40	120	3	180	6 to 8	300-365	10 to 15	180	8 to 10	365	15 to 20
20	36	50	120	4	180	6 to 8	365	15 to 20	180	8 to 15	365	20 to 30
25	28	50	120	5	180	8 to 10	365	15 to 20	180	10 to 15	365	20 to 30
30	26	50	120	5	180	10	365	20	180	15	365	20 to 30
35	30	75	120	7½	180	10 to 15	365	20 to 30	180	15 to 20	365	30
40	27	75	120	7½	180	10 to 15	365	30	180	15 to 20	365	30
45	22	75	120	7½					180	10 to 20	270	20 to 30
50	21	75	113	7½					180	15 to 20	270	30 to 40
55	18	75	113	7½					180	15 to 20	270	30 to 40
60	18	75	113	7½					180	15 to 20	270	30 to 40

NOTE: All cranes 45 to 60 ton capacity are box girder construction. Consult Milwaukee for application of wide flanged girders.

DEPENDABLE PARTS AND SERVICE BACKUP

Harnischfeger accepts complete responsibility for the design, fabrication and testing of all structural, mechanical and electrical systems and components of P&H Industrial Duty Cranes. This permits a total commitment to cost-effectiveness and requires comprehensive, worldwide parts and service support — something our customers have come to expect from a company whose basic objectives have been quality and service for over 90 years.

A stock of replacement parts is maintained for shipment from strategically located warehouses — with quality guaranteed to equal or exceed the performance of the original part. In-stock parts are shipped the same day as an order is received.

Our service organization is on-call 24 hours a day including weekends. Service engineers are stationed throughout the country — as close to our customers as his own telephone.

Parts books and service manuals are supplied with each P&H product to give maintenance personnel assistance in the proper care of equipment. In addition, the Harnischfeger Institute provides a modern training facility to keep customer's personnel up-to-date on latest maintenance and operating techniques.

Such undivided responsibility is unique in the industry and assures the P&H customer of continued satisfaction. For assistance in determining your requirements, contact your Harnischfeger District Office. There is one located conveniently near you. See facing page for listings.

	MOTOR HORSEPOWER	
	20T	35T
HOIST	50	75
TROLLEY	4	7½
TURNTABLE	4	7½ (EST)
BRIDGE	20	30
	78*	120
* say	80	120

ASSUME THAT MOTOR H.P. VALUES ARE TYPICAL

continued →

SIGNATURE DBHall DATE 28 May 85 TRB NO. GH-01 PAGE 75

CHECKED BY [illegible] 7-2-85

G.O. or CHARGE NO. _____ PROJECT MKS-2B

SUBJECT SIZING OF CRANE POWER WIRING

cont from p 75

THE FOLLOWING TABLES ARE FROM HANDBOOK OF TABLES FOR APPLIED ENGINEERING SCIENCE, 2ND ED., CRC PRESS:

Table 5-56. FULL-LOAD CURRENT OF ELECTRIC MOTORS

Typical Approximate Values in Amperes at Full Voltage

Motor rating, hp*	Direct-current motors			Single-phase a-c motors		Three-phase a-c motors: Induction				Three-phase a-c motors: Synchronous		
	115v	230v	550v	115v	230v	220v	440v	550v	2300v	220v	440v	2300v
½	4.6	2.3		9.8	4.7	2.0	1.0	0.8				
¾	6.6	3.3	1.4	13.2	5.1	2.8	1.4	1.1				
1	8.6	4.3	1.8	13.0	6.5	3.5	1.8	1.4				
1½	12.6	6.3	2.6	18.4	9.2	5.0	2.5	2.0				
2	16.4	8.2	3.4	24	12	6.5	3.3	2.6				
3	24	12	5.0	34	17	9	4.5	4				
5	40	20	8.3	56	28	15	7.5	6				
7½	58	29	12	80	40	22	11	9				
10	76	38	16	100	50	27	14	11				
15	112	56	23			40	20	16				
20	148	74	31			52	26	21				
25	184	92	38			64	32	26	7.0	54	27	5.4
30	220	110	46			78	39	31	8.5	65	33	6.5
40	292	146	61			104	52	41	10.5	86	43	8
50	360	180	75			125	63	50	13	108	54	10
60	430	215	90			150	75	60	16	129	64	12
75	536	268	111			185	93	74	19	161	81	15
100		355	145			246	123	98	25	211	106	20
125		443	184			310	155	124	31	264	132	25
150		534	220			360	180	144	37		158	30
200		712	295			490	240	195	48		210	40
250						600	300	240	57		266	51
300						716	358	266	69		318	61
350						832	416	333	79		370	71
400						948	474	379	91		422	80
450						1,068	534	427	102		473	91
500							590	472	108		524	100
600							704	563	135		627	120
700							803	656	157		729	140
800							934	747	179		830	159
900							1,046	836	200		932	178
1,000							1,160	927	222		1,034	198

Note: Line currents are approximately the same for squirrel-cage or wound-rotor motors. In either case the values will be higher than above if speed is less than 1,200 rpm; for example, add 5% for 720 rpm and add 25% for 277 rpm.

*For watts multiply by 746.

Table 2-25. AMPERE CAPACITIES—HEAVY COPPER WIRE AND CABLE

Copper size, AWG (or MCM)	AIEE–IPCEA POWER CABLE AMPACITIES* 90°C conductor, 40°C ambient air, and 20°C ambient earth					NATIONAL ELECTRICAL CODE† for buildings 75°C conductor, 30°C ambient	
	Single conductor in air, one cable per support	Underground, direct burial, single-conductor cable	Underground, direct burial, 3-conductor cable	Underground duct: one 3-conductor cable	Underground duct bank: six 3-conductor cables	In free air	In conduit, one to three conductors
8	83	108	83	59	46	65	45
6	109	139	106	78	60	95	65
4	145	180	137	102	77	125	85
2	192	231	178	133	98	170	115
1	223	261	201	154	112	195	130
0	258	297	229	177	127	230	150
00	298	337	260	202	144	265	175
000	345	384	297	231	163	310	200
0000	400	434	335	264	185	360	230
(250)	445	472	367	292	202	405	255
(350)	552	569	442	354	242	505	310
(500)	695	690	531	429	289	620	380
(750)	898	847	648	529	348	785	475
(1,000)	1,076	980	729	599	390	935	545
(1,250)	1,228	1,083				1,065	590
(1,500)	1,367	1,176				1,175	625
(1,750)	1,493	1,257				1,280	650
(2,000)	1,606	1,325				1,385	665

†Maximum capacities depend on insulation.

*From "Power Cable Ampacities", AIEE–IPCEA Publications S-135-1 and P-46-426. Ampere capacities in these five columns are for unshielded conductors for potentials to 3,000 volts, 100 percent load factor. At 75 percent load factor (max 1 hr max 24 hr) the capacities underground are almost 15 percent higher. For higher conductor temperatures or lower ambient temperatures, the ampacities will be higher. For effects of temperature, shielding, voltage, or other cable arrangements, see the above source. At high frequencies the ampacities will be lower than above.

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SIGNATURE 95 VB Hall DATE 28 May 85 TRB NO. GH01 PAGE 76

CHECKED BY Jeff Mitchell 7-2-85

G.O. or CHARGE NO. _____ PROJECT MRS 23

SUBJECT SIZING OF CRANE POWER WIRING

cont from p 76

for the crane motors @ 440V, 3φ AC

	20 T		35 T	
	HP	Amps	HP	Amps
Hoist	50	63	75	93
Trolley	4	7.5	7.5	11
Turntable	4	7.5	7.5	11
Bridge	20	26	30	39
Σ		104.0 Amps		154 Amps

20 T cranes (Cells 1, 2, 3, & 4) at 100 Amps, per NEC for buildings, wire in conduit - can use #2

35 T cranes (Cells 5 & 6) at 155 Amps - same conditions as above - must use #00 - in free air, could use #2 - our installation is between these two - so can probably use #0 - but because of long (~300 ft) run - use #00 to reduce I^2R losses

SIGNATURE SVB Hall DATE 28 May TRB NO. GH-01 PAGE 77

CHECKED BY: J. Mitchell 7-3-85

G.O. or CHARGE NO. SB1239-08-008 PROJECT MRS / 2B

SUBJECT CRANE WIRING

cont from p 77

Table 11-16.
STANDARD GAGES FOR WIRE, SHEET, AND TWIST DRILLS

Dimensions in Approximate Decimals of an Inch

Gage	(1) Mfrs. steel sheet	(2) U.S. steel sheet (old)	(3) Birmingham or Stub	(4) W & M or Roebling steel wire	(5) AWG or B & S non-ferrous wire or sheet	Numbered twist drills	Copper wire (AWG) Circular mils	Ohms 1000 ft. 77 F	Lb/1000 ft	Sheet steel Lb/sq ft
0000000		0.500		0.4900						20.00
000000		0.469		0.4615	0.580					18.75
00000		0.438		0.4305	0.516					17.50
0000		0.406	.454	0.3938	0.460		212.000	0.0500	641.0	16.25
000		0.375	.425	0.3625	0.410		168.000	0.0630	508.0	15
00		0.344	.380	0.3310	0.365		133.000	0.0795	403.0	13.75
0		0.313	.340	0.3065	0.325		106.000	0.100	319.0	12.50
1		0.281	.300	0.2830	0.289	0.2280	83.700	0.126	253.0	11.25
2		0.266	.284	0.2625	0.258	0.2210	66.400	0.159	201.0	10.625
3	.2391	0.250	.259	0.2437	0.229	0.2130	52.600	0.201	159.0	10
4	.2242	0.234	.238	0.2253	0.204	0.2090	41.700	0.253	126.0	9.375
5	.2092	0.219	.220	0.2070	0.182	0.2055	33.100	0.319	100.0	8.75
6	.1943	0.203	.203	0.1920	0.162	0.2040	26.300	0.403	79.5	8.125
7	.1793	0.188	.180	0.1770	0.144	0.2010	20.800	0.508	63.0	7.5
8	.1644	0.172	.165	0.1620	0.128	0.1990	16.500	0.641	50.0	6.875
9	.1495	0.156	.148	0.1483	0.114	0.1960	13.100	0.808	39.6	6.25
10	.1345	0.141	.134	0.1350	0.102	0.1935	10.400	1.02	31.4	5.625
11	.1196	0.125	.120	0.1205	0.0907	0.1910	8.230	1.28	24.9	5
12	.1046	0.109	.109	0.1055	0.0808	0.1890	6.530	1.62	19.8	4.375
13	.0897	0.0937	.095	0.0915	0.0720	0.1850	5.180	2.04	15.7	3.75
14	.0747	0.0781	.083	0.0800	0.0641	0.1820	4.110	2.58	12.4	3.125
15	.0673	0.0703	.072	0.0720	0.0571	0.1800	3.260	3.25	9.86	2.813
16	.0598	0.0625	.065	0.0625	0.0508	0.1770	2.580	4.09	7.82	2.5
17	.0538	0.0562	.058	0.0540	0.0453	0.1730	2.050	5.16	6.20	2.25
18	.0478	0.0500	.049	0.0475	0.0403	0.1695	1.620	6.51	4.92	2
19	.0418	0.0437	.042	0.0410	0.0359	0.1660	1.290	8.21	3.90	1.75
20	.0359	0.0375	.035	0.0348	0.0320	0.1610	1.020	10.4	3.09	1.50
21	.0329	0.0344	.032	0.0318	0.0285	0.1590	810	13.1	2.45	1.375
22	.0299	0.0312	.028	0.0286	0.0253	0.1570	642	16.5	1.94	1.25
23	.0269	0.0281	.025	0.0258	0.0226	0.1540	509	20.8	1.54	1.125
24	.0239	0.0250	.022	0.0230	0.0201	0.1520	404	26.2	1.28	1
25	.0209	0.0219	.020	0.0204	0.0179	0.1495	320	33.0	0.970	0.875
26	.0179	0.0187	.018	0.0181	0.0159	0.1470	254	41.6	0.769	0.75
27	.0164	0.0172	.016	0.0173	0.0142	0.1440	202	52.5	0.610	0.6875
28	.0149	0.0156	.014	0.0162	0.0126	0.1405	160	66.2	0.484	0.625
29	.0135	0.0141	.013	0.0150	0.0113	0.1360	127	83.4	0.384	0.5625
30	.0120	0.0125	.012	0.0140	0.0100	0.1285	101	105	0.304	0.5
31	.0105	0.0109	.010	0.0132	0.0089	0.1200	79.7	133	0.241	0.4375
32	.0097	0.0102	.009	0.0128	0.0080	0.1160	63.2	167	0.191	0.4063
33	.0090	0.0094	.008	0.0118	0.0071	0.1130	50.1	211	0.152	0.375
34	.0082	0.0086	.007	0.0104	0.0063	0.1110	39.8	266	0.120	0.3438
35	.0075	0.0078	.005	0.0095	0.0056	0.1100	31.5	335	0.0954	0.3125
36	.0067	0.0070	.004	0.0090	0.0050	0.1065	25.0	423	0.0757	0.2813
37	.0064	0.0066		0.0085	0.0045	0.1040	19.8	533	0.0600	0.2656
38	.0060	0.0062		0.0080	0.0040	0.1015	15.7	673	0.0476	0.25
39				0.0075	0.0035	0.0995	12.5	848	0.0377	
40				0.0070	0.0031	0.0980	9.9	1070	0.0200	
41				0.0066	0.0028	0.0960				
42				0.0062	0.0025	0.0935				
43				0.0060	0.0022	0.0890				
44				0.0058	.0020	0.0860				
45				0.0055	.0018	0.0820				
46				0.0052	.0016	0.0810				
47				0.0050	.0014	0.0785				
48				0.0045	.0012	0.0760				
49				0.0046	.0011	0.0730				
50				0.0044	.0010	0.0700				

Note: The present trend, especially for sheet and strip, is to quote thickness as decimal or fraction of an inch rather than gage number. ANSI Standard preferred thicknesses have been adopted. These preferred sizes for thickness of uncoated sheet, strip, and plate under 0.25 in. are as follows: .224, .220, .180, .160, .140, .125, .112, .100, .093, .090, .071, .063, .056, .050, .045, .040, .036, .032, .028, .025, .022, .020, .018, .016, .014, .012, .011, .010, .009, .008, .007, .006, .005, .004.

KEY: (1) Manufacturer's standard for hot- and cold-rolled uncoated carbon steel sheet and most alloy steel sheet.
(2) U.S. Standard for cold-rolled steel strip and stainless and nickel alloy sheet.
(3) Birmingham or Stub for hot-rolled carbon and alloy steel strip and tubing.
(4) Washburn and Moen, Roebling, or U.S. Steel for steel wire.
(5) American wire gage or Brown and Sharpe for non-ferrous wire, sheet, and strip.

CRANE WIRING - WGTS

I&C

Par Resolvers

30 @ #16 ea 7.82 #/MFt

CCTV

(Hydra Prod. Spec) 290 #/MFt

Instruments

92 @ #16 ea 7.82 #/MFt

Crane Controls

17 @ #16 ea 7.82 #/MFt

Power

Par Manipulator

36 @ #16 ea 7.82 #/MFt

Crane

4 @ #00 ea 403 #/MFt

I&C Cable Weight: (30+92) 7.82 + 290* = 1244 #/1000 ft

1.25 #/ft + 50% for insulation on #16

1.72 #/ft

POWER: ((17+36) x 7.82 + 4 x 403) 1.5 = 3040 #/1000 ft, or

3.04 #/ft

*INCLUDES INSULATION

SIGNATURE DVB Hall DATE 28 May 85 TRB NO. GH-01 PAGE 78

CHECKED BY: JJ Mitchell 7-3-85

85

G.O. or CHARGE NO. 561239-08-008 PROJECT MRS/2B Process Cranes

SUBJECT DRUM DECON CELL CRANES

CELL SIZE: 13' x 30' (approx)

ALREADY INCLUDED IN CELL - 5 T JIB CRANE FOR MOVING DRUMS FROM DELIVERY CHUTE TO SHREDDER CARTS

NEEDED IN CELL - HANDLING CAPABILITY FOR DRUMS:

- SHREDDER CART TO DECON TANK - (~800#)
- DECON TANK TO TRANSFER PALLET/CART (~800#)

- GENERAL MAINTENENCE:
  - LIFTS - (UP TO 2000# - CELL EQUIPMENT)
  - CELL EQUIPMENT REMOVAL & INSTALLATION

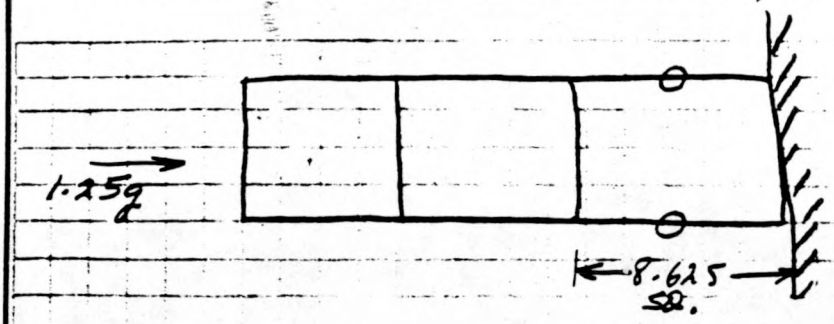
For all items except the last one above, a crane would be applicable. Small (< 5T) bridge cranes are not economical according to crane vendors. Therefore a wall-mounted manipulator with a 1½ TON shoulder hook will be supplied. This will be very similar to the units in cells 1 thru 4, except that a lock-lock mechanism will replace the hook - so that handling of drums by a rigid grapple is possible. To assist in holding/moving during maintenance operations a traveling jib crane (hoist powered only) will be mounted on wall opposite the P&R manipulator - this crane will be positioned by the manipulator.

SIGNATURE JVB Hall DATE 4 June 85 TRB NO. GH-01 PAGE 79

CHECKED BY Jeff McKee 7-2-85

G.O. or CHARGE NO. SB123907001 PROJECT MRS

SUBJECT IN-PROCESS LAG STORAGE, MODIFIED DESIGN



—o— these are the two critical columns

A column is one side of the square tube.

Force on a column = $F = mg \times 1.25$

Assume column width = 0.1094 (12 gauge)

wt. / sq. ft. of 12 gauge sheet of 30455 = 4.595 lbs/ft²

area of sheet for above column = 8.625 × 144

↳ ~~12 feet length~~

$= \frac{1242}{12 \times 12} = 8.625 \text{ ft}^2$

wt. of column = 8.625 × 4.595 = 39.63 lbs.

mass of column $= \frac{39.63}{32.2} \frac{\text{lbs-sec}^2}{\text{ft}} = 1.23 \frac{\text{lb-sec}^2}{\text{ft}}$

$\therefore F = 1.23 \frac{\text{lb-sec}^2}{\text{ft}} \times 32.2 \frac{\text{ft}}{\text{sec}^2} \times 1.25$

$\therefore F = 49.54$ lbs

Assume column made of 14 gauge material (thickness = 0.0751)

$K = \frac{h\sqrt{3}}{6}$; $h = 0.0751$

$\therefore K = 0.022$

SIGNATURE [illegible] DATE 1/30/85 TRB NO. MB-01 PAGE 37

Checked by SVB Hall

G.O. or CHARGE NO. SB123907001 PROJECT MRS

SUBJECT IN-PROCESS LAG STORAGE, MODIFIED DESIGN

$$\frac{L}{k} = \frac{8.625}{0.022} = 398$$

$$F_{CR} \text{ (Euler's formula)} = \frac{0.25 \times \pi^2 \times 30 \times 10^6 \times 0.0751 \times 144}{(L/k)^2}$$

$$\therefore \boxed{F_{CR} = 5058 \text{ lbs.}}$$

Thus, 14 gauge material can withstand far more than what the column is actually subjected to. Therefore, use 14 gauge to build tubes. $\left[FOS = \frac{5058}{49.54} = 102 \right]$

Use 19ga. sheets ; two 19ga. sheets = 0.084 in. thick $\approx$ 14ga

[14ga is 0.0751 thick]

See p. 53 for loaded module analyses.

Estimated weight of one PWR crate (Dwg. H-3-54937*)

area of 1 face of 1 tube = $\frac{8.625 \times 144}{12 \times 12}$ = 8.625 ft^2 [assuming length = 144 and not 145]

wt. of 1 face of 1 tube = 8.625 ft^2 × 1.764 = 15 lbs. (1.764 → wt. of 1 ft^2 of 19ga. sheet.)

Wt. of 4 faces of 1 tube = 15 × 4 = 61 lbs. [using the decimals following 15]

∴ Wt. of 9 tubes = 61 × 9 = 549 lbs.

Wt. of bottom plate = 28 × 28 × 0.5 × 0.284 = 111 lbs.

Wt. of four side Ls = 3.19 × 12 × 4 = 152 lbs.

Wt. of four top Ls = 3.19 × 4 × $\frac{28}{12}$ = 30 lbs.

(each angle is $\angle 2 \times 2 \times \frac{1}{4}$] wts. from Pearson Catalog

Total = 842 lbs. ≈ 850 lbs

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checked by [illegible]

G.O. or CHARGE NO. SB123907001 PROJECT MRS

SUBJECT IN-Process Lag Storage, Modified Design

Estimated Weight of one BWR Crate

area of 1 face of tube = 150×6.75

total area of a tube = $4 \times 150 \times 6.75$

Wt. of 1 ft^2 of 19 Ga. sheet = 1.764 lbs.

$\therefore$ Wt. of 1 tube = $\frac{4 \times 150 \times 6.75 \times 1.764}{144}$

$\therefore$ Wt. of 16 tubes = $\frac{16 \times 4 \times 150 \times 6.75 \times 1.764}{144}$ = 794 lbs.

Wt. of bottom plate = $28 \times 28 \times 0.5 \times 0.284$ = 111 lbs.

Wt. of four side L^s = $3.19 \times \frac{150}{12} \times 4$ = 160 lbs.

Wt. of four top L^s = $3.19 \times 4 \times \frac{28}{12}$ = 30 lbs.

These wts. are for $L\,2 \times 2 \times \frac{1}{4}$ from Ryerson catalog.

Total wt. = 1095 lbs.

$\approx$ $\boxed{1100 \text{ lbs.}}$

Loaded weight of a PWR crate = $850 + (1707 \times 9)$ = 16,213 lbs.

(This assumes that each PWR assembly in the crate is the Westinghouse Electric 14x14; see Fig. 2 on p. 18 of the Spent fuel Consolidation Optimization study. WE 14x14 is of max. wt. in above figure.)

Loaded weight of a BWR crate = $1100 + (16 \times 638)$ = 11,308 lbs.

(This assumes that each BWR assembly is the Exxon 8x8, the longest and most heavy assembly in Figure 1 on p. 17 of above report. Weight obtained from "Domestic LWR Fuel Design Evolution, Vol. III, Sept. 1981, Nuclear Assurance Corp.", Table-6-2, p. 6-4.

(Turn to page 42)

SIGNATURE MSAli DATE 11Feb85 TRB NO. MB-01 PAGE 39

checked by MJB Hall

G.O. or CHARGE NO. SB123908n010 PROJECT MRS

SUBJECT In-Process Log Storage

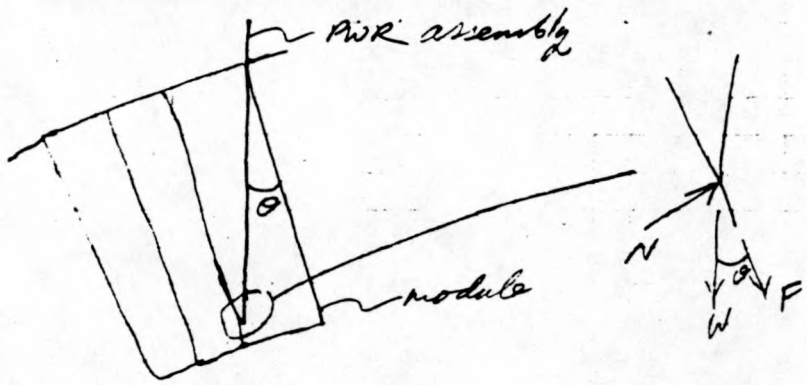
MODULE LIFTING ANALYSIS

The preceding analysis analyzed the possibility of lifting a module during a gravity off-normal condition. This analysis is another approach.

If, for some reason, the module is standing askewed binding the assembly, then will the assembly slide out of the module when pulled out by the crane?

Assume again that the module cell inner walls are smooth and offer no ledge or other protrusion that can prevent the assembly from sliding out.

The worst case for the possibility of lifting the module is when the module is completely empty except for one assembly in a cell along one edge of the module, not in the center. Assume that the assembly is attached to the crane when the module tilts over as much as the assembly will allow.



Assume a PWR assembly and module. Assume PWR assembly has minimum X-section, as of Exxon CE 14x14. [see p. 18 of consolidation report]

Assembly X-section = 8.11 in. square

Assembly weight = 588 kg × 2.2 = 1294 lbs.

$F = 0.42\,N = 0.42\,W\sin\theta$

[0.42 = coeff. of friction from Marks' Handbook for Mech. Engrs., p3-26, hard steel on hard steel, dry]

Maximum offset of assembly in cell = cell width − assembly width

= 9 − 8.11 = 0.89

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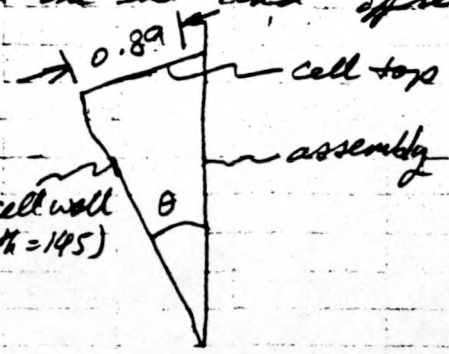
checked by [illegible] for V. S. Hall

G.O. or CHARGE NO. SB1239 08 #010 PROJECT MRS

SUBJECT IN-PROCESS CAG STORAGE

Assume that the module tilts such that the assembly contacts the bottom at one end and offsets the max. at other end.



Cell depth = 145. Then $\theta = \tan^{-1}\left(\frac{0.89}{145}\right) = 0.35°$

W = weight of module = 850 lbs.

$\therefore F = 0.42 \times 850 \times \sin 0.35 = 2.18$ lbs.

[For info. – even if μ is 1.0, very conservative, then F = 5.19#]

For the assembly to slide out of tilted module, the above frictional force should be less than the weight component of the module = $W\cos\theta$.

$W\cos\theta = 850 \times \cos 0.35 = 849.98$ lbs.

$\therefore$ the frictional force is far less than the force component due to the weight of the module. Therefore, the module cannot be lifted by the assembly even in the worst case scenario.

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Checked by
J.V. Hall

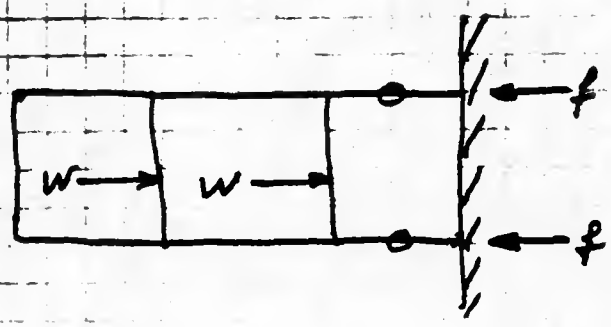
G.O. or CHARGE NO. SB12390801D PROJECT MRS

SUBJECT IN-PROCESS LAG STORAGE MODULE DESIGN

~~If the module is loaded, then~~

Note: Lag Storage redesign required by upgraded MRS throughput rates specified in FDC, Rev 3, March 1985 (MRS-3-85)

For the loaded module (see drg. H-3-56880 for module design):



W = weight of one PWR (PWR wt. > BWR wt.) = 1707 #

Euler's relation = $P = \dfrac{C\pi^2 EA}{(L/r)^2}$ [Formulas for Stress & Strain, 5th Ed., Roark and Young].

$C = 1$ (for round ends)

$E = 29 \times 10^6$ lbs/in^2

A = area of X-section = 0.042 × 144

→ module height

→ thickness of 19 ga. sheet metal (Rycom cabling)

$r = \dfrac{t\sqrt{3}}{6} = \dfrac{0.042 \times \sqrt{3}}{6}$

$= 0.0121$

L = length of column = ~~8.625~~ 9.0 (see drg. H-3-56880, Sh. 3)

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checked by JS VB Hall

G.O. or CHARGE NO. SB123908010 PROJECT MRS

SUBJECT In-process Keg Storage Module Design.

$$\cancel{\therefore P = \frac{\pi^2 \times 29\times10^6 \times 0.042 \times 144}{\left(\frac{9/0}{0.121}\right)^2}}$$

$$\therefore P = \frac{\pi^2 \times 29\times10^6 \times 0.042 \times 144}{(9/0.121)^2} = 3141.53 \text{ lbs.}$$

wt. of 1PWR crate.

$$f = \left(\frac{2W}{2} + \frac{850}{6}\right) 1.25 = \left(1707 + \frac{850}{6}\right) \times 1.25 = 2311 \#$$

$$\text{Factor of Safety} = \frac{3141.53}{2311} = 1.36$$

$\therefore$ 19 ga. sheet is ~~given~~ safe to use for the modules.

*

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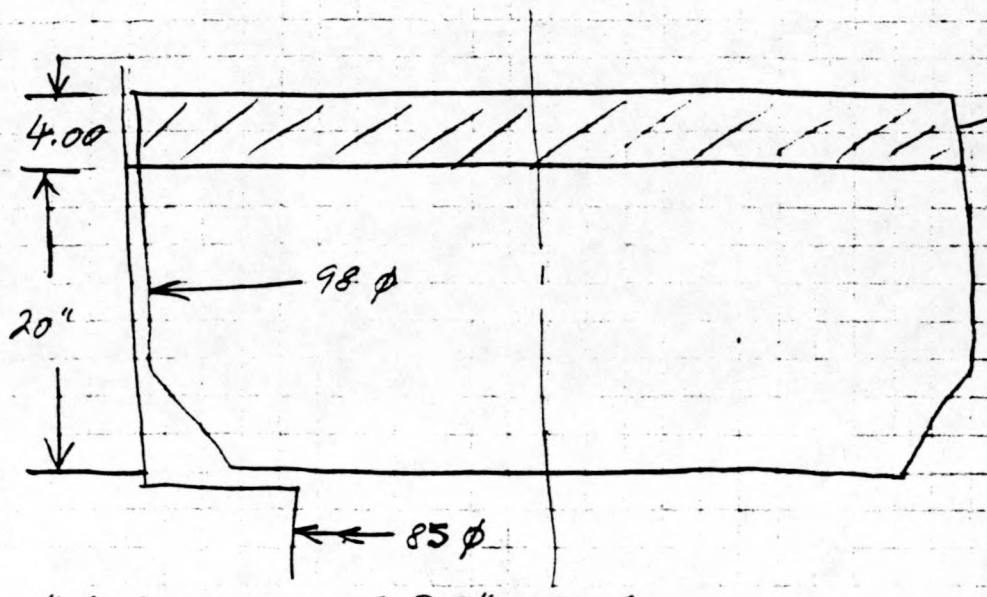
Checked by J V B Hall

G.O. or CHARGE NO. 581239-08 or 010 PROJECT MRS (MODIFIED)

SUBJECT CANYON CELL REPOSITORY / PORT PLUG

CANYON CELL REPOSITORY OVERPACK PORT PLUG

The crane capacity available in this cell is 35T. Can the plug thus be a single piece plug?
Assume plug is all of steel and BISCO NS-3. (as in dwg. 4-3-54932)



1" of Concrete = 0.303" of Steel

then to replace 60" thick concrete, we need 6 × 0.303 = 18" of steel.

Say 20".

Sp. wt. of steel = 0.284 lbs./in³.

Plug dia = 98"

∴ Steel wt. = $\frac{\pi}{4} \times 98^2 \times 20 \times 0.284$ = 42,844 lbs.
× 0.0005
= 21.422

Sp. wt. of Bisco NS-3 = 0.064 lbs./in³. [from BISCO Products, Inc., Park Ridge, Illinois]

Bisco wt. = $\frac{\pi}{4} \times 98^2 \times 4 \times 0.064 \times 0.0005$ = 1 T

Angle around Bisco = $\angle 4 \times 3 \times \frac{1}{4} = \pi \times \frac{98}{12} \times 5.8 \times 0.0005$ = 0.01 T
(from Ryerson catalog)

Total = 22.5 T

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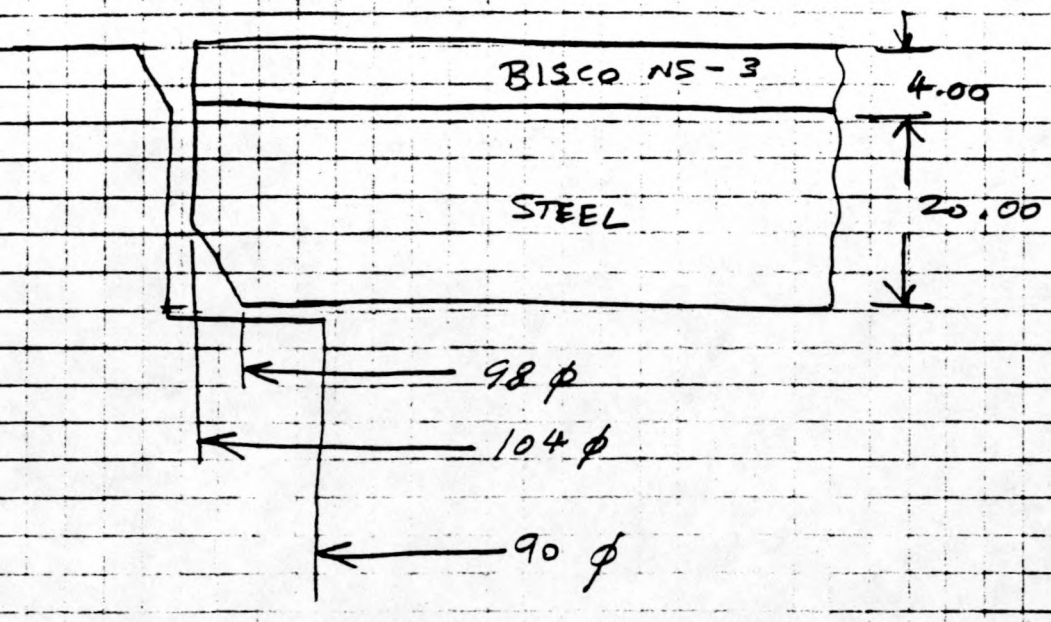
S.V.B. Hall

G.O. or CHARGE NO. SB 123508 or 010 PROJECT NRS (modified)

SUBJECT CANYON CELL REPOSITORY PORT PLUG



For the above geometry, the weight picture will be:

Steel Casting $= \frac{\pi}{4} \times 104^2 \times 20 \times 0.284 \times 0.0005 = 24\ T$

BISCO $= \frac{\pi}{4} \times 104^2 \times 4 \times 0.064 \times 0.0005 = 1\ T$

$L\,4 \times 3 \times \frac{1}{4} = \pi \times \frac{104}{12} \times 5.8 \times 0.0005 = 0.08\ T$

Total $= 25.29\ T$

This is well within the 35T crane capacity.

SIGNATURE [illegible] DATE 5/22/85 TRB NO. MB-01 PAGE 49

Checked by [illegible] Hall

G.O. or CHARGE NO. SB123908010 PROJECT MRS (INTEGRATED)

SUBJECT Repository OVERPACK WELDING SHELL WEIGHT

See Drawing SK-MH-003, Sh. 2.

Weights ↓ Tons

Shell top = $\frac{\pi}{4} \times 94^2 \times 1 \times 0.284 \times 0.0005$ = 0.99

Shell sides = $\frac{\pi}{4} \times [89^2 - 88^2] \times 41 \times 0.284 \times 0.0005$ = 0.81

scaled off

Shell bottom = $\frac{\pi}{4} \times [89^2 - 50^2] \times 0.5 \times 0.284 \times 0.0005$ = 0.30

Gear angle $[9 \times 4 \times \frac{1}{2}]$ = $\frac{\pi \times 88}{12} \times 21.3 \times 0.0005$ = 0.25

→ Ryerson catalog p. 15

Gear = $\frac{\pi}{4} [90^2 - 66^2] \times 3 \times 0.284 \times 0.0005$ = 1.25

scaled off

Gear motor + reducer (1/2 hp.) approx. 200×0.0005 = 0.10

Electron gun wt. = $1500 \times .0005$ = 0.75

Counter wt. = 1500×0.0005 = 0.75

Gun motors wts (1/4 hp) = $[200 \times 0.0005] \times 2$ = 0.20

Gun platform = $\frac{\pi}{4} \times 78^2 \times 0.5 \times 0.284 \times 0.0005$ = 0.34

scaled

Neglect stabilizing rod

Shell neck (w/o seal) = $\frac{\pi}{4} [55^2 - 50^2] \times 8.25 \times 0.284 \times 0.0005$ = 0.48

Scaled

Actuator wt. (from Duff Norton) = 140×0.0005 = 0.07

6.297

SIGNATURE MJSchi DATE 6/14/85 TRB NO. MB-01 PAGE 51

checked by JBHall

G.O. or CHARGE NO. SB123908010 PROJECT MRS (INTEGRATED)

SUBJECT Repository OVERPACK WELDING SHELL WEIGT

6.29 T = 12,575 lbs. ≈ 13,000 lbs.

∴ Jib Crane Capacity = 15,000 lbs.

Jactuator capacity = [6.29 − 0.07] × 1/0.0005 = 12,440 lbs.

↳ Jactuator wt.

→ For welding shell

For Decon shell ↓

		Tons
Shell top = $\frac{\pi}{4} \times 60^2 \times 0.625 \times 0.284 \times 0.0005$	=	0.25
Shell side = $\frac{\pi}{4}[60^2 - 59^2] \times 35.5 \times 0.284 \times 0.0005$ (↳ scaled)	=	0.47
Approx. nozzle and piping wt. = 500 × 0.0005	=	0.25
Neglect stabilizing rod		
		0.97 T
Jactuator wt. (same as welding) = 140 × 0.0005	=	0.07
		1.04 T

1.04 T = 2080 lbs.

Jib Crane Capacity (Suggested) = 4,000 lbs.

Jactuator Capacity = [1.04 − 0.07] × 1/0.0005 = 1940 lbs.

∴

			Actuals (lbs.)
Welding Crane Capacity	=	15,000 lbs. (7.5T)	12,575
Welding Jack Capacity	=	13,000 lbs. (6.5T)	12,440
Decon Crane Capacity	=	4,000 lbs (2T)	2080
Decon Jack Capacity	=	4,000 lbs. (2T)	1940

SIGNATURE [illegible] DATE 6/14/85 TRB NO. MB-01 PAGE 52

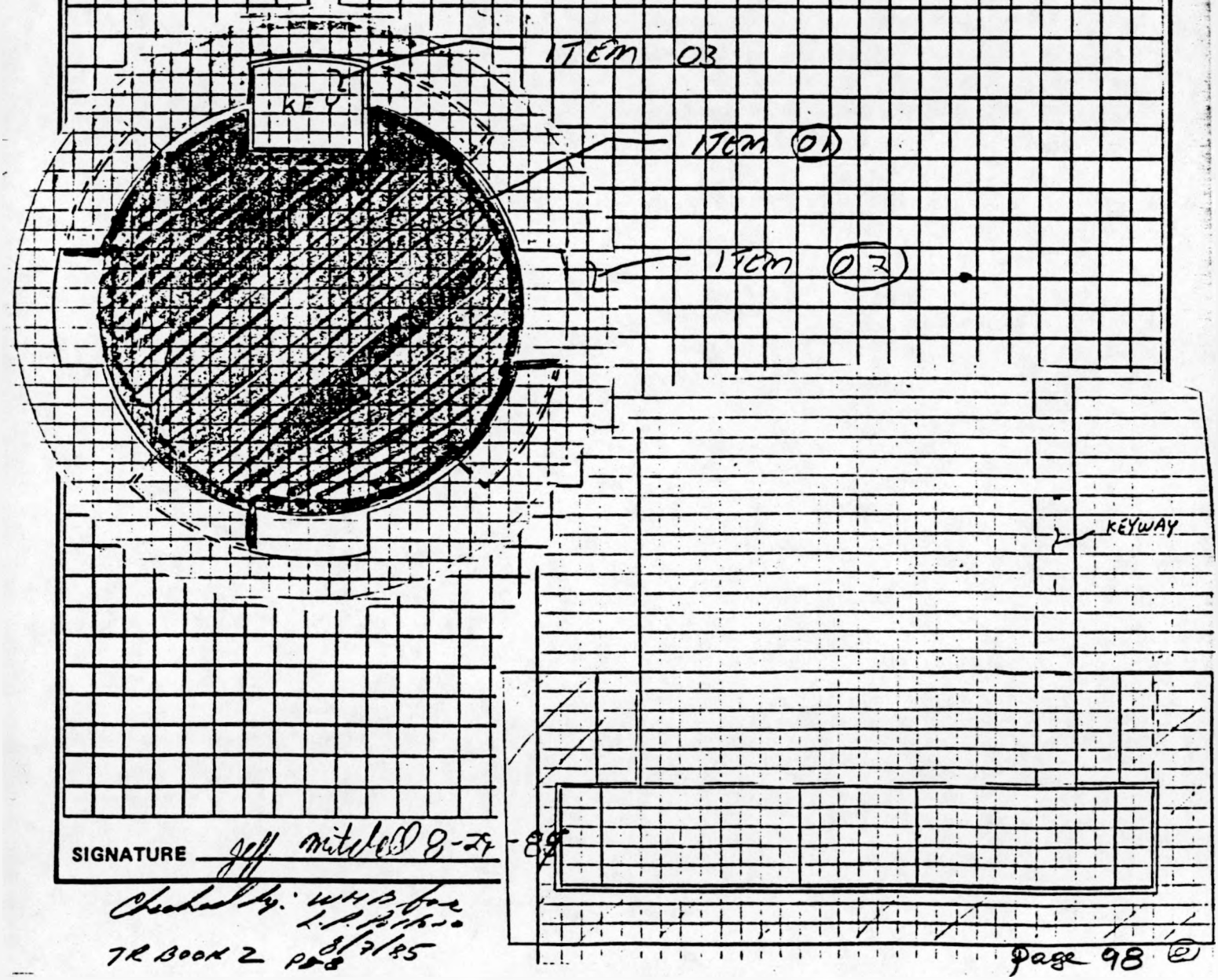
checked by George W B Hall

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT HOT CELL CRANE GRAPPLE ATTACHMENT

TO: R. WATTS
L. POLONO
D. UNTERZUBER
M. BACI
D. DERMASTRO
G. HALL
F. FRATANGELO
E. LAMEN
B. BUSSEC

FOLLOWING IS THE PROPOSED GRAPPLE ATTACHMENT TO THE CRANE. PLEASE REVIEW & PROVIDE ANY COMMENTS OR SUGGESTIONS YOU HAVE.



SIGNATURE Jeff Mitchell 8-27-85

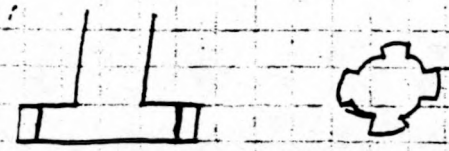
Checked by: WHB for L.P. Polono 8/27/85

TR BOOK 2 PG 8

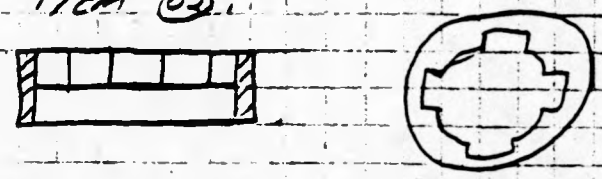
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

THE BASIC CONCEPT IS A BAYONET CONNECTION. ATTACHED TO THE END OF THE CRANE IS THE MALE PORTION OF THE FITTING ITEM 01:



THE GRAPPLE SECTION CONTAINS THE MATING FEMALE MEMBER ITEM 02:

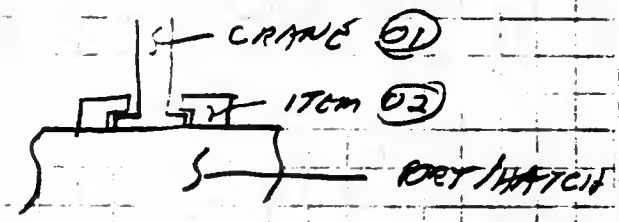


CONNECTION IS MADE BY INSERTING ITEM 01 INTO 02 AND ROTATING. A KEY 03 IS THEN INSERTED TO PREVENT SEPARATION. KEY INSTALLATION IS ACCOMPLISHED BY USING EITHER THE CRANE PAR MANIPULATOR, OR A MASTER-SLAVE UNIT ON THE WALL.

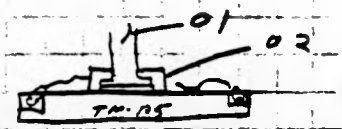
THE MECHANICAL KEY ALSO DOUBLES AS AN ELECTRICAL CONNECTOR FOR GETTING POWER INTO THE GRAPPLE IF NEEDED.

RECOMMENDED ARRANGEMENTS:

1. INLET PORTS
2. OUTLET PORTS
3. CIRCULAR MAINT. HATCH(S)
4. LAG STORAGE HATCH(S)
5. SHIELD PLUG OF CONCRETE CASK



6. TRANS CASK LID



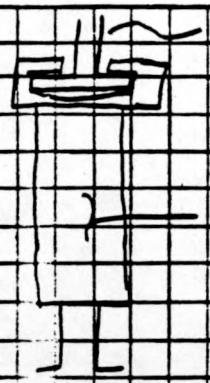
SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 99

Checked by: W. H. Blumer for L. P. Pedone 8/7/85

G.O. or CHARGE NO. _____ PROJECT _____

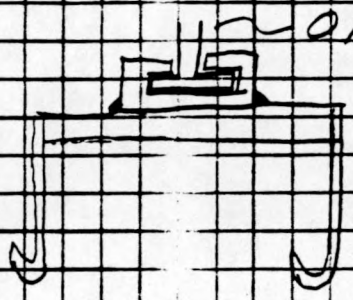
SUBJECT _____

7. FUEL ASSY



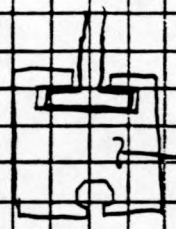
FUEL ASSY GRAPPLE WITH ITEM 02 ATTACHED

8. CONSOLIDATION EQUIPMENT



YOKE W/ITEM 02 ATTACHED

9. CANISTERS



GRAPPLE FOR PINTLE W/02

etc.

SO EVERYBODY HAS THE SAME SCALE THE FOLLOWING DIMENSIONS ARE GIVEN.

HOWEVER BECAUSE THIS IS JUST A CONCEPT I WOULD NOT PUT THE ACTUAL DIMENSIONS ON THE PART.

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE ~~10~~

Checked by: [illegible] for L. P. Fuller 8/7/85

p. 100

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

SHAFT DIA $\sigma = \frac{F}{A}$

FORCE = 20 TON = 40,000 lbs
SAFETY FACTOR of 5 (5)(40,000) = 200,000 lbs

ALLOWABLE STRESS (USE YIELD of A-36 ≈ 36,000)

CONSERVATIVE AS F.S. of 5 IS TO TENSILE

$$36{,}000 = \frac{200{,}000}{A} \qquad A = 5.5 \text{ in}^2 = \frac{\pi}{4} d^2$$

$$d = 2.07''$$

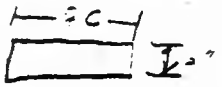
ANY THING OVER 2" IS O.K.

TABS 

SHEAR $\tau_{ALL} = (\frac{1}{2})(36{,}000) = 18{,}000$

$\tau = F/A \qquad 18{,}000 = 200{,}000/A$

$A = 11.1 \text{ in}^2$



TOTAL LENGTH FOR 2" TAB

$A = 11.1 = (2)(L)$
$L = 5.55$

ASSUME 2 TABS TAKE LOAD EACH TAB LENGTH MUST BE 5.55/2 = 2.7" LONG

TOTAL $C = (2.7)(8) = 21.6''$

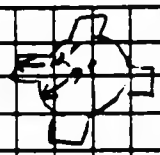
$$d = \frac{C}{\pi} = \frac{21.6}{\pi} = 6.8''$$

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 4

Checked by: W. H. Blanchard for L. P. Pollard 7/8/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____



TAB TENSILE AREA ? > 3.5"

1.5" (ASSUME 1" ENGAGED

ℓ

$C = \pi d = (\pi)(9) = 28.2$

$\ell = 28.2/8 = 3.53"$

ASSUME 3" ENGAGED & 2 TABS IN TENSION

$(3)(1)(2) = 6"$ ∴ O.K.

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. _____ PAGE 12

Checked by: W. M. Blumer for R. P. Pellerin 7/8/85

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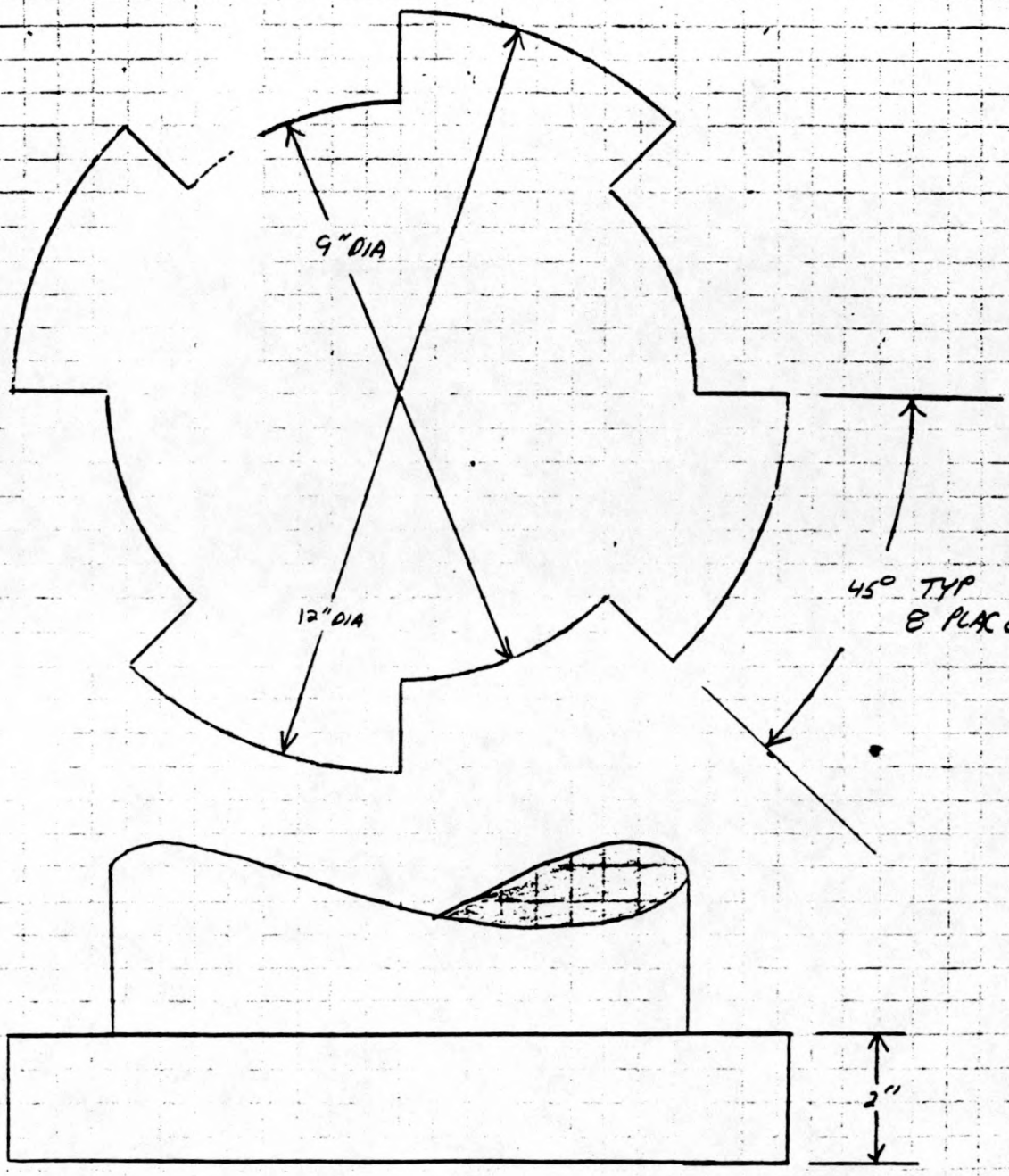
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

SCALE $\frac{3}{8}'' = 1''$



ITEM 01

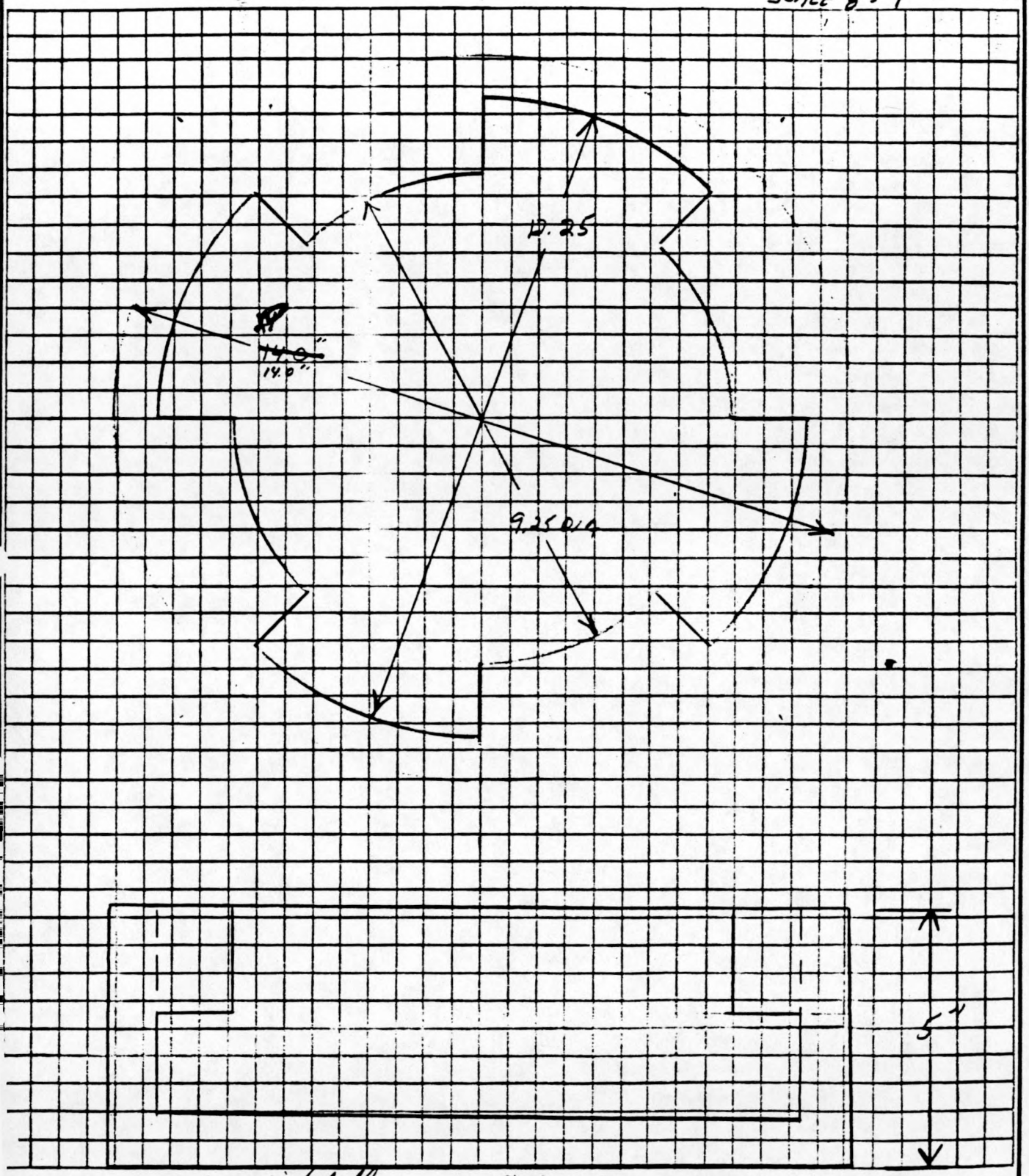
SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 15

Checked by: W. H. Blanchard for
L. P. Poulos
7/8/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

SCALE 1/8 = 1"



SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 14

Checked by: WMB for L. P. Pollard 7/8/85

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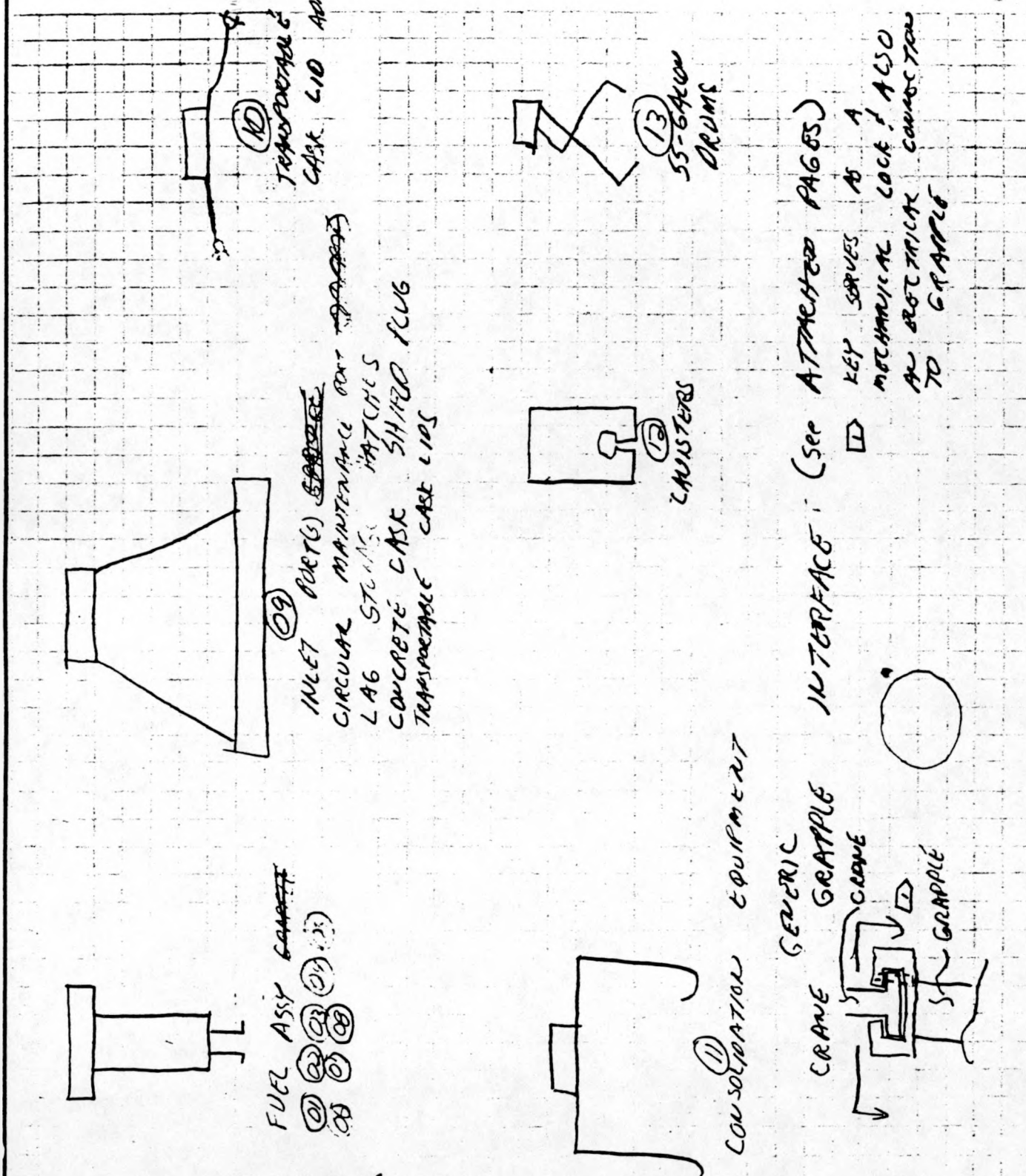
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT GRAPPLE LAYOUT



SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 45.

Checked by: W. H. Rehner for L. P. Pedone 7/18/85

p. 105

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

ITEM		GRAPPLE USE			1A 1B	CELL 2A 2B	3A 3B	MAINT BAY	CASK RECEIVING BAY	NOTES
01	(W)	12x12	PWR	F/A	X		X			
02	(W)	15x15	PWR	F/A	X					
03	(W)	14x14	PWR	F/A	X					
04	BWR	15x15	BWR	F/A	X					
05	CE	16x16	BWR	F/A	X					
06	CE	15x15	BWR	F/A				X		
07	CE	14x14	BWR	F/A	X					
08	GE	BWR F/A				X	X			
09	MISC PARTS				X X	X X	X X			
10	TRANSPORTABLE CAN LIDS								X	D
11	CONSOLIDATION EQUIPMENT				X	X	X			
12	CANISTERS (PINTLE)				X	X	X			
13	55-GALLON DRUM						X X			

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 16

Checked by: W. H. Blanchard for L. P. Pedone 9/18/85

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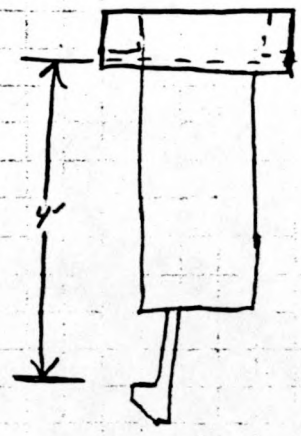
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

ITEM 01 → 08 SHOW DAMS DRAWING



(09) SEE PAGE 9

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 17

Checked by: W.H. Blanton for L.P. Pollard 7/8/85

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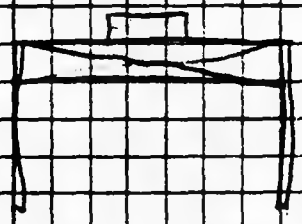
G.O. or CHARGE NO. / PROJECT

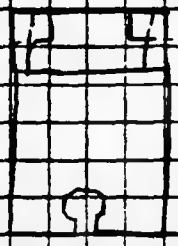
SUBJECT

ITEM (10)

ITEM (11) SEE ATTACHED H-3-54918 AND ADD ON FEMALE ADAPTER L.P.



ITEM (12)



← MATCH WITH DRAWER CANISTER

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 18

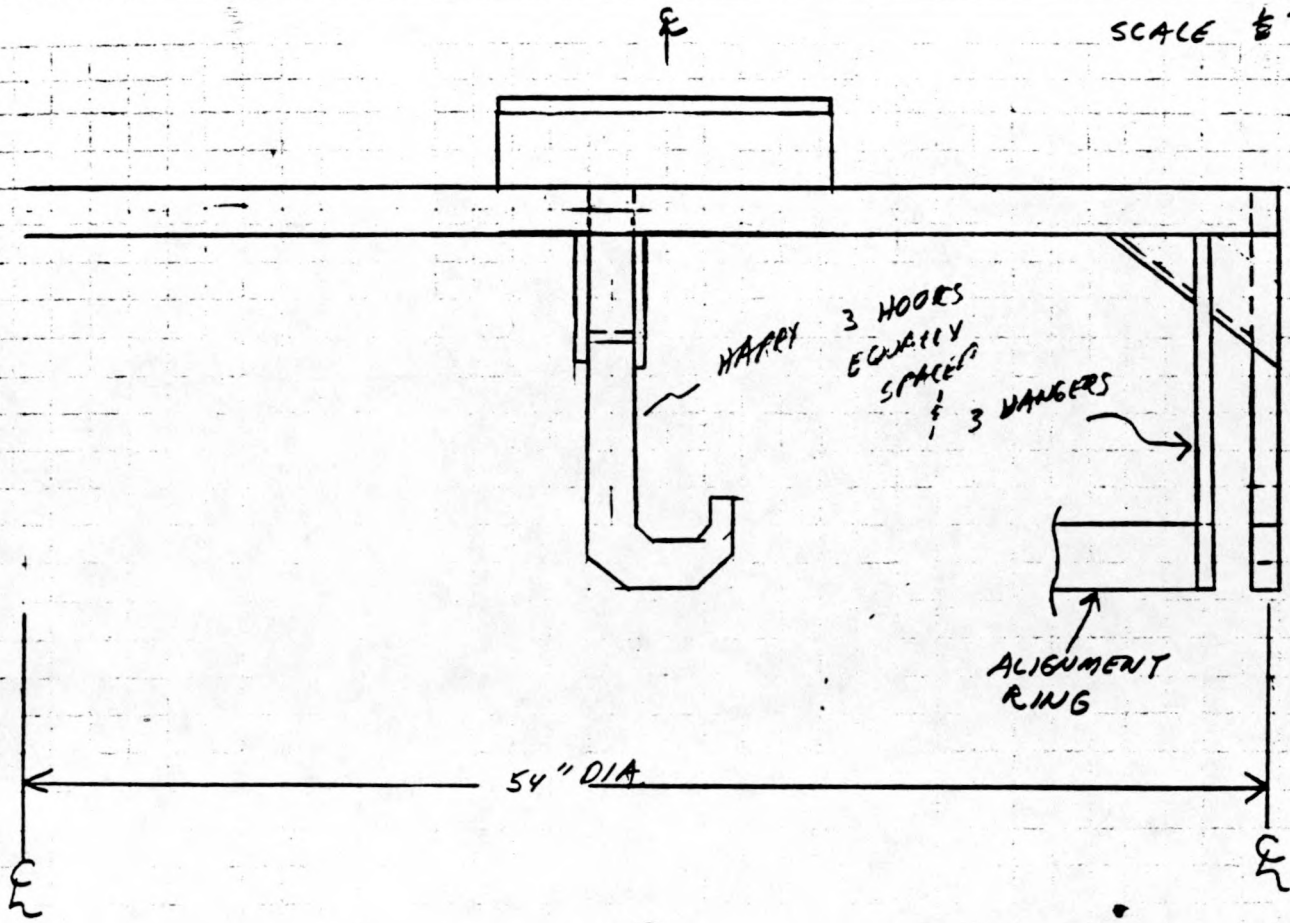
p. 108

Checked by: W. N. Blair for L. P. Pollard 8/8/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

SCALE 1/8" = 1'



ITEM 09

MAY NEED OR WANT TO GIVE A PLAN VIEW W/ A CUTAWAY

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 15

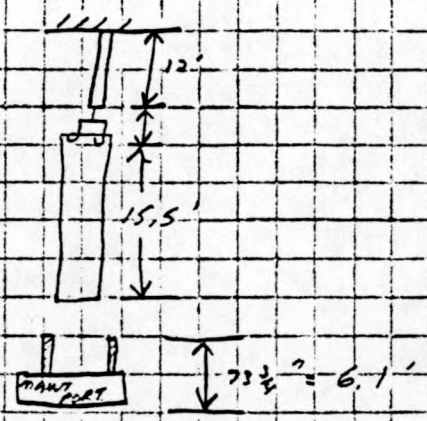
Checked by: W.H. Shaw for L.P. Sellers 7/18/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT MODULE STORAGE RACKS

~ 4 RACKS/CELL → = # IN ALL THREE
- DOUBLE FOR MOST PREDOMINANT FUELS
- SINGLE MODULE FOR ODBALL MODULE

- LENGTH 186" + 5" = 191" = 15.9'

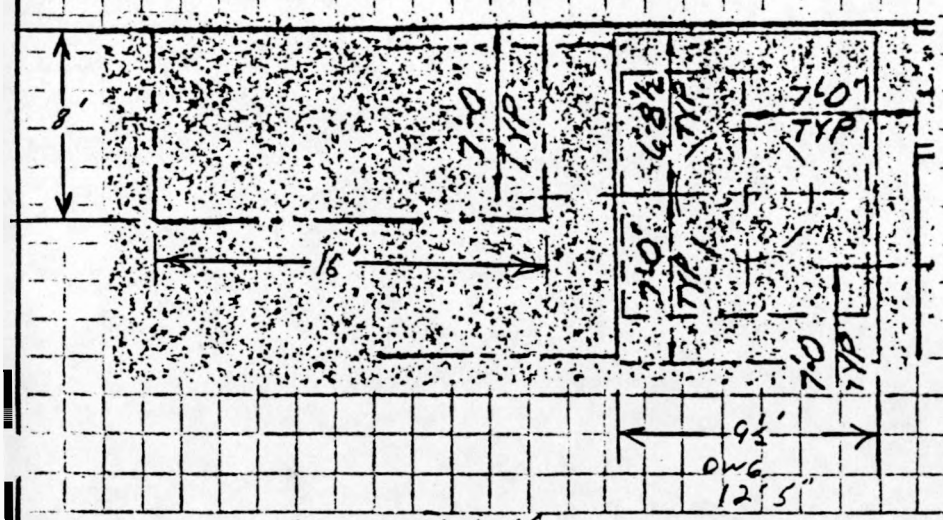


12
15.5
6.1
33.6' PLUS YOKE & CLEARANCE WHICH IS TO HIGH.

ASSUME 4' YOKE
PLUS 1' CLEARANCE

35
- 12
- 15.5
- 5
= 2.5'

NEED @ LEAST 5' 6" FOR PLUG ALONE ∴ HAVE TO AVOID (PLAN) MAINT HATCH



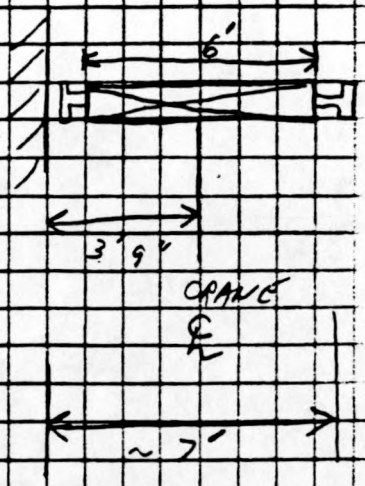
SIGNATURE Jeff Mitchell DATE 8-29 TRB NO. 2 PAGE 3

Checked by: W.H.B. for L.P. Pollono 8/7/85

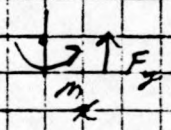
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

• NEED TO SUPPORT FROM FLOOR RATHER THAN WALL ?



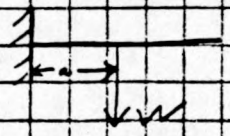
REACTIONS @ O



$F_y = 10,000$ lb

$M_x = (9)(5000) + (84)(5000)$

$M_x = 465,000$ in. lb



$a = 46.5"$

$W = 10,000$ lb

$\sigma = \frac{Mc}{I}$ $\sigma = \frac{M}{S_x}$

$M_x = 465,000$ in lb

$= 38,750$

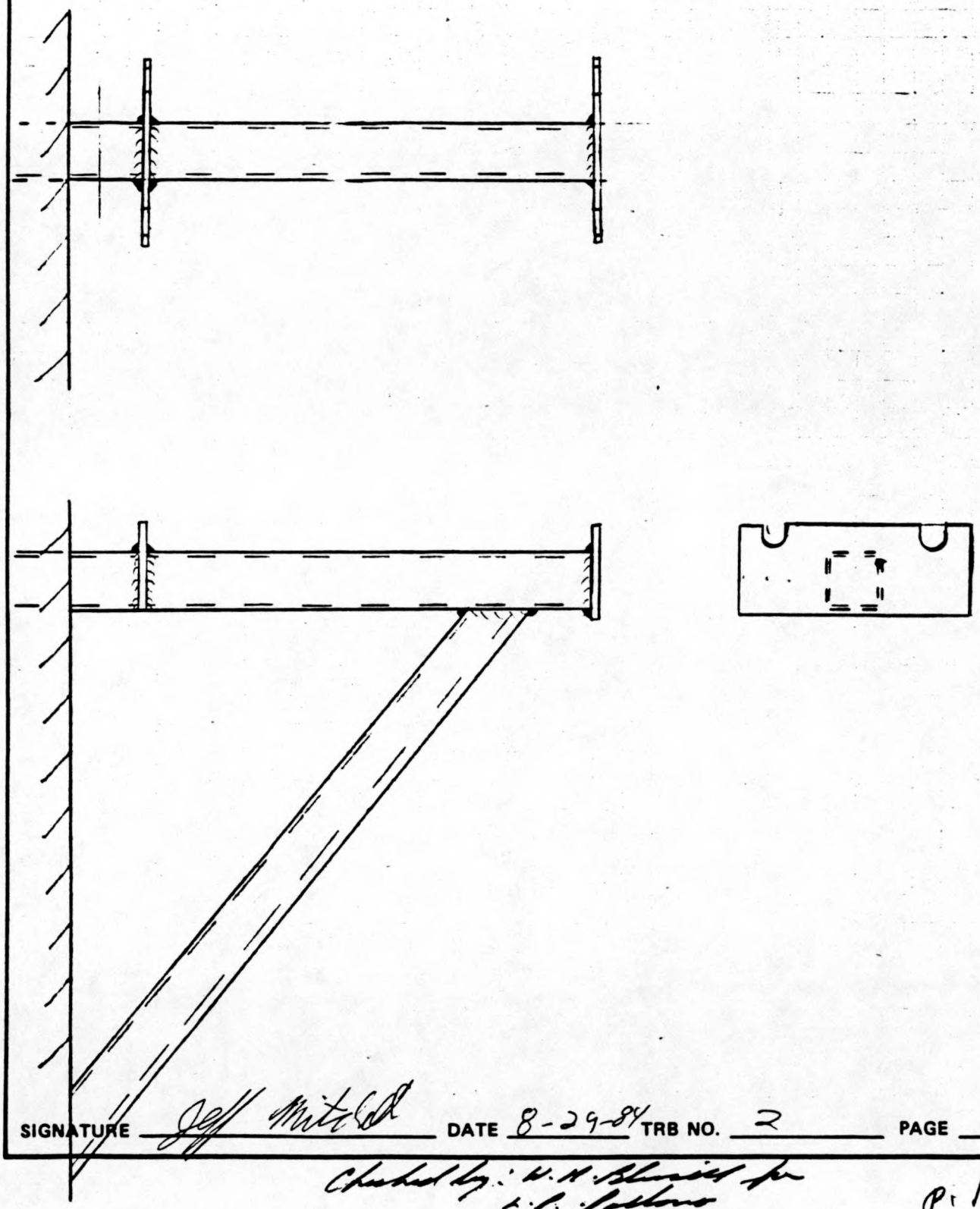
SIGNATURE Jeff Mitchell DATE 8-29-81 TRB NO. 2 PAGE 4

Checked by: W H Blanchard for L. P. Pelton 7/8/85 Page 111

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT CONCEPTUAL LAYOUT OF STORAGE RACK

SCALE ½" = 1'



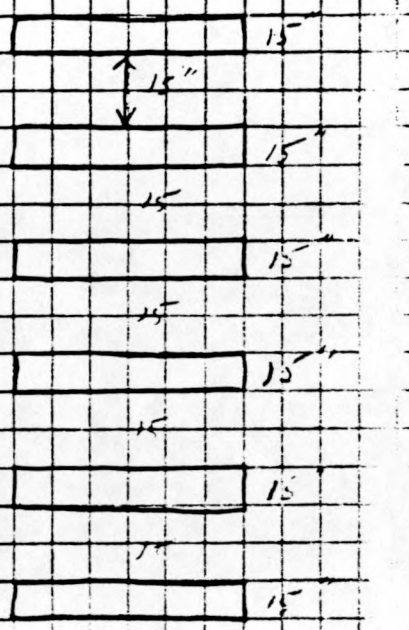
SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 5

Checked by: W. N. Blevins for L. P. Sobers 7/18/85

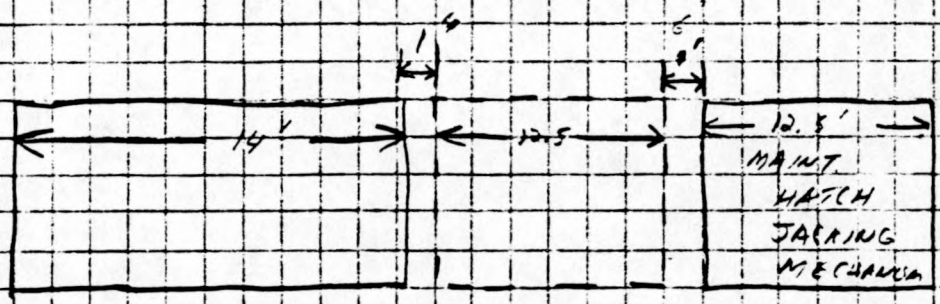
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

THREE DUAL RACKS → SPACE ENVELOPE



(15)(11) = 165' = 13.75'

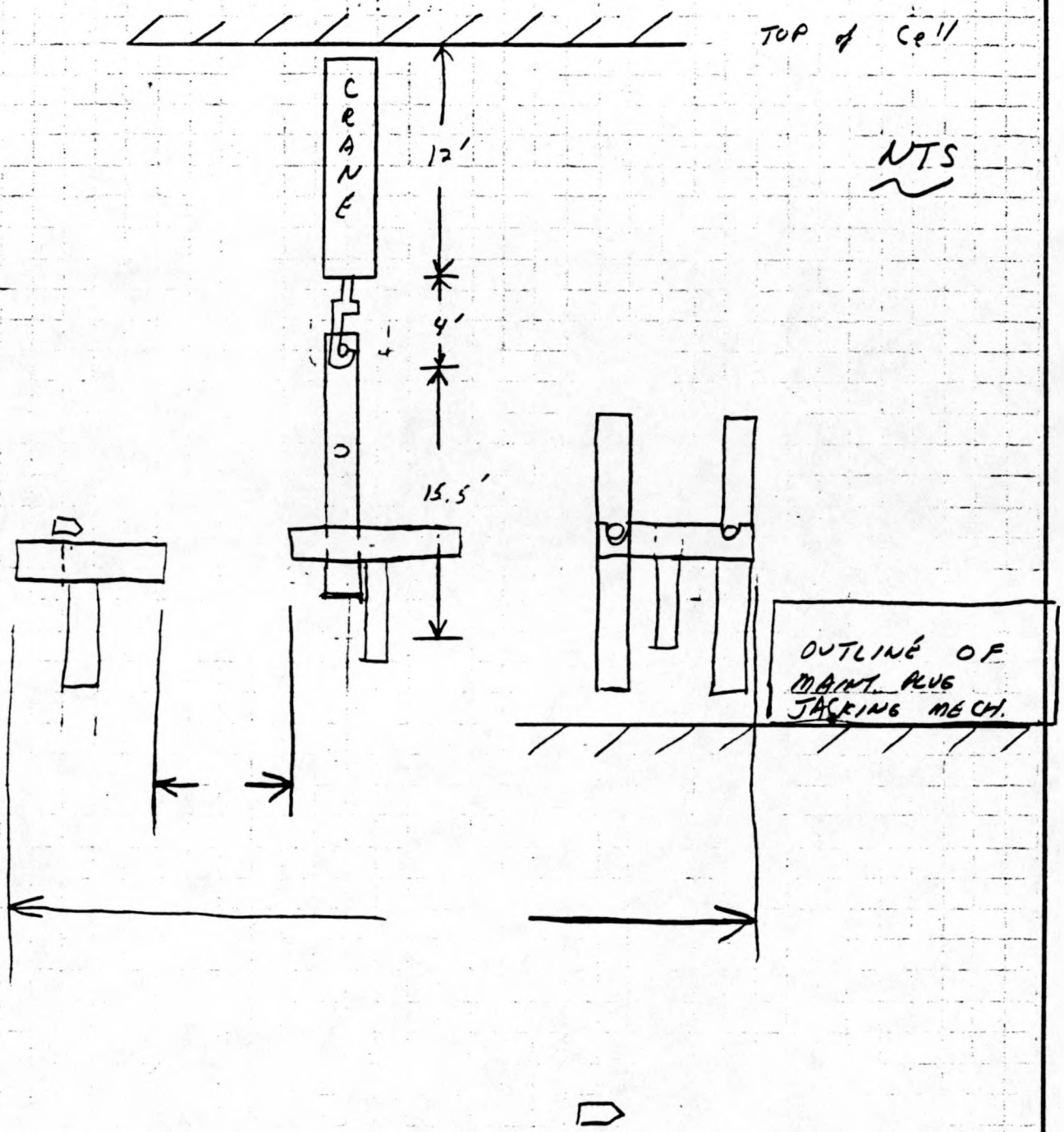


SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 6

Checked by: W. H. Blanchard for J. P. Fellows 2/6/85 Pl 113

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____



SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 7

Checked by: W. H. Blunt for L. P. Pelons 9/18/85

G.O. or CHARGE NO. _____ PROJECT Dwg SK-MH-011

SUBJECT Shipping Cask CART DESIGN

1.0 FROM FDC. Weight of Largest cask is 125 Tons 250,000 Pounds

2.0 Assume Cask similar To NL-10/24

Body dia max 96" 8'-0" dia

Body Length 204" 17'-0" long

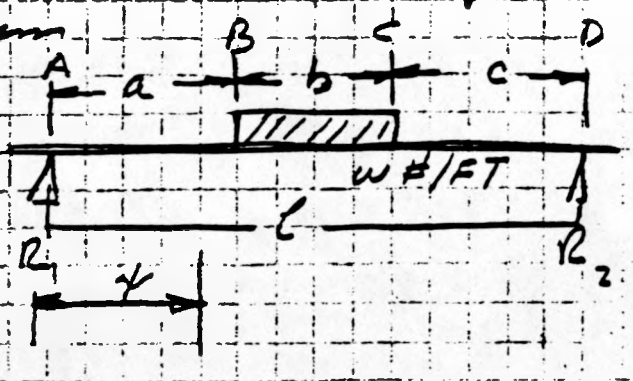
Loaded weight 195,000#

3.0 Design Concept

Steel construction, FLAT BED CART with steel rail wheels, with self contained motive power, capable of supporting 250,000#s Dead Weight

Use H-36 STRUCTURAL STEEL Body STRUCTURE

General Equation for partially loaded Simple Beam



SIGNATURE [illegible] DATE 6/11/84 TRB NO. 1 PAGE 95

Checked by WTB for D. Palmarto 8/7/85

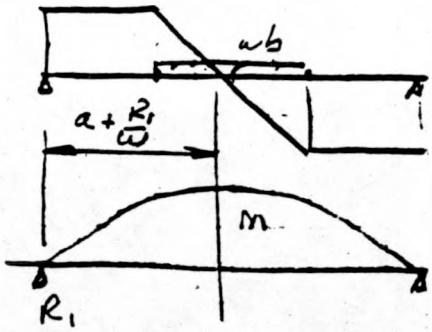
David D. [illegible] 1/21/85

p. 115

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Shipping Cask Skirt design

shear diagram



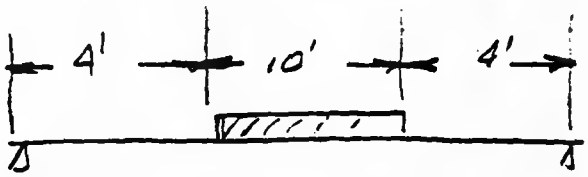
moment diagram

$$M_{max} = R_1\left(a + \frac{R_1}{2w}\right)$$

$$R_1 = \frac{wb(2c+b)}{2\ell}$$

$$R_2 = \frac{wb(2a+b)}{2\ell}$$

$$M = \frac{wb(2c+b)[4a\ell + b(2c+b)]}{8\ell^2}$$



1.0 loading - cask is 250,000# DW

assume 1.5 x DW to account for shock loading 250,000 x 1.5 = 375,000 #

$$w = \frac{375{,}000}{10} = 37{,}500 \ \#/FT$$

2.0 max moment

SIGNATURE L A Pellon DATE 6/5/84 TRB NO. _____ PAGE 96

Dennis A. DeMarco 1/21/85

p. 116

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Shipping Cask CHIRT design

$$M_{max} = \frac{wb(2c+b)[4ad + b(2c+b)]}{8 \times d^2}$$

$$M_{max} = \frac{37{,}500 \times 10(18)[288 + 180]}{8 \times 18 \times 18}$$

$$M_{max} = 1{,}218{,}750 \text{ in\#}$$

Assuming A-36 structural steel

the allowable Bending load

$F_b = .66 F_y$ Appendix A AISC

$\therefore F_b = .66 \times 36{,}000$

$F_b = 24{,}000$ PSI

$\therefore \sigma_b = \frac{M}{Z}$

When the required $Z = \frac{M}{\sigma_b}$

$$Z = \frac{1218{,}750 \times 12 \text{ in\#}}{24{,}000 \text{ PSI}}$$

SIGNATURE L. A. Pallen DATE 6/5/84 TRB NO. _____ PAGE 97

Dwd D. DeMaster 1/21/85

p. 117

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Shipping Disk Cart Design

$Z = 609 \text{ in}^3$

assume

6 I beams on 2'-0" centers

Size of I Beam - assume wide flange Beams

$$\therefore Z_{beam} = \frac{Z}{6}$$

$$Z_{beam} = \frac{609}{6} = 101 \text{ in}^3 / \text{Beam}$$

From AISC Manual

Use W12x85 wide flange Beam

$I = 723 \text{ in}^4$ $S = 116 \text{ in}^3$

$$\sigma_b = \frac{M}{Z} = \frac{1,218,750}{6 \times 116}$$ $C = 6.25$ in

$\sigma_b = 1751$ PSI

Use Channel Beam since

12" Channel

SIGNATURE [illegible] DATE 6/5/84 TRB. NO. _____ PAGE ~~98~~

[illegible] 1/22/85

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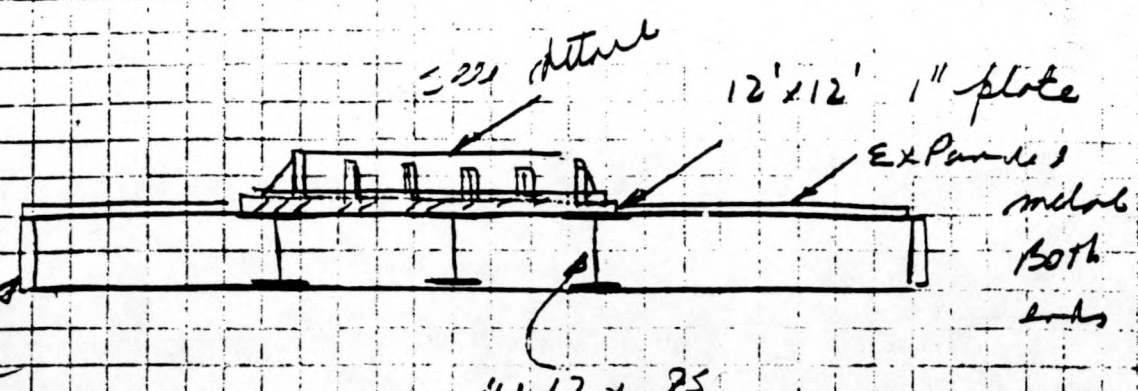
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cask Cart - Design



# of Bolts for Hor. shear

$\tau_v = F_v = .45 F_y = .45 \times 36000 = 16,200$ PSI

assume 1/5 load Horizontal Friction Force excluded

$\therefore \tau_v = \frac{V}{A} \quad A = \frac{P}{\tau} = \frac{250,000\#}{16,200}$

$A = 15 \text{ in}^2 \quad 1/2 \text{ Bolt} = 1.76 \text{ in}^2$

$\therefore$ use 9 1/2" A 307 Bolts or 12 1/4 Bolts

Bottom Guide plate

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Dave J. DeMaster 1/21/85

P. 119

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cask CART Design

Spacer plates

Compressive stress

For A36 $F_a = .60 F_y$

$F_a = .60 \times 36{,}000$

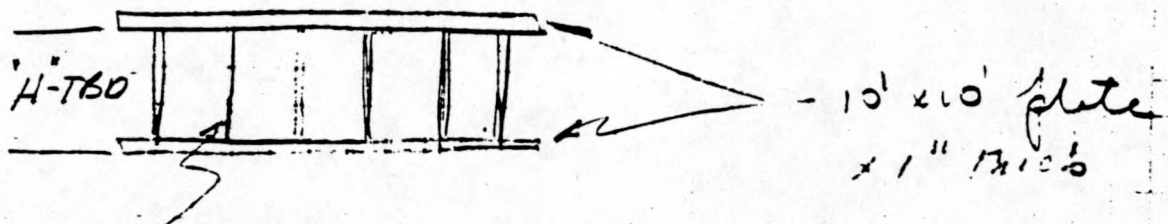
$F_a = 21{,}600$ PSI

O WT of cask 375,000 #

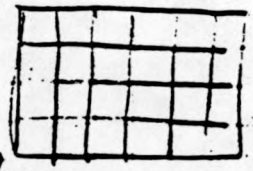
Req supporting Area =

$\sigma_c = \frac{P}{A}$, $A = \frac{P}{\sigma_c} = \frac{375000}{21{,}600}$

$\therefore A = 17.36 \text{ in}^2$ min.



1/2" plate Honey combed



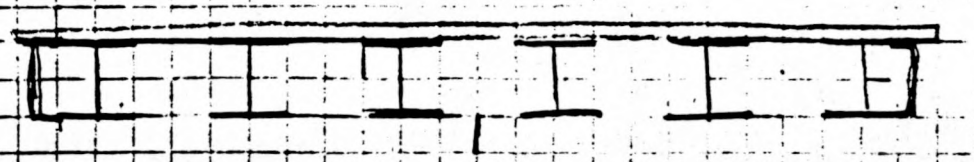
SIGNATURE L. Pallmer DATE 6/8/84 TRB NO. _____ PAGE 100

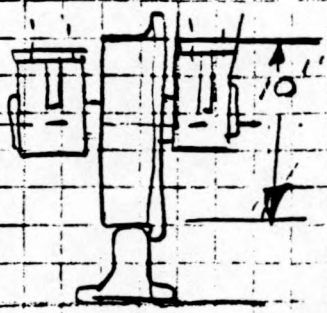
Dennis & Bob Martin 1/21/85

Pr 120

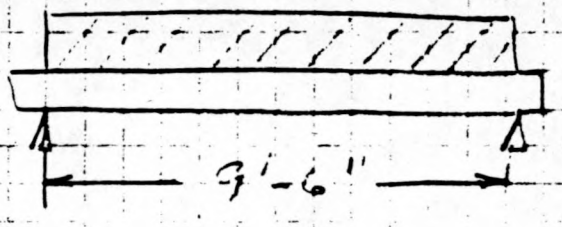
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT See page 111 for d/t cals





Use 14" steel wheel
Rated 15 TON capacity
Lech (McMaster Carr)
use - 12 ass'y



375,000 # over
1'-6"
Rail width OK
with Pozzum "Mayek"

$$W = \frac{375,000}{9.5} = 39,47 \text{ \#/ft}$$

$$M = \frac{Wl^2}{8} = \frac{39,474 \times 9.5 \times 9.5}{8}$$

$$M = 445316 \text{ FT-\#}$$

$$Z = \frac{445316 \times 12}{24,000} = 12 \text{ in}^3$$

SIGNATURE L. C. Allen DATE 6/5/84 TRB NO. _____ PAGE ~~101~~

Dave D. Bell 1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cable CART power Drive System

Conceptual Design of Drive

1. Design load of Cables 125 Tons

2. Weight of CART

I Beam 7 - W12 x 85 x 18' long

5 - W12 x 85 x 12' long

Steel Plates 1 - 12x12 x 1 1/2"

1 - 10x10 x 1"

2 - 10x10 x 1"

12 - 12" x 1/2" x 10' long

Steel wheels 14" dia x 3" wide

+ Brgs = Housing

Wt of Beam = 7 x 18 = 126 x 85 = 10,710 #

= 5 x 12 = 60' x 85 = 5100 #

Steel plates w_t = 12 x 12 x $\frac{1.5}{12}$ x 480 = 8640 #

w_t 12 - 12" x $\frac{.5}{12}$ x 10' x 480 = 28,800 #

w_t = 3 x 10 x 10 x $\frac{1}{12}$ x 480 = 12,000 #

SIGNATURE L.P. Allen DATE 7/3/86 TRB NO. _____ PAGE 115

Dennis D. DeMarco 1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cask CART Power Drive

12 wheels at 400# each

Wt = 12 x 400 = 4800#

10,710	Beams
5100	Beam
8640	steel plate
28,800	steel plates
12,000	steel plates
4800	wheels

Wt Total 35 Tons

Total Weight on Wheels

Wt of cask 125 Tons

Wt of CART 35 Tons

Total Wt 160 Tons

Load per wheel

$L = \frac{160}{12} = 13.3$ Tons

SIGNATURE [illegible] DATE 7/3/86 TRB NO. _____ PAGE ~~120~~

[illegible] 1/21/85

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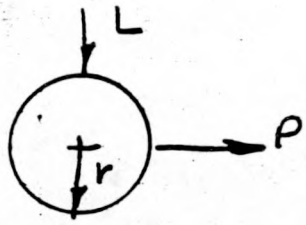
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cable and Pulley Drive



P = Friction Resistance

L = Load

r = Radius of wheel inches

K. Rolling friction

.002 Rolling

.242 Static

$$P = \frac{K}{r} L$$

$$P = \frac{.002 \times 160 \text{ Tons}}{7''}$$

P = 91.4 # Rolling

$$P = \frac{.242 \times 160 \times 2000}{7}$$

P = 11,063 # Static Resistance

with 4 wheels driving each wheel must overcome

$$P_{wheel} = \frac{11,063}{4} = 276 \pm$$

$$\text{Torque} = P \frac{r}{12} \quad \text{FT \#}$$

$$T = \frac{2766 \times 7}{12} = 1613 \text{ FT\#}$$

SIGNATURE L. P. Pellow DATE 7/3/76 TRB NO. _____ PAGE RT

1/21/05

p. 124

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Power Drive for Cask cart

Assuming wheel speed of 2 mile/hr

$$V = \frac{2 \times 5280}{60} = 176 \text{ FT/min}$$

To meet 176'/min a 12" wheel must turn

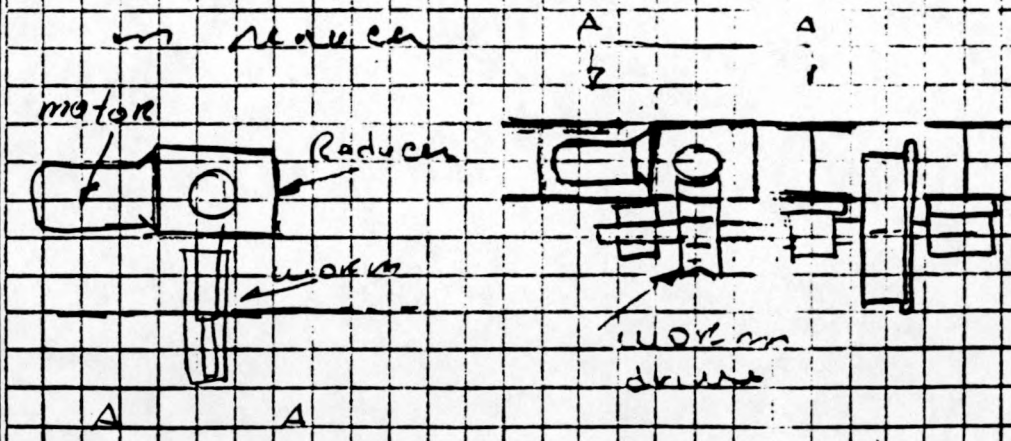
$$RPM = \frac{176}{\pi \frac{D}{12}} = \frac{176 \times 12}{\pi D''} = 48 \text{ RPM}$$

HP req for each wheel wheel be (From sh

$$HP = \frac{RPM \times Torque \times 2\pi}{33{,}000}$$

$$HP = \frac{48 \times 1613 \times 2\pi}{33{,}000} = 1.473 \text{ HP/wheel}$$

the Worm Drive fit, Double reducer gear Box on DC motor mounted on reducer



SIGNATURE L P Pullman DATE 7/3 TRB NO. _____ PAGE 12

Dwo S. Delgmeier 1/21/85

p. 125

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Power Drive

Assume time to cross 40' (from unloading Dock to Crane operating area) in Two min.

∴ Travel Rate = $\frac{40}{2}$ = 20'/min

∴ RPM of wheel = $\frac{20' \times 12}{\pi \times 14}$ = 5.5 RPM

∴ HP req at each wheel =

$$HP = \frac{RPM \times Torque \times 2\pi}{33{,}000}$$

$$HP = \frac{5.5 \times 16 \times 2\pi}{33{,}000} = .7 \text{ HP at wheel}$$

SIGNATURE [illegible] DATE 2/3/80 TRB NO. _____ PAGE ~~125~~

[illegible] 1/21/85

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Upender - Consolidation Cell

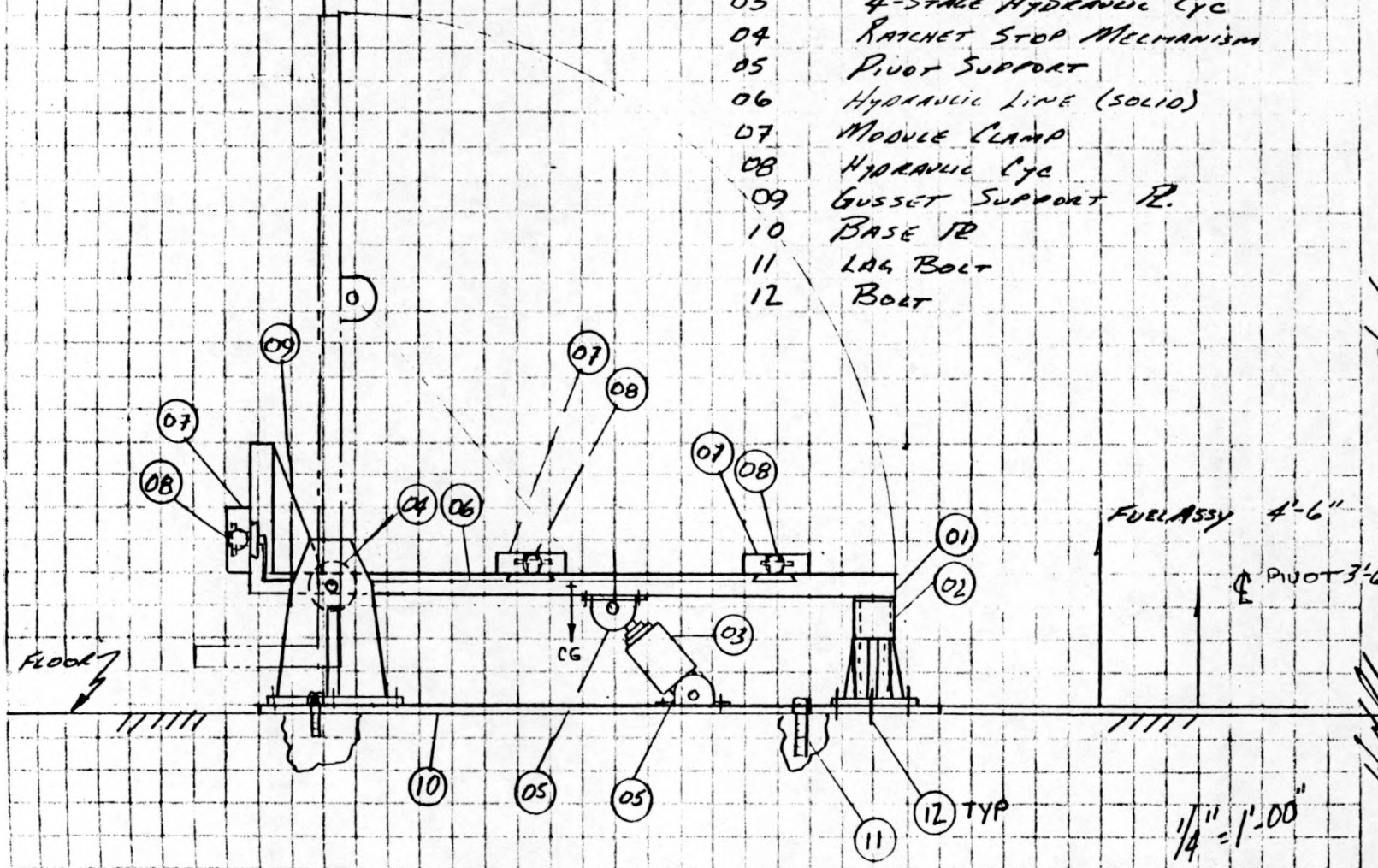
Notes

If 04 has H.P.O. cyc to retract checklock
If 02 has shock absorbed lower to correct position

Upender

Equipment List

Item	Description
01	Upender Table
02	Mechanical Stop w/sensors
03	4-Stage Hydraulic Cyc
04	Ratchet Stop Mechanism
05	Pivot Support
06	Hydraulic Line (solid)
07	Module Clamp
08	Hydraulic Cyc
09	Gusset Support R.
10	Base R
11	Lag Bolt
12	Bolt



SIGNATURE _____ DATE 7/28/94 TRB NO. MHB-001 PAGE 2

CHECKED BY: Jeff Mitchell
DATE: 2/6/95

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G.O. or CHARGE NO. _____ PROJECT MRS

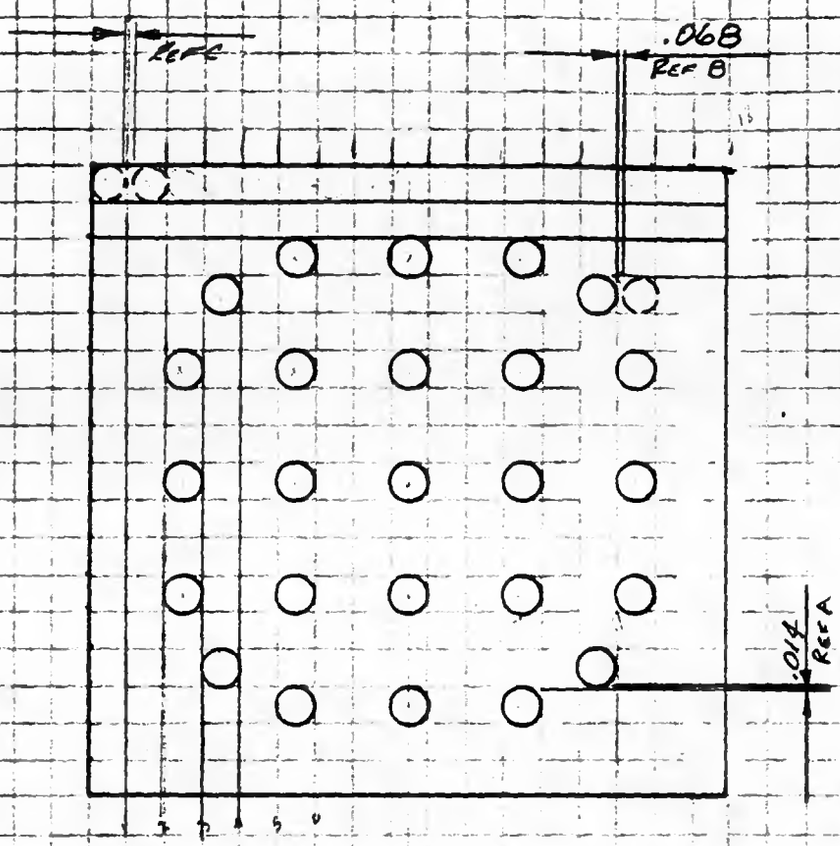
SUBJECT Core Arrangement

(w) 17x17

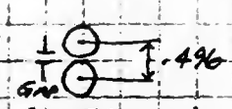
Rod Dia = 0.374

Thimble Dia = 0.482/.429

Rod Pitch = 0.496



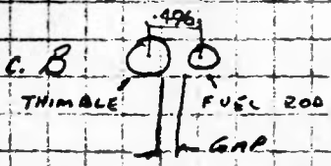
CALC. A



(2-THIMBLE)

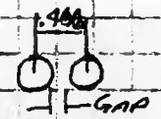
GAP = Pitch - Thimble Dia
A = .496 - .482
= .014 (NOMINAL) WORST CASE
= .496 - .429
= .067 (NOMINAL) BEST CASE

CALC. B



GAP$_B$ = Pitch - ½ Thimble Φ - ½ Rod Φ
= .496 - .482/2 - .374/2
= .068 (NOMINAL) WORST CASE
= .496 - .429/2 - .374/2 = 0.0945 (NOM. BEST CASE)

CALC. C



(2-RODS)

GAP$_C$ = Pitch - Rod Φ
= .496 - .374 = 0.122 (NOMINAL)

SIGNATURE [signature] DATE 6/2/84 TRB NO. WMS-001 PAGE 8

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

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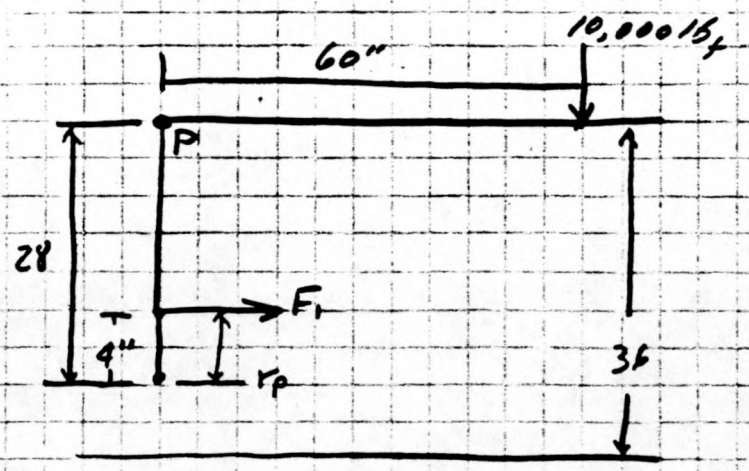
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Downender



To Find F_1

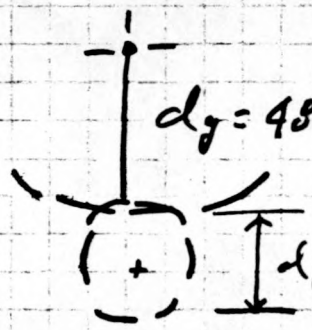
$\Sigma M_P = 0$

$(10{,}000\,lb)(60\,in) = 24 F_1$

$\therefore F_1 = 25{,}000\,lbf$

To Reducer $= 25{,}000 \times 4$
$= 100{,}000\,lb\text{-}in$

w/ Kg on Gears load $= 1.5 \times 100{,}000$
$= 150{,}000\,lb\text{-}in$



$d_g = 48"$, $N = 120$, $P = 2.5$

$d_p = 8$, $N = 20$, $P = 2.5$

} COARSE Pitch

Assume Face $= 5 \times p$ & $p = \frac{\pi}{P} = \frac{\pi}{2.5} = 1.25$
$= 5 \times 1.25 = 6.5"$

Choose Reducer @ 215,000 lb-in out & HP equal = 422
ASSUME @ 5 HP

$$\therefore w_T = \frac{T2}{d} = \frac{(215{,}000)(2)}{8} = 53{,}775\,lbf$$

$$\sigma = \frac{w_T}{F_1 P y} = \frac{53{,}775}{(6.5)(1.25)(.283)} = 23{,}400\,psi$$

safe

$y = .283$ (19½ @ 20 teeth)

SIGNATURE W R Thomas DATE 4/15/82 TRB NO. WHB-001 PAGE 10

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Estimated Weight Parameters for Downender

1.) Largest Weight PWR

15x15, B&W @ 1516 lbf/assy

Combined load @ 3 assy

1516 lbf/assy x 3 assy = 4548 lbf ~ **4550 lbf PWR**

(Design Basis ↑ see #9 below)

2.) Largest Weight BWR

8x8 - GE - Type 3, 4, 5 & 6

$.290 \frac{kg}{assy} \times 2205 \frac{lbf}{kg} = 639.5$ lbf/assy

Combined load @ 7 assy

639.5 lbf/assy x 7 assy = **4476 lbf BWR**

3.) Δ PWR - BWR ≅ 75 lbf

4.) Design wise the variation between PWR & BWR fuel is virtually negligible. and design should be based on PWR fuel, particulary B&W 15x15 type fuel.

6.) Estimated Weight of clamping module

PWR = 2075
BWR = 3215
} see T. Kramer note book for breakdown.

7.) Worst Case Analysis

Bwr combined loads = 3215 lbf + 4476 = 7691 lbf

SIGNATURE William H Blessell DATE 7/1/84 TRB NO. WHB-001 PAGE 14

CHECKED BY: Jeff Mitchell

DATE: 2/6/85

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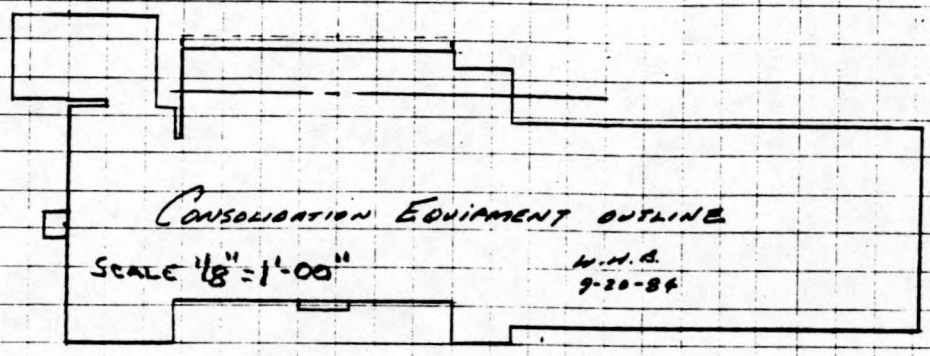
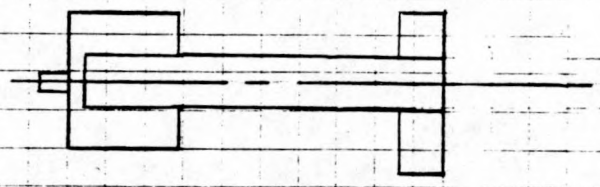
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT FUEL CONSOLIDATION EQUIPMENT SPACE ENVELOPE
FROM DWG H-3-54914





INTACT UPENDER
WHB 9-20-84
SCALE 1/8" - 1'-00"

SIGNATURE W.H. Blanchard DATE 3/1/85 TRB NO. WHB-001 PAGE 15

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Tube (PWR) Parameters

PWR Thimble and Guide Tube I.D. Variations

Manufacturing & Array	O.D. (inch)	Wall (inch)	I.D. (inch)	No. Tubes	Notes
Babcock & Wilcox					
15x15 (G)	.530	.016	.498	16	See Sample Cal
(I)	.493	.026	.441	1	
17x17 (G)	.465	.0175	.43	24	
(I)	.420	.015	.39	1	
Combustion Engineering					
15x15 (G)	1.115	.040	1.035	4	
(I)	.440	.026	.338	1	
14x14 (G)	1.135	.030	1.075	4	.....Largest
(I)	.440	.026	.338	1	
(G)	1.115	.030	1.055	4	
(I)	.440	.026	.338	1	
16x16 (G)	.97	.035	.90	4	
(I)	.382	.025	.332	1	
(G)	.98	.035	.91	4	
(I)	.382	.025	.332	1	.....Smallest
Westinghouse					
14x14 (G)	.539	.034	.471	16	
(I)	.539	.034	1		
(G)	.4805	.034	.4125	16	
(I)	.539	.034	.471	1	
15x15 (G)	.543	.012	.519	20	
(I)	.543	.012	.519	1	
(G)	.478	.012	.454	20	
(I)	.543	.012	.519	1	
(G)	.545	.015	.515	20	
(I)	.545	.015	.515	1	
(G)	.484	.015	.454	20	
(I)	.545	.015	.515	1	
17x17 (G)	.482	.016	.450	24	14' Core
(I)	.545	.015	.515	1	
(G)	.429	.016	.397	24	14' Core
(I)	.545	.015	.515	1	
17x17(L) (I)	.482	.016	.450	1	
Exxon Refills					
14x14 (G)	1.115	.036	1.043	4	
(I)	1.115	.036	1.043	1	
15x15 (G)	Information N/A				
(I)	.417	.027	.363	1	
15x15 (G)	.544	.017	.510	20	
(I)	.544	.017	.510	1	
17x17 (G)	.480	.016	.448	24	
(I)	.480	.016	.448	1	

SAMPLE CALCULATION: ID = OD-2X Wall Thickness
.530-2X .016 = 0.408

REF. NUCLEAR ASSURANCE CORP. VOL III DOE/ET/47912-3
DOMESTIC LIGHT WATER REACTOR FUEL DESIGN EVOLUTION NAC-C 8129

SIGNATURE W. H. Bloomer DATE 8/21/84 TRB NO. 003 PAGE 1

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Kerf Calc.

SUBJECT: Gram/Kerf of Material Vaporization of PWR/BWR ~~Fuel~~ Thimble, Instrument and Tie Rods, from Laser Disassembly.

General Information ~~[illegible]~~

① Conversation with Dan Ricci:

A.) Laser Kerf = 0.030 in (nominal)

B.) Most material vaporizes when cut.

② Material Properties of Zircaloy-2 & 4

Density = ρ = 6.55 gram/cm^3

~~[illegible]~~

③ 2.54 cm = 1 in (conversion factor)

PWR Disassembly Worst Case Analysis - Largest Wall Thickness

CE 15x15 ; OD = 1.115 in = 2.8321 cm
ID = 1.035 in = 2.6289 cm
WALL = 0.040 in = 0.1016 cm

Number of tubes to be cut = 5

C = cut = 0.030 in = 0.0762 cm

$$A = \text{Area} = \frac{\pi(OD^2 - ID^2)}{4} = \frac{\pi(2.8321^2 - 2.6289^2)}{4} = 0.8715\,cm^2$$

$$V = \text{Volume} = A \times C = 0.8715\,cm^2 \times 0.0762\,cm = 0.0664\,cm^3$$

SIGNATURE [signature] DATE 7/29/84 TRB NO. 003 PAGE 2

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Kerf Calc.

g/cut = V × ρ = 0.0664 cm³ × 6.55 g/cm³ = 0.4350 g/cut

@ 5 cuts = 5 × 0.4350 g/cut = 2.175 g/5 cut

PWR Disassembly Worst Case Analysis - Most Trimmers & Largest Wall Thickness

(W) 17×17 O.D = 0.482 in = 1.22428 cm
I.D = 0.450 in = 1.143 cm
Wall = 0.016 in = 0.04064 cm

Number of Tubes to be cut = 25

C = cut = 0.030 in = 0.0762 cm

$A = \text{Area} = \frac{\pi(OD^2 - ID^2)}{4} = \frac{\pi(1.22428^2 - 1.143^2)}{4} = 0.1511 \text{ cm}^2$

V = Volume = A × C = 0.1511 cm² × 0.0762 cm = 0.0115 cm³

g/cut = V × ρ = 0.0115 cm³ × 6.55 g/cm³ = 0.0754 g/cut

@ 25 cuts = 25 × 0.0754 g/cut = 1.886 g/25 cut

BWR Disassembly Worst Case Analysis - Largest Tie Rod Extension

GE 7×7 O.D = 0.570 in = 1.4478 cm

Number to be Cut = 8 top
= 8 bottom
total = 16

C = cut = 0.030 in = 0.0762 cm

$A = \text{Area} = \frac{\pi d^2}{4} = \frac{\pi \times 1.4478^2}{4} = 1.6463 \text{ cm}^2$

V = Volume = A × C = 1.6463 cm² × 0.0762 cm = 0.1254 cm³

g/cut = V × ρ = 0.1254 cm³ × 6.55 g/cm³ = 0.8217 g/cut

SIGNATURE [signature] DATE 7/29/14 TRB NO. 003 PAGE 3

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Heat Calc.

THE GOVERNING CASE FOR MOST MATERIAL VAPORIZED IS THE GE 7x7 BWR TYPE FUEL ASSEMBLY @ 13.147 & 116 cut. THIS IS DUE TO CUTTING OF SOLID RODS VS. PWR TUBING.

SIGNATURE [signature] DATE 7/29/84 TRB NO. 003 PAGE 4

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Mirror Metals

Metals →	Oxygen Free Copper	Molybdenum	Tungsten
Physical Properties			
Density, lb/cu in.	0.323	0.37	0.70
Melting Temp °F	1981	4730	6170
Specific Heat (68°F) Btu/lb°F	0.092	0.065	0.034
Coef of Thermal Exp (68-572°F) in/in°F	9.8×10^{-6}	2.7×10^{-6}	2.5×10^{-6}
Thermal Conductivity (68°F), Btu/hr/sq ft/°F/ft	226	84.5	96.6
Electrical Resistivity (68°F) Annealed, microhm-cm	1.71	5.2	5.48
Mechanical Properties			
Modulus of Elasticity, psi	17×10^6	47×10^6	59×10^6
Tensile Stress 1000 psi	32-35	95	220
Yield Stress 1000 psi	10-11	82	220
Reduction of Area %	45-55	60	-
Hardness (annealed)	40-45 RF	250 VHN	450 VHN
Optical Properties			
Reflectivity 10.6 μm	99%	98%	96%
Cleanability	Poor	Good	Excellent

SIGNATURE WHB for Ron Ponci DATE 8/22/89 TRB NO. 003 PAGE 5

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Cutting (PWR)

LASER CUTTING SEQUENCE FOR PWRs

Cutting Sequence	Velocity of Cutting Motion (IPM)	Power (kW) at Cutting Surface	Estimated Material Removal (0.030 width) (cubic inch)	Approximate Time (sec)
1. Stow Position				
2. Position for Upper Handling Attachment Cut (Locate First Tube and Insert Nozzle)	150 X, Z 60 Y	NA NA	NA NA	5 6
3. Rotate Cutter	150 (θ)	0.2	.001	1
4. Retract Cutter	60 (Y)	NA	NA	6
5. Repeat Steps 2, 3, 4 23 times	---	--	.022	414
6. Proceed to Second Assembly and Repeat				5 427
7. Proceed to Third Assembly and Repeat				5 427
Total Time				1296 sec 21.6 min

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CHECKED BY: Jeff Mitchell
DATE: 2/6/85

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Cutting (Bank)

Cutting Sequence	Velocity of Cutting Motion (IPM)	Power (kW) at Cutting Surface	Estimated Material Removal (0.030 width) (cubic inch)	Approximate Time (sec)
10. Cut Eight Tie Rods per Assembly, Total of Seven Assemblies.			0.21	1232
11. Position LDS to Stow Position.				100
TOTAL TIME				2864 sec 47.7 min

SIGNATURE WMB for Dan Ricci DATE 8/22/84 TRB NO. 003 PAGE 7

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Laser Cutting (BWR)

LASER CUTTING SEQUENCE FOR BWRs

Cutting Sequence	Velocity of Cutting Motion (IPM)	Power (kW) at Cutting Surface	Estimated Material Removal (0.030 width) (cubic inch)	Approximate Time (sec)
1. Stow Position				
2. Position for Upper Lifting Attachment Cut (Locate First Tie Rod).	150 X, Z 60 Y	NA NA	NA NA	5 6
3. Oscillate Cutter	100 X	0.5	0.004	5
4. Retract Cutter	60 Y	NA	NA	6
5. Repeat Steps 2, 3, and 4 Seven Times.	--	--	0.028	154
6. Proceed to Second Assembly and Repeat.			0.030	176
7. Proceed to Third Through Seventh Assembly and Repeat (5 Additional Assemblies).			0.150	880
8. Retract to Stow Position, Horizontally Position BWR Assemblies.				300
9. Reposition LDS to Lower Elevation for Lower Attachment Cuts.				100

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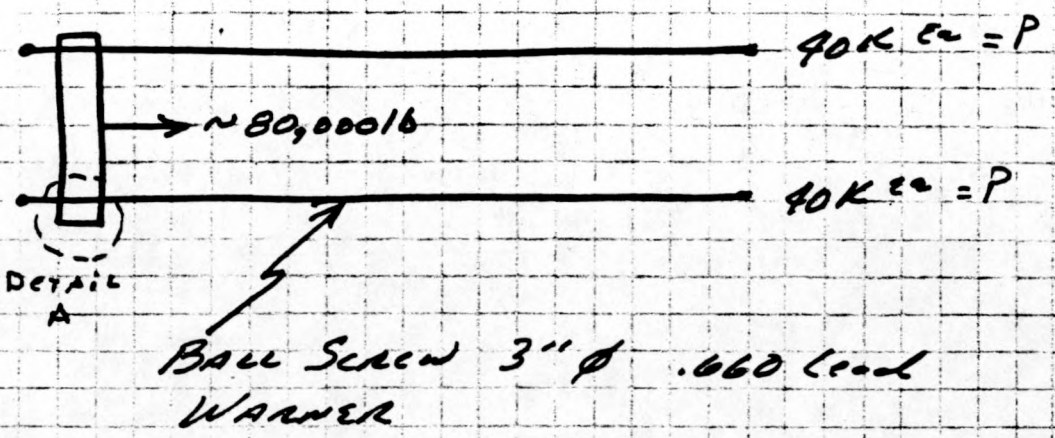
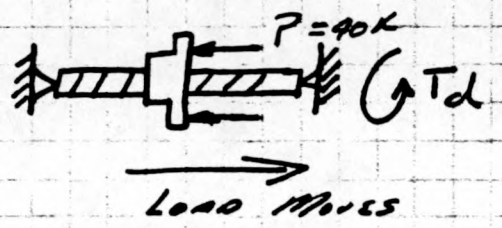
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Gripper Drive





The amount of effort, measured in pound-inch, required to turn the ball screw and move the load

$$T_d = \frac{P \times L}{2\pi e} = .177\, P \times L \text{ (pound-inches)}$$

T_d = Direct Torque (lb-in)
P = Load (lb) = 40,000
L = Screw Lead (inch/turn) = .660
e = Ball screw efficiency ~90% = .9

SIGNATURE [illegible] DATE 5/23/85 TRB NO. 009 PAGE 1

CHECKED BY: Jeff Mitchell
DATE: 2/6/85

p.140

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

$$T_d = \frac{(40{,}000\ lb)(.660\ \frac{in\ of\ lead}{turn})}{2\pi(.9)} \cong 4700\ lb\text{-}in$$

Reqd.

$$HP/_{screw} = \frac{RPM \times TORQUE}{63{,}000} = \frac{91 \times 4700}{63{,}000} = 6.75\ HP$$

$$\sim \underline{\underline{7\ HP}}$$

REQD

WANT A VELOCITY of ~5 FPM for FUEL ROD EXTRACTION.

$$\therefore\ RPM = \frac{Velocity}{Lead} = \frac{(5\ ft/min \times 12\ in/ft)}{(.660\ in/turn)} \cong 91\ \frac{Rev}{min}$$

SIGNATURE W H Blanchard DATE 5/23/64 TRB NO. 004 PAGE 2

CHECKED BY: Jeff Mitchell

DATE: 2/6/85

P-141

G.O. or CHARGE NO. 5B123904003 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN – TWO PLUGS

Equivalency figures from Hedgecock (AESD)

11" of Concrete = 2" Pb = 3" Steel

Equivalency figures from Nick Savin (WTSD)

1" of concrete = 0.303" of Steel = 0.213" Pb

Use Savin's figures

Specific weight of steel = 0.284 lbs./in^3

" " " Pb = 0.41 lbs/in^3

" " " Bisco NS-3 = 0.064 lbs./in^3

1 lb. = 0.0005 Short tons

Melting point of pure Pb = 620°F

" " " Steel > 2000°F

WEIGHT ANALYSIS

Steel plug

Top Pl = $\frac{\pi}{4} \times 128^2 \times 0.25 \times 0.284 \times 0.0005 = 0.46$ T

NS-3 = $\frac{\pi}{4} \times 128^2 \times 4 \times 0.064 \times 0.0005 = 1.65$ T

L4×3×$\frac{1}{4}$ = $\pi \times \frac{128}{12} \times 9.8 \times 0.0005 = 0.16$ T

Casting = $\frac{\pi}{4} \times 128^2 \times 6.75 \times 0.284 \times 0.0005 = 12.33$ T

Total = 14.60 T

SIGNATURE [illegible] DATE 13 July 84 TRB NO. MB-01 PAGE 1

Checked by: WHB for J.W. Willis 8/7/85

p. 142

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN — TWO PLUGS

Pb wt.

Top Pl $= \frac{\pi}{4} \times 105^2 \times 0.25 \times 0.284 \times 0.0005 = 0.31\,T$

Pb $= \frac{\pi}{4} \times 104^2 \times 7 \times 0.41 \times 0.0005 = 12.20\,T$

Bottom Pl $= \frac{\pi}{4} \times 105^2 \times 2 \times 0.284 \times 0.0005 = 2.46\,T$

Channel $= \pi \times \frac{105}{12} \times 22.7 \times 0.0005 = 0.31\,T$

Total $= 15.30\,T$

See Dwg. SK-MH-037 for design concept

Conversation today with Frank Montana of BISCO

Why not replace both plugs by a single BISCO NS-3 plug?

The NS-3 for above plug will have 65% Pb blended into NS-3, and 36" thickness of this plug will contain more H_2 than will 60" of concrete. The plug (NS-3 mat'l) will weigh as much as 60" of concrete. Cost of NS-3 (this particular composition) ≈ $2/lb.

SIGNATURE [illegible] DATE 13 Feb 1984 TRB NO. MB-01 PAGE 2

Checked [illegible] 1/2/85

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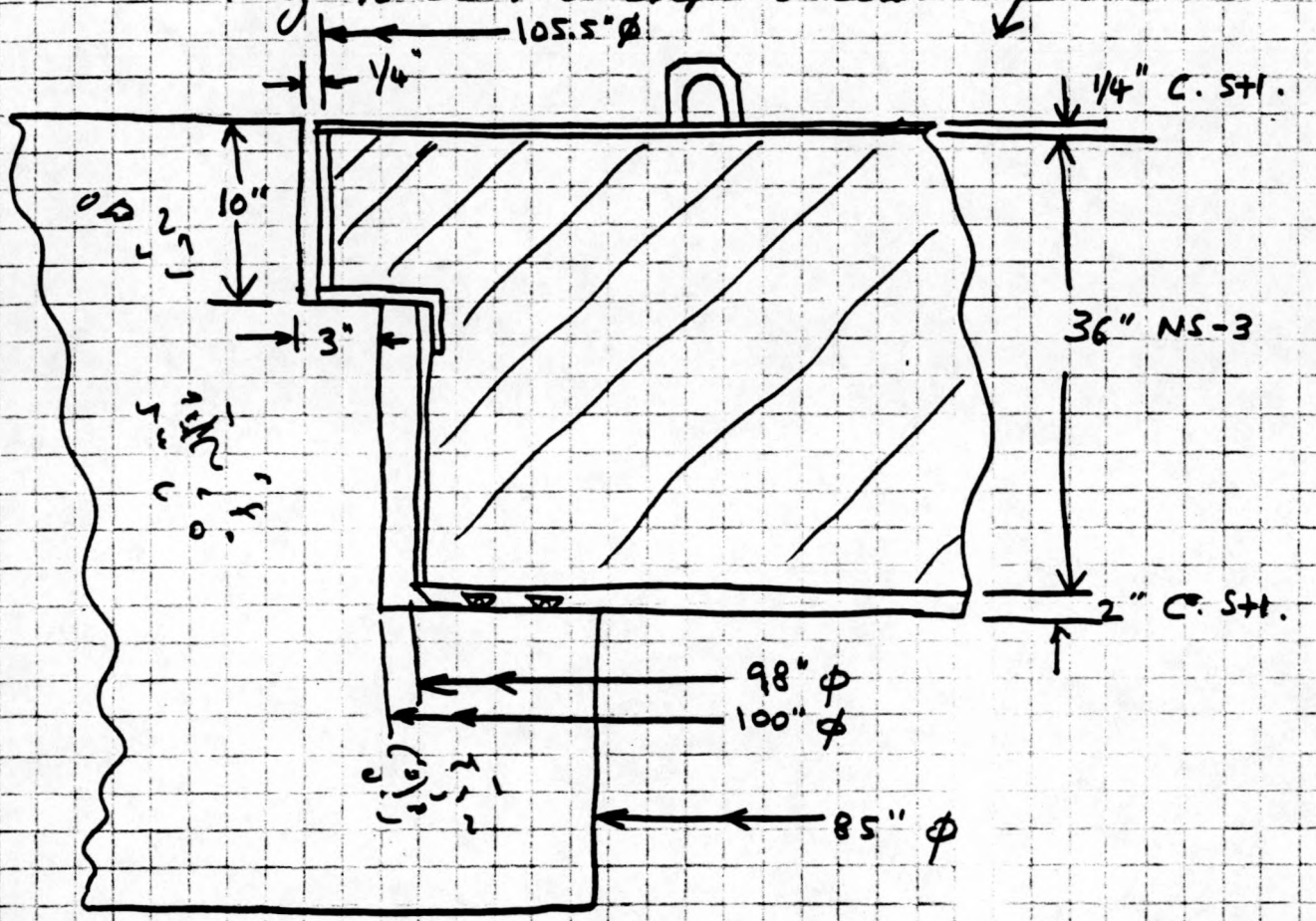
G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN – Single Plug Design

NS-3 single-plug investigation

~~Cost of single plug~~

Plug to be two-step as below:



~~Vol. of NS 3 = $\left(\frac{\pi}{4} \times 105.5^2 \times 10 + \frac{\pi}{4} \times 98\right.$~~

$$\text{Vol. of NS-3} = \left[\frac{\pi}{4} \times (105.5 - (.375 \times 2))^2 \times 9.75\right] + \left[\frac{\pi}{4} \times (\overset{98}{\cancel{100}} - (.375 \times 2))^2 \times (36 - 9.75)\right] = \overset{279008\ in^3}{\cancel{287110\ in^3}}$$

SIGNATURE [signature] DATE 13 Jul 1984 TRB NO. MB-01 PAGE 3

Orig seen Checked by J. Mullis 1/24/85

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G.O. or CHARGE NO. SB 123904003 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN — Single Plug

Wt. of NS-3 = 0.064 × NS-3 vol. = ~~18375~~ 17856 lbs. × 0.0005 $\frac{T}{lb.}$

= ~~9.20~~ 8.93 T ≈ 9.0 T

~~Bottom Pb = $\frac{\pi}{4}$ × (98 − .75)~~

Bottom Pb = $\frac{\pi}{4} \times 98^2 \times 2 \times 0.284 \times 0.0005 = 2.14$ T

Top Pb = $\frac{\pi}{4} \times 105.5^2 \times .25 \times .284 \times 0.0005 = 0.31$ T

Lower side Pb = $\frac{\pi}{4}\left[100^2 - 99.25^2\right] \times 26.25 \times 0.284 \times 0.0005 = 0.44$ T

Top side Pb = $\frac{\pi}{4}\left[105.5^2 - 104.75^2\right] \times 9.75 \times 0.284 \times 0.0005$ = ~~0.62~~ 0.17 T

L4×3×$\frac{3}{8}$ = $\pi \times \frac{98}{12} \times 8.5 \times 0.0005$ = 0.11 T

12.17

≈ 13 T

Actually, the NS-3 will be impregnated with Pb to the extent that NS-3 weighs equal to 60" of concrete;

~~Concrete weight = $\frac{\pi}{4}$ × 105.5² × 60~~

~~Concrete weight vol.~~

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Original checked by J.W. Ellis 1/2/85 p. 145

G.O. or CHARGE NO. SB12390400 3 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN — Single Plug

Concrete volume displaced $= \left[\frac{\pi}{4} \times 106^2 \times 10\right] +$

$\left[\frac{\pi}{4} \times 100^2 \times 28.25\right] +$

$\left[\frac{\pi}{4} \times \cancel{100^2}\, 85^2 \times 21.75\right] = 433{,}543 \text{ in}^3.$

Sp. wt. of concrete $= 144 \text{ lb/ft}^3$ [Handbook, McGraw Hill, p. 6-8]

$\therefore$ Wt. of concrete displaced $= \frac{433{,}543}{12^3} \times 144 \times 0.0005$

$= 18.1 \text{ T}$

~~So, assume wt. of NS-3 single plug ≈ 19T~~

So, assume NS-3 wt. ≈ 18 T.

Add to this wt. of steel casing:

NS-3 = 18T

+ Bottom Pl = 2.14 T

+ Top Pl = 0.31 T

+ L. side Pl = 0.44 T

+ T. side Pl = 0.17 T

+ L = 0.11 T

— Calculations on p. 4

21.17 T ≈ 22T

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Original Checked by J. Wells 1/21/85

p. 14b

G.O. or CHARGE NO. SB123904 0003 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN — SINGLE PLUG vs. Double Plug

Single Plug cost vs. Double plug cost

Single plug Cost

Cost of NS-3 = $2 / lb. [BISCO — Frank Montana]

NS-3 wt. = 18T [from p. 5]

∴ NS-3 cost = $72,000

Wt. of steel in plug = 3.17 T [p. 5]

Cost of raw steel / T = $1000 / T

∴ cost of steel = $ 3,170 (Bala Nair)

Assume rolling costs are same, = $3170

Fabrication costs (roughly) = $~~5000~~ 2000

Total = ~~$ 83,340~~ $80,340

Double - Plug cost

Wt. of Steel in plugs = 12.95 T (p.1)

+ 3.08 T (p.2)

16.03 T

~~∴ wt. Cost of stl. plugs~~

Cost of steel in plugs = $ 16,030

Wt. of Pb in plug = 12.20 T (p.2)

SIGNATURE MBali DATE 13 July 84 TRB NO. MB-01 PAGE 6

Original checked by [illegible] 1/24/85

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G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT UNLOADING PORTS DESIGN — SINGLE VS. DOUBLE PLUG

Cost of Pb = 32.34 c/lb. [Wall Street Jnal.]

$\therefore$ Cost of Pb $= \$\left[\frac{12.20}{0.0005} \times \frac{32.34}{100}\right]$

$= \$7891, \approx \$8000$

Cost of NS-3 $= \frac{1.65}{0.0005} \times \$\frac{2}{lb} = \$6,600$

$\therefore$ Total cost of double plug = 16,030 — Steel
+ 6,600 — NS-3
+ 8000 — Pb
+ ~~2000~~ 5000 — Fab.

~~\$29,030~~
\$35,630
+ 5,000 — more fab.

~~\$34,030~~ \$40,630

Difference between the Single and Double-Plug Costs

= 80,340 — Single
− ~~34,030~~ 40,630 — Double

~~\$46,310~~ \$39,710

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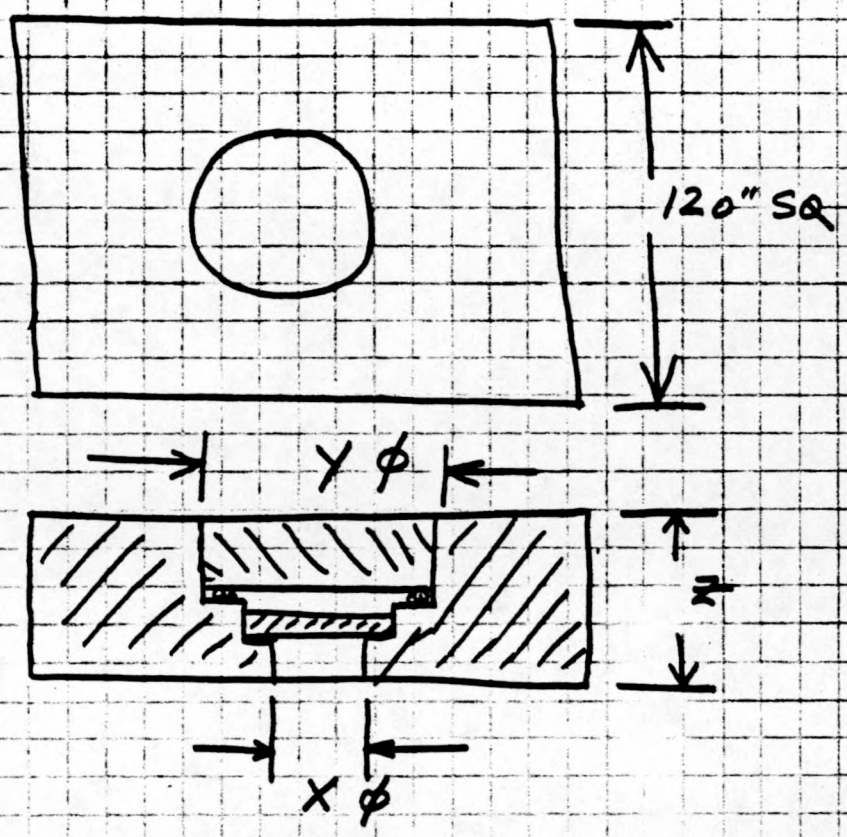
Orig and Checker by J. Ellis 11/2/85 p. 148

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH ~~PORTS~~ PLUGS



Equipment to pass through part (round)
= 2' φ drums (Lou Pollona)

∴ X need not be > ~~36" φ~~ 48" φ

Z = equivalent of ~~=~~ 60" of Concrete

Y = 60" φ —— same as dia at which lifting lugs are placed for the Unloading Parts Design [p-1 to 7]

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Checked by: WHB for J. W. Willis 8/7/85

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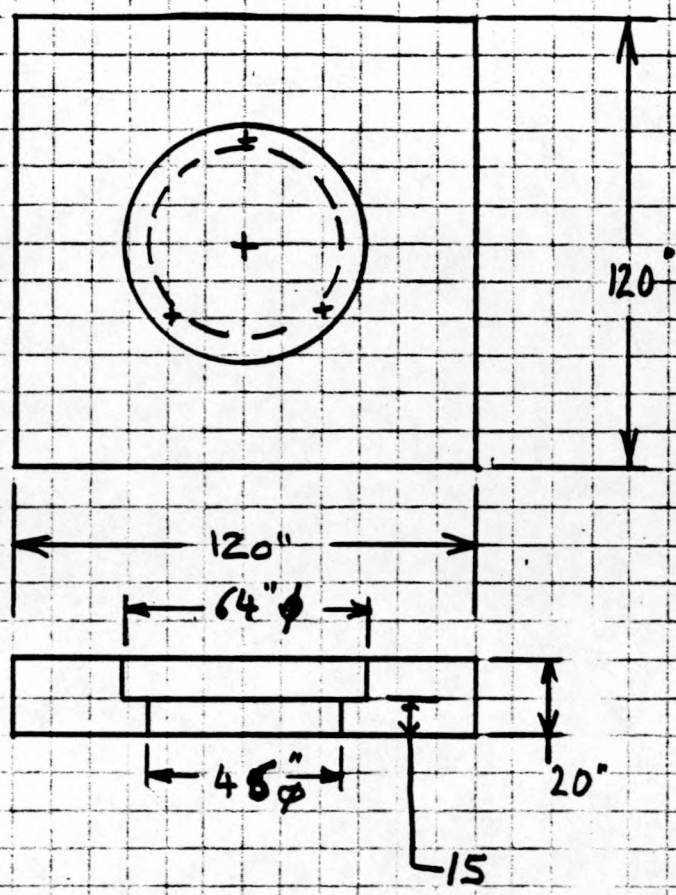
G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS



Above design no good. What about material for neutron capture?

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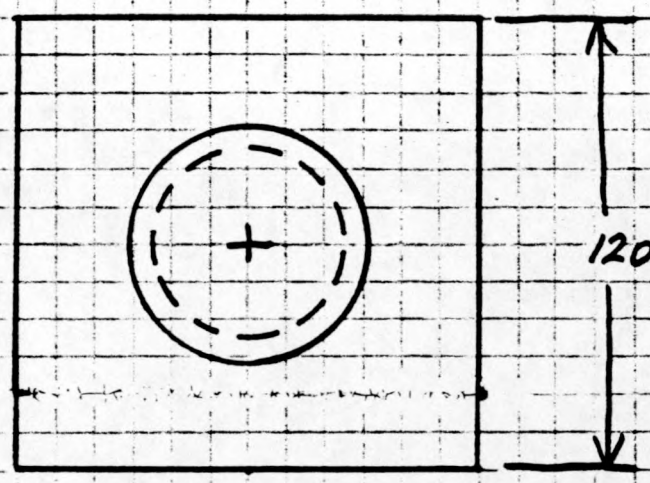
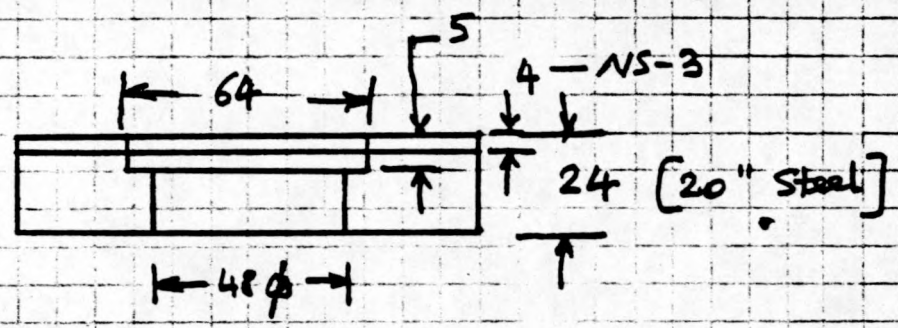
Original Checked by [illegible] 1/24/85 p-150

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS





~~Weight Analysis~~

~~Weight of steel block = 120 × 120 × 20 × 0.284 × 0.0005~~

~~Minus hole = $\frac{\pi}{4} \times 48^2 \times 19 \times 0.284 \times 0.0005$ =~~

~~Add NS3 wt = 4 × 120 × 120 × 0.064 × 0.0005~~

~~$\frac{\pi}{4} 64^2 \times 4 \times$~~

SIGNATURE [illegible] DATE 10 Jul 84 TRB NO. MB-01 PAGE 10

Original checked by J. W. Willis 11/2/84 p. 151

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS

Weight Analysis

Wt. of complete block = 120×120×20×0.284×0.0005 = 41 T

Wt. of NS-3 = 120×120×4×0.064×0.0005 = 2T

Wt. of top NS-3 circle = $\frac{\pi}{4}$ × 64² × 4 × 0.064 × 0.0005 = (0.4 T)

Wt. of top Stl. circle = $\frac{\pi}{4}$ × 64² × 1 × 0.284 × 0.0005 = (0.5 T)

Wt. of bottom circle = $\frac{\pi}{4}$ × 48² × 19 × ×0.284 ×0.0005 = (5 T)

~~44 T~~

37 T

Wt. of plug

NS3 = $\frac{\pi}{4}$ × 64² × 4 × 0.064 × 0.0005 = 0.4 T

Stl. = $\frac{\pi}{4}$ × 64² × 1 × 0.284 × 0.0005 = 0.5 T

plus $\frac{\pi}{4}$ × 48² × 19 × 0.284 × 0.0005 = 5 T

5.9 T

≈ 6 T

So, Crane to Lift (6T)

dedicated mechanism to lift 6+37 = (43T)

SIGNATURE [illegible] DATE 16 July 84 TRB NO. MB-01 PAGE 11

Original Checked by J.W. Ellis 1/2/85 pr-152

G.O. or CHARGE NO. SB123904003 PROJECT TMRS

SUBJECT HATCHES WITH PLUGS

If hatch ~~and plug~~ and plug of SH., made of Pb, then max. Pb thickness reqd. to replace 60" of concrete = 12.78" ≈ 13"

~~Then, wt~~

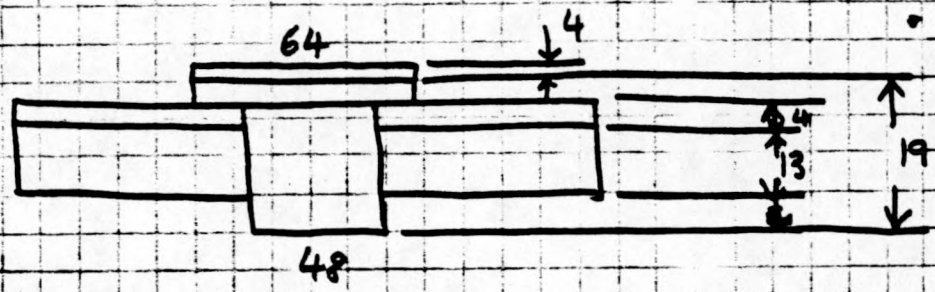
~~Complete block = π 120^2 x 13 x 0.41 x 0.0005 =~~

~~NS-3 = 120^2 x 4 x 0.064 x 0.0005 =~~

~~NS-3 missing = $\frac{\pi}{4}$ x 48^2 x 4 x 0.064 x 0.0005 =~~

~~Pb cap missing = $\frac{\pi}{4}$ 64^2 x 1 x 0.41 x~~

~~bottom side = (same as~~



Total plug weight analysis

Wt. of Pb-block + NS-3 :

$$Pb = \left\{\left[120 \times 120 \times 13\right] - \left(\frac{\pi}{4} \times 48^2 \times 13\right)\right\} \times 0.41 \times 0.0005 = 33.55T$$

$$NS\text{-}3 = \left[\left(120 \times 120 \times 4\right) - \left(\frac{\pi}{4} \times 48^2 \times 4\right)\right] \times 0.064 \times 0.0005 = 1.61T$$

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Original checked by J. Wallis 1/2/85

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G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS

Plug + NS-3 :

$$Stl. = \left[\left(\frac{\pi}{4} \times 48^2 \times 17\right) + \left(\frac{\pi}{4} \times 64^2 \times 2\right)\right] \times 0.284 \times 0.0005$$

$$= 5.28\,T$$

$$NS\text{-}3 = \frac{\pi}{4} \times 64^2 \times 4 \times 0.064 \times 0.0005 = 0.41\,T$$

total = 40.86

≈ 41 T

Note: above does not include a steel casing for the Pb, so this ~~pla~~ Hatch + Plug will be significantly heavier than the pure steel hatch + plug.

DROP PURE Pb idea

SIGNATURE [illegible] DATE 17 Jul 84 TRB NO. MB-01 PAGE 13

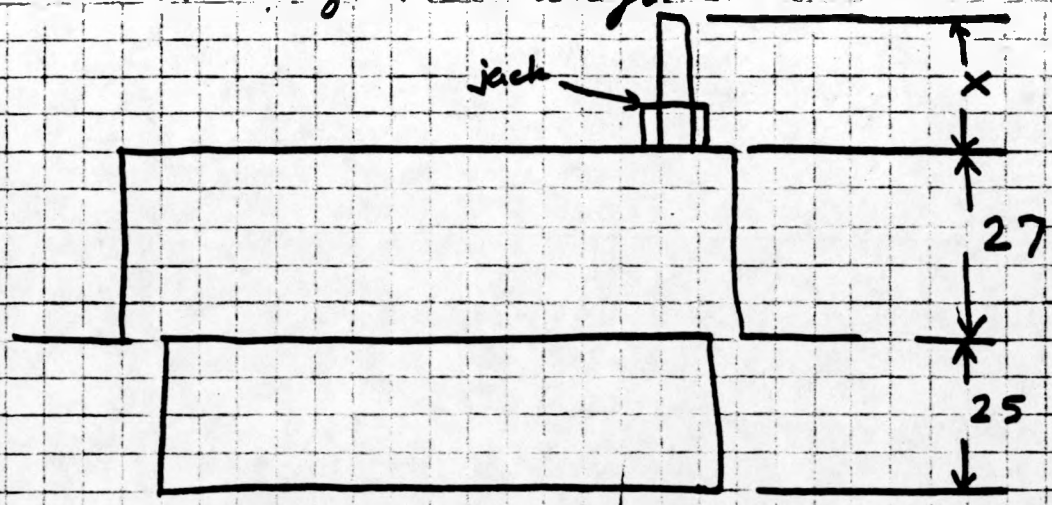
Original Prepared by J.W. [illegible] 1/24/85

p. 154

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

Consider diagram below for steel-hatch:



Min. hatch Lift required = 27", if it is to be moved

Consider POW-R-JAC ball-screw jacks, four reqd.

Then load on each JAC = $\frac{50}{4}$ — [assumed wt. of Hatch + plug, p. 11

= 12.5 T

Factor of Safety = 2

∴ Load per JAC = 25 T

~~Then~~ + Lifting ht. of JAC is essentially irrespective of load; assume 30T JAC capacity (25T not available in POW-R-JAC);

Then, POW-R-JAC 30 BSJ-I length = →

SIGNATURE [signature] DATE 18 Jul 84 TRB NO. MB-01 PAGE 14

Checked by: WHB for J. W. Wallace 8/14/85 p. 155

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

$= X = 3 + 27 + 19 + 2.9375 = 51.9375 \approx 52$ in.
[from Pow-R-JAC Catalog, p. 24]

Four jacks will be reqd, 30T each. Total capacity = $30 \times 4 = 120T$

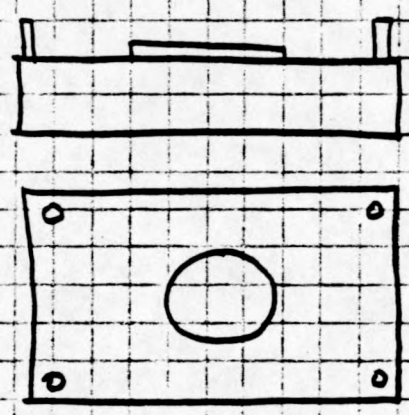
If no factor of safety is used, total load = 50T
Divided amongst 4 Jacks, ea. = 12.5T
Say 20T/Jack for 6 Jacks, ea. 10T capacity.

Then 10 BSJ-I =

$= X = 2 + 27 + 9.125 + 1.8125 = 39.9375 \approx 40$ in.

Saving in height = 12 in. from 30T Jacks.

Use 4 JACS, 30 BSJ-I



HATCH BOLTS – Hatch to have 4 shafts by which it'll be picked; shafts to be attached to hatch as show on next page

SIGNATURE [illegible] DATE 18 July 84 TRB NO. MB-01 PAGE 15

Original Checked by J. M. Wellis 1/21/85 p. 156

G.O. or CHARGE NO. SB 123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

Factor of Safety = 2

$$\text{Load on each bolt} = \frac{50}{0.0005} \times \underbrace{\frac{1}{4}}_{\text{4 shafts}} \times \underbrace{\frac{1}{4}}_{\text{4 bolts/shaft}} \times \underbrace{2}_{\text{fos}}$$

$$= 12,500 \text{ lbs.}$$

$$f_t = 85,000 \frac{\text{lb}}{\text{in}^2}$$ [for 18-8 SS, Handbook p. 5-3]

$$f_t = \frac{L}{A}$$

$$A = \frac{L}{f_t}$$

$$\frac{\pi d^2}{4} = \frac{12,500}{85 \times 10^3}$$

$$d = \sqrt{\frac{4 \times 12,500}{85 \times 10^3 \times \pi}}$$

$$\therefore d = 0.187 \text{ in.}$$

make bolt dia = 1 in., 304 SS

this gives a FOS = 5.35.

SIGNATURE [illegible] DATE 18 July 84 TRB NO. MB-01 PAGE 17

Original Checked by J. W. Wells 1/24/85 p: 157

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

LIFTING SHAFT DIA

# of shafts = 4

FOS = 2

$$\text{Load per shaft} = \frac{50 \times 2}{0.0005 \times 4} = \cancel{25}\ 50 \times 10^3 \text{ lbs.}$$

$$f_t = 85000 \frac{lb}{in^2} \quad \left[\text{handbook, p. 5-3, 18-8 Stn.-St.}\right]$$

$$f_t = \frac{L}{A}, \quad A = \frac{L}{f_t}, \quad \frac{\pi d^2}{4} = \frac{L}{f_t}$$

$$d = \sqrt{\frac{4L}{\pi f_t}}$$

$$= \sqrt{\frac{4 \times 50 \times 10^3}{\pi \times 85 \times 10^3}}$$

$$\therefore d = 0.865 \text{ in.}$$

make shaft = 3" ϕ, 304 SS

this gives FOS = ~~3.5~~ 7

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Original Checked by J. W. Wallace 1/2/85

p. 15B

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

POW-R-JAC Input ~~torque~~ HP

$$HP/JAC = \frac{\text{Input Torque (ft-lbs)} \times \text{Worm Speed (RPM)}}{5250}$$

Max. Input torque (Starting) = ~~95.4~~ 73.3 ft-lb.
(from POWR JAC Catalog)

Worm Speed = (# of worm turns / inch) × lifting speed in inches per minute.

Lifting height ≈ 27"

Assume 1 minute to travel 27"

Then, lifting speed = ~~27~~ 27" / min.

# of Worm turns / inch of raise = 48] POWR JAC Catalog, p. 20, for Optional Gear Ratio of 32:1

~~HP / JAC = 95.4 ×~~

∴ Worm Speed (RPM) = 48 × 27

$$\therefore HP/JAC = \frac{\cancel{95.4}\ 73.3 \times 48 \times 27}{5250} = \cancel{23.55}\ 18.1$$

Maximum allowable = 11 HP

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Original Checked by J.W. Willis 1/21/85 p. 159

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

If Gear Ratio is the Standard $10\frac{2}{3}:1$, then

$$HP/JAC = \frac{\text{Input Torque} \times \text{Worm Speed}}{5250}$$

Input Torque = 95.4 ft.lb. [POWRJAC CATALOG p. 20]

Worm Speed = (turns of worm for 1" raise) x Lifting speed (in/min)

turns / inch raise = 16

Lifting speed = 27"/min.

∴ Worm Speed = 16 x 27

$$\therefore HP/JAC = \frac{95.4 \times 16 \times 27}{5250} = 7.85$$

~~CHOOSE STANDARD RATIO~~

For loads less than rated, ~~to~~ Input Torque is directly ∝ to load (for POWRJAC BSJ models)

so $IT \propto L$

or $\frac{IT}{L} = K$

If load is actually $\frac{50}{4} = 12.5$ T,

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G.O. or CHARGE NO. S8123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

then $\frac{\text{Input torque}}{12.5\,T} = \frac{95.4}{30\,T}$ — standard ratio.

#:

or Input torque $= \frac{95.4 \times 12.5}{30} = 39.75$ ft-lb.

~~For optional ratio (32:1)~~

~~HP/JAC = $\frac{\text{Input Torque} \times \text{Worm Shaft Speed}}{5250}$~~

~~$= \frac{39.75 \times 48 \times 27}{5250} = 9.81$~~

For Standard ratio $(10\frac{2}{3}:1)$

$HP/JAC = \frac{39.75 \times 16 \times 27}{5250} = 3.27$

Use these figures

SYSTEM η

for four jack arrangement = 86 % [P. 37 of JAC catalog]

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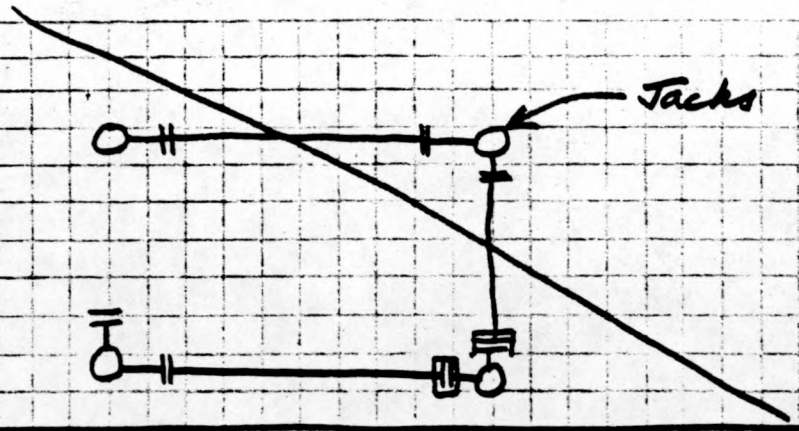
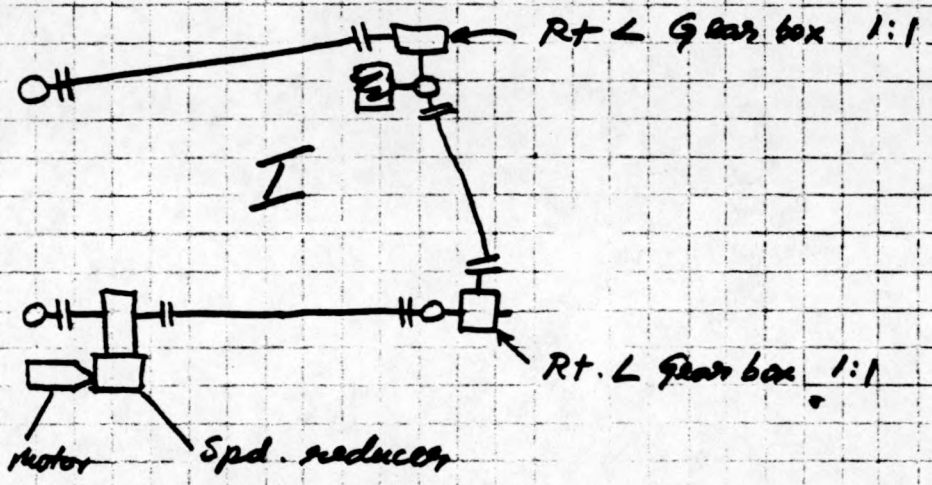
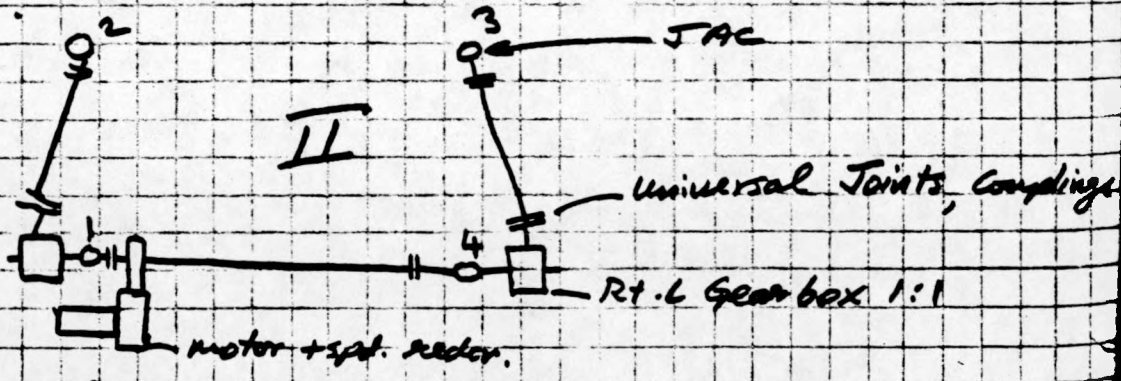
G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE





OR



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Original Checked by J.W. Willis 1/24/85 p. 162

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

Choose standard motor:

$$\text{Motor HP} = \frac{\#\text{ of jacs} \times \text{HP/jac}}{\text{arrangement } \eta \times \text{gear box} \times \eta\text{s}}$$

assume each gear box η = 95%

assume arrangement η (for 4 jacs) = ~~0.86~~ 86%
(p. 37 POWR JAC manual)

$$\text{then Motor HP} = \frac{4 \times 3.27}{0.86 \times \underbrace{0.95 \times 0.95}_{\text{for two Rt. C gear boxes}}}$$

$$= 16.85$$

Include 98.5% η for a single-reduction speed reducer;

$$\therefore \text{Motor HP} = \frac{16.85}{0.985} = \boxed{17.11 \text{ HP}}$$

Speed reducer output speed = 16 × 27 = 432 RPM

~~(Input torque out of MOTOR BRAKE~~

$$\text{torque output of reducer} = \frac{39.75}{0.86 \times 0.95 \times 0.95}$$

$$= \boxed{51.21 \text{ ft-lbs.}}$$

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original checked by Joel Willis 1/21/85 P. 163

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

($\eta = 97\%$)

If a double reduction reducer is used, then

Motor hp $= \dfrac{16.85}{0.97} =$ **17.37 HP**

reducer output RPM $=$ **432 RPM**

torque output of reducer

$= \dfrac{39.75}{0.86 \times 0.95 \times 0.95} =$ **51.21 ft.-lb.**

Motor HP could also be $\dfrac{16.85}{0.985} = 17.11$, for a single-reduction reducer

~~Now select the damper system~~

MOTOR BRAKE

Assume max. stopping distance = 1".

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Original checked by J.W. Willis 1/26/85
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G.O. or CHARGE NO. SB123904003 PROJECT MRS

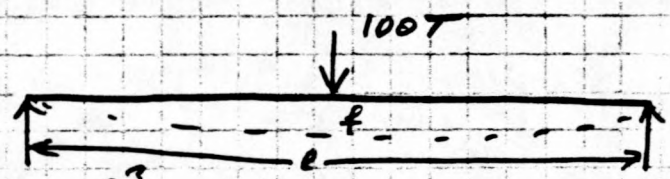
SUBJECT HATCH LIFTING DEVICE

Beam strength

use square sect. beam.

~~Assume stopping distance~~

Assume concentrated load at center of beam.



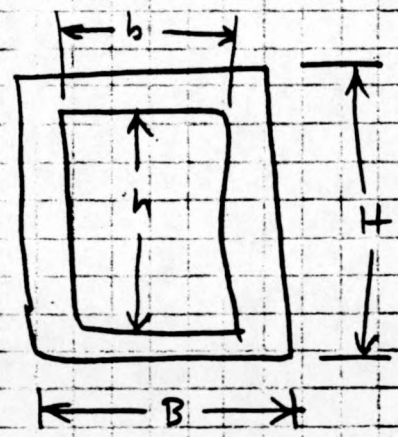
$$f = \frac{W}{EI}\frac{l^3}{48}$$

$$W = \frac{100}{0.0005} = 2\times10^5 \text{ lbs.}$$

$$E = 2.9\times10^7 \ \frac{\text{lbs.}}{\text{in}^2}$$

$$I = \frac{BH^3 - bh^3}{12}$$

$$l = 140''$$



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Original Checked by J. W. Willis 11/20/85

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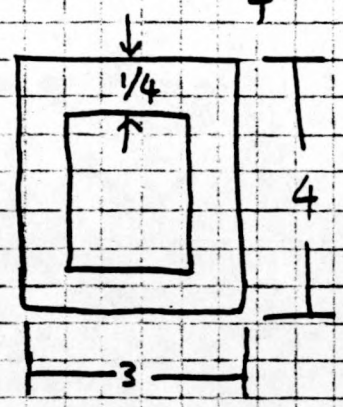
G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

Assume Sect. tube of size $4 \times 3 \times \frac{1}{4}$



$B = 3$
$H = 4$
$h = 4 - 0.5 = 3.5$
$b = 3 - 0.5 = 2.5$

$$I = \frac{(3 \times 4^3) - (2.5 \times 3.5^3)}{12}$$

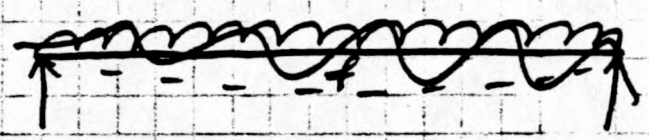
$= 7.07 \text{ in}^4$ [use 6.45 from AISC tables]

$$f = \frac{w \ell^3}{48 EI} = \frac{2 \times 10^5 \text{ lbs.} \times 140^3 \text{ in}^3}{48 \times 2.9 \times 10^7 \text{ lbs.} \times 6.45 \text{ in}^4}$$

$= \cancel{100}$

$\therefore f = \cancel{54.18}\ 61.12$ Beam no good.

~~Assume UDL~~



$$\cancel{f = \frac{W}{EI} \frac{5\ell^3}{384}} \ (\cancel{max})$$

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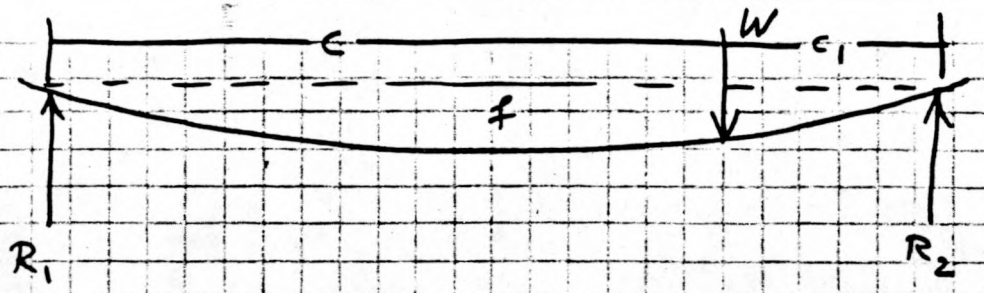
G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE



$$f = \frac{W c_1}{3EIL}\left[\frac{c(\ell + c_1)}{3}\right]^{3/2} \quad \text{(max)}$$

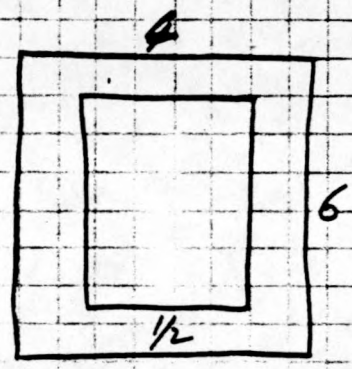
$$W = \frac{100\,T}{4} = \frac{25}{0.0005}\ \text{lbs.} = 5\times10^4\ \text{lbs.}$$

$c_1 = 15$ in.

$c = 140$ in.

$L = 155$ in.

$E = 2.9\times10^7$



$$I = \frac{BH^3 - bh^3}{12}$$

$B = 4$, $b = 3$

$H = 6$, $h = 5$

$$= \frac{4\times6^3 - 3\times5^3}{12}$$

$$= \cancel{40.25}\ 40.75 \quad \text{(use 33.4 from AISI tables)}$$

$$f = \frac{5\times10^4 \times 15}{3\times2.9\times10^7\times \cancel{40.25}\ 33.4 \times 155}\left[\frac{140(155+15)}{3}\right]^{3/2}$$

$$f = \cancel{0.96}\ 1.18 \text{ in.}$$

Beam still no good

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Original Checked by J.W. Willis 1/2/81 p. 167

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

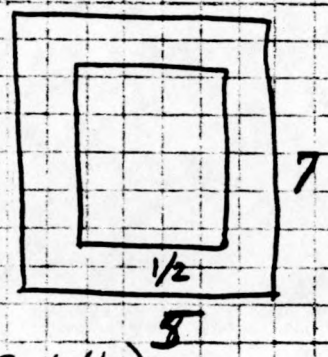
~~Assume beam = 7×5×$\frac{1}{2}$~~

~~Assume beam = 7×5×1/2 WE~~

Assume beam = 7×5×$\frac{1}{2}$

same loading as on p. 22

$$I = \frac{BH^3 - bh^3}{12}$$



$$= \frac{5 \times 7^3 - 4 \times 6^3}{12}$$

$$= 70.92 \quad (\text{use } 60.8 \text{ from AISI tables})$$

$$f = \frac{WC_1}{3EIL}\left[\frac{C(\ell + C_1)}{3}\right]^{3/2}$$

$$= \frac{5 \times 10^4 \times 15}{3 \times 2.99 \times 10^7 \times \cancel{70.92}\ 60.80 \times 155}\left[\frac{140\,(155 + 15)}{3}\right]^{3/2}$$

$$\boxed{f = \cancel{0.54}\ 0.63}$$

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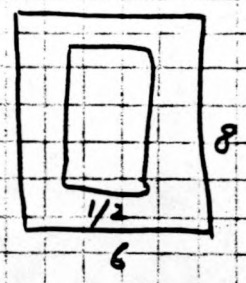
Original Checked by J.W. Willis 1/22/85 p. 168

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

Assume beam = 8 x 6 x 1/2



$$I = \frac{6 \times 8^3 - 5 \times 7^3}{12} = 113.08$$

[use 96.2 from AISI tables]

$$f = \frac{5 \times 10^4 \times 15}{3 \times 2.99 \times 10^7 \times \cancel{113.08}\ 96.2 \times 155} \left[\frac{140(155+15)}{3} \right]$$

$= 0.34$ in.

$\boxed{f = \cancel{0.34}\ 0.396 \text{ in.}}$ max. ~~[illegible]~~

deflection must be $\leq \frac{\text{the beam span}}{360}$ [AISI thumb rule]

Beam span = 155 ; $\frac{155}{360} = 0.431$ in.

f calculated above < 0.431

∴ above beam satisfactory.

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Original Checked by J.W. Wellis 7/24/85

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G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

From page 20, load / JAC = $\frac{50}{4}$ = 12.5 T

Assume a 20 BSJ-I JAC

Total height of JAC = 2.25 + 27 + 14.75 + 2.6875 = 46.6875

[30 BSJ-I was 52" high]

Starting input torque for rated load = 61 ft-lbs

Starting input torque for actual load = $\frac{61 \times 12.5}{20}$ = 38.125 ft-lbs

Worm Shaft Speed = (turns of worm for 1" raise) × lifting speed in inches/min.

= 16 × 27 = 432 RPM

∴ Required HP / JACK = $\frac{\text{Input torque (ft lbs)} \times \text{Worm shaft speed}}{5250}$

= $\frac{38.125 \times 432}{5250}$

= 3.14 HP

Arrangement η = 0.86 for four jacks (p. 37 of POWERJAC catalog)

So, arrangement HP = $\frac{4 \times 3.14}{0.86}$ = 15 HP

Input η of two right angle gear boxes = 0.95

So arrangement HP = $\frac{15}{0.95 \times 0.95}$ = 16.2 HP.

Select single-reduction gearmotor; η = 0.985

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G.O. or CHARGE NO. SB 123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

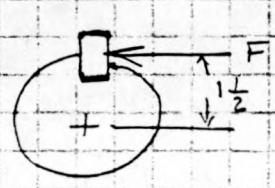
$\therefore$ arrangement HP $= \dfrac{16.2}{0.985} = \boxed{17\ hp}$

Worm shaft speed $= \boxed{432\ RPM}$

Torque output of reducer $= \dfrac{38.125}{0.86 \times 0.95 \times 0.95} = \boxed{50\ ft\text{-}lb.}$

TROLLEY MOTOR HP

Shaft dia = 3"



Min. distance the hatch travels = 15' = S [Trolley size is 12'-5"]

Assume that the hatch must be moved aside in 1 min.

$\therefore$ trolley velocity = 15'/min. = 1.25 ft./sec

Wheel dia = 15 in.; Assume that the wheel weighs 60T [50T for the hatch and 10T (assumed) for the trolley]. Assume a 60T solid cylinder of radius 7.5 in has to be moved at above vel. starting from rest. Then:

Moment of Inertia $= WK^2 = \frac{1}{2} \cdot WR^2 = \frac{1}{2} \times \frac{60}{0.0005}\ lb. \times \left(\frac{7.5}{12}\right)^2 ft^2$

$= 2.34 \times 10^4\ lb - ft^2$

Accelerating torque $= T = \dfrac{(WK^2)\,\Delta N}{308\,t}$

ΔN = Change in speed (rpm); initial rpm = 0; final rpm; for above → ones

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Original Checked by Lal Wellis 1/21/85

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G.O. or CHARGE NO. 5B123904003 PROJECT MRS

SUBJECT HATCH LIFTING DEVICE

Sketch below received today from Ken Becraft of POW-R-JAC: →

The need for a double U-Joint is to prevent "random" velocities — caused by the whipping effect inherent in a long, slender shaft. Note also the elimination of a reducer but the use of 2:1 bevel boxes to reduce speed and increase power.

*

TROLLEY HP (Contd.)

wheel circumference = 47.12 in.;

@ 180 in./min, wheel rpm = $\frac{180}{47.12}$ = 3.82 rpm = ΔN

t = time to accelerate load (secs) = 5 secs, say

Then, $T = \frac{2.34 \times 10^4 \times 3.82}{308 \times 5} = 58.04$ ft-lb.

Horse Power $P = \frac{TN}{5250} = \frac{58.04 \times 3.82}{5250} = 0.04$ hp.

Loss in internal trolley friction = 5%, say; so hp = 0.042
Loss in chain = 5%, say; hp = 0.044
Loss in reducer = 5%, say; hp = 0.05

∴ Assume motor required is 1.5 hp.

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Original Checked by J.W. Willis 1/24/55 p.172

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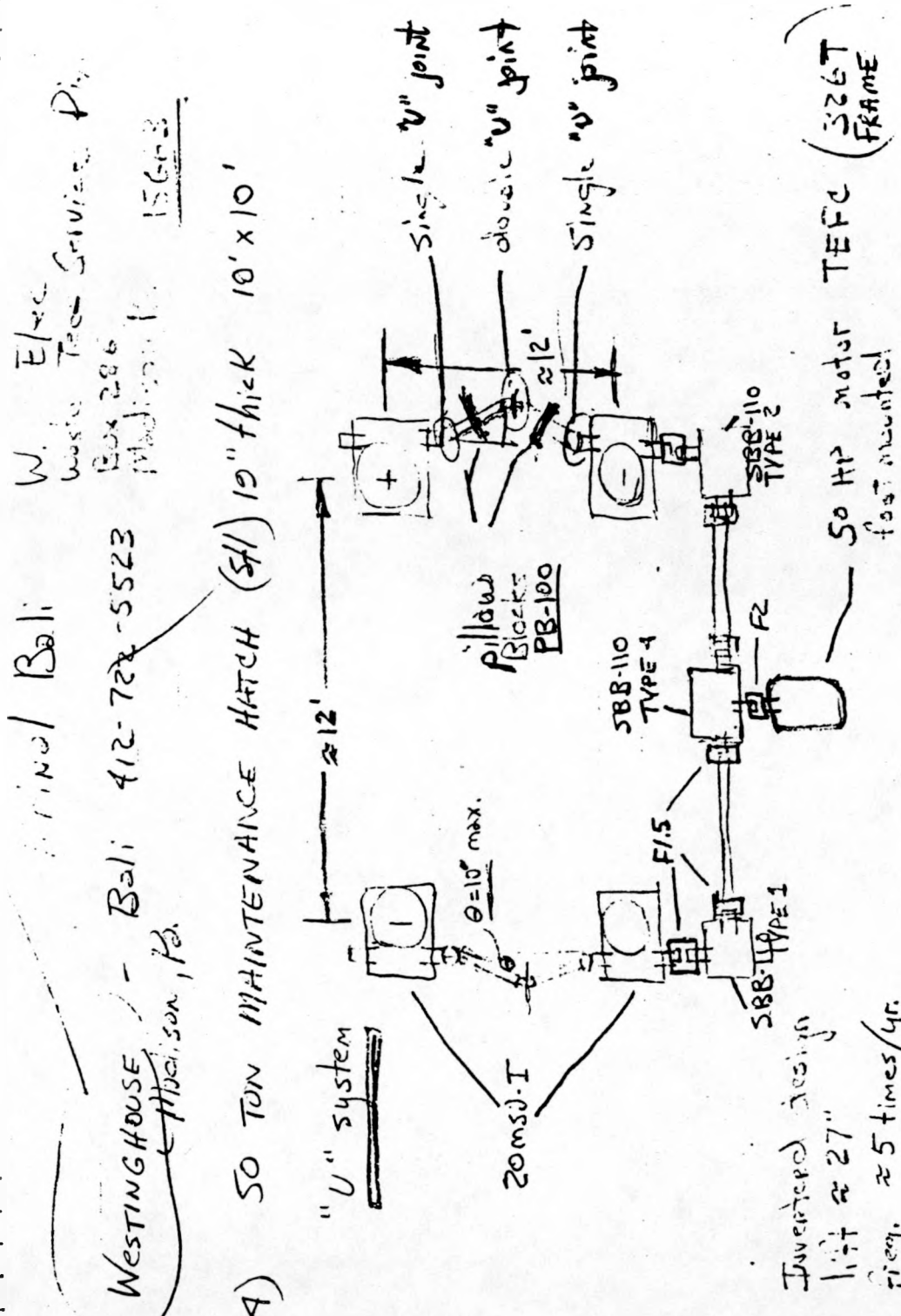
SUBJECT HATCH LIFTING DEVICE



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Original Checked by J. Williams 1/2/85 pr 173

G.O. or CHARGE NO. SB123904004 PROJECT MRS.

SUBJECT AS-DESIGNED WEIGHTS OF HATCHES AND PLUGS

Concrete Cask Unloading Port Plug — Cell # 3

See Drawing H-3-54932, Sht. 2

Steel volume $= \frac{\pi}{4} \times 136^2 \times 7$

$+ \frac{\pi}{4} \times 130^2 \times 7$

$+ \frac{\pi}{4} \times 116.5^2 \times 5$

$= 2.48 \times 10^5 \text{ in}^3$.

Sp. wt. of steel $= 0.284 \text{ lbs/in}^3$.

$\therefore$ Stl. wt. $= 2.48 \times 10^5 \times 0.284 = 7.04 \times 10^4$ lbs.

$= \underline{\underline{35.20 \text{ short tons}}}$.

BISCO vol. $= \frac{\pi}{4} \times 116.5^2 \times 4 = 4.26 \times 10^4 \text{ in}^3$.

BISCO sp. wt. $= 0.064 \text{ lbs/in}^3$.

BISCO wt. $= 4.26 \times 10^4 \times 0.064 = 2.73 \times 10^3$ lbs.

$= \underline{\underline{1.36 \text{ T}}}$

Angle length $= \pi \times 116.5 = 366$ in. $= 30.50$ ft.

Wt. of angle/ft. $= 5.8$ lbs.

$\therefore$ Angle wt. $= 176.90$ lbs

$= \underline{\underline{0.09 \text{ T}}}$

Vol. of bottom plate $= \frac{\pi}{4} \times 116.5^2 \times 0.25 = 2.66 \times 10^3 \text{ in}^3$.

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Checked by: W.H.B. for J.W. W.H.S 8/7/85

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G.O. or CHARGE NO. SB 123904004 PROJECT MRS

SUBJECT AS-DESIGNED WEIGHTS OF HATCHES AND PLUGS

Wt. of bottom Pl = $2.66 \times 10^3 \times 0.284$ = 756.83 lbs.

= 0.38T

Neglect all other parts of the plug.

Total weight = 35.20 + 1.36 + 0.09 + 0.38 = 37.03T

≈ 37T

Other Port Plugs

See Drawing H-3-54932 Sht. 1

Steel volume = $\frac{\pi}{4} \times 113^2 \times 6.75$ = 6.77×10^4 in^3

Steel wt. = $6.77 \times 10^4 \times 0.284$ = 1.92×10^4 lbs

= 9.61 T

Lead top Pl vol. = $\frac{\pi}{4} \times 98^2 \times 0.25$ = 1.89×10^3 in^3

Lead top Pl wt. = $1.89 \times 10^3 \times 0.284$ = 535.55 lbs.

= 0.27T

Lead channel length = $\pi \times \frac{98}{12}$ = 25.66 ft.

Lead channel weight = 25.66 × 22.7 = 582.40 lbs. = 0.29T

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Original checked by J.W. Willis 1/21/85 p. 175

G.O. or CHARGE NO. SB123904004 PROJECT MRS

SUBJECT AS-DESIGNED WEIGHTS OF HATCHES AND PLUGS

Dead Bottom Pl. vol. = $\frac{\pi}{4} \times 98^2 \times 2 = 1.51 \times 10^4$

Dead Bottom Pl wt. = $1.51 \times 10^4 \times 0.284 = 4.28 \times 10^3$ lbs.

= **2.14 T**

(assuming BISCO at bottom)

BISCO vol. = $\frac{\pi}{4} \times 85^2 \times 4 = 2.27 \times 10^4$ in^3.

BISCO wt. = $2.27 \times 10^4 \times 0.064 = 1.45 \times 10^3$ lbs.

= **0.73 T**

BISCO bottom Pl vol. = $\frac{\pi}{4} \times 85^2 \times 0.25 = 1.42 \times 10^3$ in^3.

BISCO bottom Pl wt. = $1.42 \times 10^3 \times 0.284 = 4.03 \times 10^2$ lbs.

= **0.20 T**

Angle length = $\pi \times \frac{85}{12} = 22.25$ ft

Angle wt. / ft. = 5.8 lbs.

Angle weight = $22.25 \times 5.8 = 129.07$ lbs.

= **0.06 T**

Dead Volume = $\frac{\pi}{4} \times 98^2 \times 7 = 5.28 \times 10^4$ in^3

Dead wt. = $5.28 \times 10^4 \times 0.41 = 2.16 \times 10^4$ lbs.

= **10.82 T**

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G.O. or CHARGE NO. SB123904004 PROJECT MRS

SUBJECT AS-DESIGNED WEIGHTS OF HATCHES AND PLUGS

Total wt. of Steel Plug = $\boxed{7.61\ T}$

Total wt. of Lead Plug = 0.27 + 0.29 + 2.14 + 0.73 + 0.20 + 0.06 + 10.82

= $\boxed{14.5\ T}$ ← crane to lift this wt. max.

Maintenance Hatches (see Drawing H-3-54932)

Steel volume = 120 × 120 × 19 = 2.74×10^5 in³.

Steel wt. = $2.74 \times 10^5 \times 0.284 = 7.77 \times 10^4$

(this assumes no plug in middle) = 38.85 T.

BISCO volume (assuming BISCO at bottom) = $107^2 \times 4 = 4.58 \times 10^4$ in³

BISCO wt. = $4.58 \times 10^4 \times 0.064 = 2.93 \times 10^3$ lbs

= 1.47 T

Square angle length (Outer angle) = $\frac{107 \times 4}{12}$ = 35.67 ft.

Square angle wt. = 35.67 × 5.8 = 206.87 lbs. = 0.10 T

Plug angle length = $\pi \times \frac{67}{12}$ = 17.54 ft.

Plug angle wt. = 17.54 × 5.8 = 101.74 lbs. = 0.05 T

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original checked by J.W. Wells 1/2/85 p. 177

G.O. or CHARGE NO. SB123904004 PROJECT MRS

SUBJECT AS-DESIGNED WEIGHTS OF HATCHES AND PLUGS

Inner angle on hatch $= \pi \times \frac{67.5}{12} = 17.67$ ft.

Inner angle wt. $= 17.67 \times 5.8 = 102.49$ lbs $= \underline{\underline{0.05T}}$

Steel vol. of plug $= \frac{\pi}{4} \times 67^2 \times 2$

$+ \frac{\pi}{4} \times 53^2 \times 3$

$+ \frac{\pi}{4} \times 47.5^2 \times 14$

$= 3.85 \times 10^4$ in^3

Steel wt. of plug $= 3.85 \times 10^4 \times 0.284 = 1.09 \times 10^4$ lbs.

$= \underline{\underline{5.46T}}$

Bisco vol. of plug $= \frac{\pi}{4} \times 47.5^2 \times 4 = 7.09 \times 10^3$ in^3

Bisco wt. of plug $= 7.09 \times 10^3 \times 0.064 = 4.54 \times 10^2$ lbs.

$= \underline{\underline{0.23T}}$

Bottom Plate volume $= 107^2 \times 0.25 = 2.86 \times 10^3$ in^3

Bottom Pl wt. $= 2.86 \times 10^3 \times 0.284 = 8.13 \times 10^2$ lbs

$= \underline{\underline{0.41T}}$

Plug bottom Pl vol. $= \frac{\pi}{4} \times 47.5^2 \times 0.25 = 4.43 \times 10^2$ in^3

Plug bottom Pl wt. $= 4.43 \times 10^2 \times 0.284 = 125.82$ lbs

$= \underline{\underline{0.06T}}$

SIGNATURE MSali DATE 8/28/84 TRB NO. MB-01 PAGE 33

Original checked by J.W. Willis 1/21/85 - p. 178

G.O. or CHARGE NO. SB123904004 PROJECT MRS

SUBJECT AS-DESIGNED WEIGHTS OF HATCHES AND PLUGS

Total hatch wt. = 38.85 + 1.47 + 0.10 + 0.05 + 0.05 + 0.41

= 40.93

≈ 41 T

Plug wt. = 5.46 + 0.23 + 0.06 + 0.05 = 5.8 T

PLASTIC ON TOP

(See drawing H-3-54932 Sheet 1)

Steel Plug weight

Plastic = $\frac{\pi}{4} \times 113^2 \times 4 \times 0.064 \times 0.0005$ = 1.28 T

Steel = $\frac{\pi}{4} \times 113^2 \times 6.75 \times 0.284 \times 0.0005$ = 9.61 T

Angle = $\pi \times \frac{113}{12} \times 5.8 \times 0.0005$ = 0.09 T

Plate = $\frac{\pi}{4} \times 113^2 \times 0.25 \times 0.284 \times 0.0005$ = 0.36 T

11.34 T

Lead Plug Weight

Channel = $\pi \times \frac{98}{12} \times 22.7 \times 0.0005$ = 0.30 T

Lead = $\frac{\pi}{4} \times 98^2 \times 7 \times 0.41 \times 0.0005$ = 10.82 T

Top Pl = $\frac{\pi}{4} \times 98^2 \times 0.25 \times 0.284 \times 0.0005$ = 0.27 T

Bottom Pl = $\pi/4 \times 98^2 \times 2 \times 0.284 \times 0.0005$ = 2.14 T

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Calcs checked by J.W. Willis 1/24/85

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G.O. or CHARGE NO. SB123904004 PROJECT MRS

SUBJECT PLUG WEIGHTS (AS BUILTS)

Total Pb plug weight = 13.53T

Plug for Cell #3 (See dwg. H-3-54932)

Plastic = $\frac{\pi}{4} \times 136^2 \times 4 \times 0.064 \times 0.0005$ = 1.86 T

Steel = $\frac{\pi}{4} \times 136^2 \times 7 \times 0.284 \times 0.0005$ = 14.44 T

Steel = $\frac{\pi}{4} \times 130^2 \times 7 \times 0.284 \times 0.0005$ = 13.20 T

Steel = $\frac{\pi}{4} \times 116.5^2 \times 5 \times 0.284 \times 0.0005$ = 7.57 T

37 T

add angle and pl wt.

angle = $\pi \times \frac{136}{12} \times 5.8 \times 0.0005$ = 0.103 T

top pl = $\pi/4 \times 136^2 \times 0.25 \times 0.284 \times 0.0005$ = 0.52 T

32.62 T

Hatch — with plug (see dwg. H-3-54932)

Plastic = $120^2 \times 4 \times 0.064 \times 0.0005$ = 1.84 T

Steel = $120^2 \times 17 \times 0.284 \times 0.0005$ = 38.85 T

Angle = $\frac{120 \times 4}{12} \times 5.8 \times 0.0005$ = 0.116 T

Pl = $120^2 \times 0.25 \times 0.284 \times 0.0005$ = 0.51 T

41.32 T

SIGNATURE [signature] DATE 9/14/84 TRB NO. MB-01 PAGE 35

Original Checked by J.W. Willis 1/21/87

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G.O. or CHARGE NO. SB123904004 PROJECT MRS

SUBJECT PLUG WEIGHTS (AS BUILTS)

Hatch Plug Wt.

Plastic = $\frac{\pi}{4} \times 67^2 \times 4 \times 0.064 \times 0.0005$ = 0.45 T

Steel = $\frac{\pi}{4} \times 67^2 \times 2 \times 0.284 \times 0.0005$ = 1.00 T

Steel = $\frac{\pi}{4} \times 53^2 \times 3 \times 0.284 \times 0.0005$ = 0.94 T

Steel = $\frac{\pi}{4} \times 47.5^2 \times 14 \times 0.284 \times 0.0005$ = 3.52 T

5.92 T

angle = $\frac{67\pi}{12} \times 5.8 \times 0.0005$ = 0.051 T

top ℞ = $\frac{\pi}{4} 67^2 \times 0.25 \times 0.284 \times 0.0005$ = 0.125 T

6.096 T

≈ 6.1 T

If both Steel and Pb plugs made of steel, and top part remains the same, the bottom wt. ↓.

Steel thickness required = 18.18 − 6.75 − 0.25 = 11.18

Steel Wt. = $\frac{\pi}{4} \times 98^2 \times 11.18 \times 0.284 \times 0.0005$ = 11.97 T

SIGNATURE [illegible] DATE 14 Sep 84 TRB NO. MB-01 PAGE 36

Original Checked by J.W. Wellis 1/21/85

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G.O. or CHARGE NO. SB1239-0 - PROJECT MRS

SUBJECT MRS: TRANSPORTER - DRY WELL CANISTERS

1ST CUT AT WEIGHT OF LOADED CANISTERS
ASSUME WE 17x17 @ 264 RODS/ASSEM
ROD WT 2.5 Kg each = 5.5 lb each

2 PWR/CANISTER
ROD WT: 2x264x5.5 = 2910 lbs
CANISTER WT 10" SCH 40 @ 40.48#/ft
for 13.5 ft: 13.5x40.48 ≈ 550 lbs
ENDS @ 2" thk - 2x10.75² π/4 x .283 ≈ 50 lbs
ASSEMBLED CASK WT 3510#

for BWR @ 5x49x4.4 kg x 2.205 lb/kg ≈ 2375 lb
CANISTER AS ABOVE (600#)
ASSEMBLED WT ≈ 2975 lb

OD OF CANISTER IS 10.75"

shielded cask for transport:
from TME 3138, p192, transport cask is 65 cm thk (carbon steel) for 33 mr/h surface dose. Cast wt:

t: 65 cm = 25.6"
d: 10.75 + 1.25 = 12"

$$wt = \left(\left((12+2\times 25.6)^2 - 12^2\right)\frac{\pi}{4}\times 14\times 12 + 63.2^2\,\pi/4 \times 25.6\times 2\right)\times .283$$

wt, cask = 189,226 lbs (94.6 TONS)
THIS SEEMS TOO MUCH

CAST IRON @ 40 cm THICK: (from NESD TME 3131, p249)
t: 40 cm = 15.75"
wt = 0.26 (((12+2x15.75)² - 12²) π/4 x 14x12 + 43.8² π/4 x 15.75x2)
wt = 72150 lbs (36.07 tons)
MORE REASONABLE!

Checked: E.J. Trutanych 2/1/85

SIGNATURE WHB for G.V.L. Hall DATE 2/7/85 TRB NO. GH001 PAGE 16

G.O. or CHARGE NO. SB1239-06-00 PROJECT MRS

SUBJECT DRYWELL TRANSFER SHIELD · WEIGHT ESTIMATES

$\rho_{PARAFIN}$ = 0.9 wt = .9 × 62.4 ÷ 1728 = .0325 #/in³ (17)
ρ_{Pb} = 11.34 wt = .4225 (12)
ρ_{steel} = 7.83 wt = .2828 #/in³ (13)

FOR CSF (G01)

STEEL	$(16^2 - 15.5^2)\pi/4 \times 216 \times .2828$	=	756 #
	$(29.5^2 - 27.5^2)\pi/4 \times 252 \times .2828$	=	6385
	$(35^2 - 34.5^2)\pi/4 \times 204 \times .2828$	=	1575
	$29.5^2\ \pi/4 \times 1 \times .2828$	=	193
	$29.5^2\ \pi/4 \times 3 \times .2828$	=	580
		Σ ~	9490
LEAD	$(27.5^2 - 16^2)\pi/4 \times 225 \times .4225$	=	37515
	$(27.5^2)\pi/4 \times 2 \times 5.75 \times .4225$	=	2885
		Σ ~	40400
BISCO NS3	$(34.5^2 - 29.5^2)\pi/4 \times 216 \times .0643$	=	3489
		Σ	53381 # say 53500

FOR CHLW1 (G02)

STEEL	$(16.0^2 - 15.5^2)\pi/4 \times 204 \times .2828$	=	715 #
	$(31.5^2 - 29.5^2)\pi/4 \times 242 \times .2828$	=	6562
	$(39.0^2 - 38.5^2)\pi/4 \times 192 \times .2828$	=	1568
	$(31.5^2\ \pi/4 \times 1 \times .2828$	=	220
	$31.5^2\ \pi/4 \times 3 \times .2828$	=	662
		~ Σ	9730
LEAD	$(29.5^2 - 16.0^2)\pi/4 \times 214 \times .4225$	=	43620
	$(29.5^2 \times \pi/4 \times 8.75 \times 2 \times .4225$	=	3900
		~ Σ	47520
BISCO	$(36.5^2 - 31.5^2)\pi/4 \times 204 \times .0643$	=	3500
		Σ	60750 say 61000

Checked: L.O. Pistangelo 2/1/85 Conf.

SIGNATURE WHB for G.V.B. Hall DATE 6/7/85 TRB NO. GH001 PAGE 26

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1.78 g/cc NS3

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

CONT. from P26

FOR CHLW2 (G03)

STEEL	$(30^2 - 29.5^2)\pi/4 \times 144 \times .2828$	=	950 #
	$(45.5 - 43.5^2)\pi/4 \times 180 \times .2828$	=	720
	$(61.0^2 - 50.5^2)\pi/4 \times 132 \times .2828$	=	1490
	$45.5^2\ \pi/4 \times 1 \times .2828$	=	460
	$45.5^2\ \pi/4 \times 3 \times .2828$	=	1380
	$\sim \Sigma_{st}$		11400
LEAD	$(43.5^2 - 30^2)\pi/4 \times 154 \times .4225$	=	50705
	$(43.5^2 \times \pi/4 \times 2 \times 8.75 \times .4225$	=	8475
	$\sim \Sigma_{pb}$	=	59180
BISCO	$(50.5^2 - 45.5^2)\pi/4 \times 144 \times .0643$	=	3490
	$\sim \Sigma$	$\sim$	74070 #
	say		74500
			80500

Checked: E.O. Stratangelo 4/1/85

SIGNATURE W.H.B. for G.V.B. Hall DATE 8/7/85 TRB NO. 64001 PAGE 27

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Drywell - Shield Plug Wts.

16.00 drywell

$$= \left[\left(\frac{\pi}{4} 18.75^2\right)6 + \left(\frac{\pi}{4} 17.78^2\right)5 + \left(\frac{\pi}{4} 3^2\right)(1.25) + \left(\frac{\pi}{4} 2.375^2\right)(2.31) + \right.$$

ave diameter of taper

$$\left.\left(\frac{\pi}{4} 1.75^2\right)1.19 + \left(\frac{\pi}{4} 1.5^2\right)2.75\right] .284 \frac{lb}{in^3} = \underline{\underline{831 \text{ lb.}}}$$

spindle weighs 10 lbs.

1800 drywell

$$= \frac{\pi}{4}(.284)\left[(13.00^2)(7.5) + (17.73^2)6.50 + (3^2)(1) + (2^2)(3.5)\right] = \underline{\underline{1065 \text{ lb}}}$$

30.00 drywell

$$= \frac{\pi}{4}(.284)\left[34.75^2(10) + 33.82^2(4) + 6.5^2(5.5) + 9.12^2(2)\right] = \underline{\underline{3803 \text{ lb}}}$$

36.00 drywell

$$= \frac{\pi}{4}(.284)\left[(40.75^2)(10) + 39.83^2(4) + 6.5^2(5.5) + 9.12^2(2)\right] = \underline{\underline{5208 \text{ lb}}}$$

Checked by: W. H. Blunk

Date: 2/8/85

SIGNATURE J. P. Fratangelo DATE 1/14/85 TRB NO. EPFO4MRS PAGE 14

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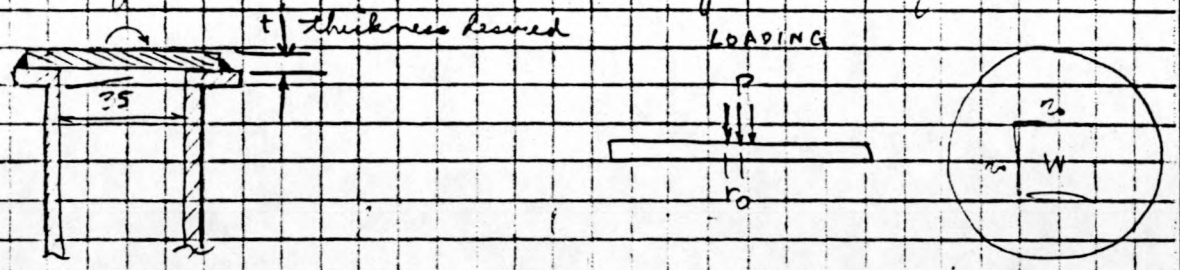
CHARGE NO. _____ PROJECT M2S

T Drywell Lid Thickness

For 30" drywell, lid is 37"ϕ covering 36"ϕ drywell



Lid will be used to prevent failure if canister transfer cart passes over it. (George Hall has info on cart)

Front wheels present biggest problem
They carry a load of 34,200 LB each and have a footprint of 20x21."
Thus, they apply the load to the lid.

Since there is more force at the center of the footprint, assumed footprint will be 10" x 20."

Roark and Young #16 page 366

$\sigma = \frac{6M}{t^2}$ $t = \sqrt{6M/\sigma}$

$r = 0$ $M = M_{max}$

$M_r = \frac{W}{4\pi}\left[(1+\nu)\ln\frac{a}{r_o} + 1\right] = \frac{34,200}{4\pi}\left[(1+.29)\ln\frac{37}{10} + 1\right] = 7315$ IN-LB

$M_t = M_r = 7315$ MAX MOMENT $\sqrt{7315^2 + 7315^2} =$

$\sigma = \frac{6(10344)}{t^2}$ = $t \geq 2.25$ IN $\sigma = 12$ KSI for A36

2 16" drywell

$M_r = \frac{34,200}{4\pi}\left[(1+.29)\ln\frac{21}{10} + 1\right] = 5346$ 7551 $\sqrt{}$ 5346

$\sigma = \frac{(7551)6}{t^2}$ $t \geq 2.00"$

Checked by: W. H. Rhines 2/8/85

URE B. P. Fitzgerald DATE 9/20/84 TRB NO. EPF03M2S PAGE 68

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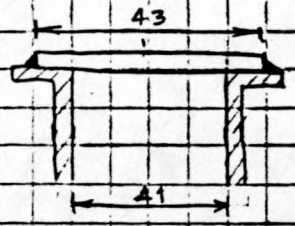
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Drywell Lid Thickness

Refer to page 68 in TRB EPF03

Refer to H-3-55052 GR. 2



$$M_r = \frac{W}{4\pi}\left[(1+\nu)\ln\frac{a}{r_o}+1\right] = \frac{34,200}{4\pi}\left[(1+.29)\ln\frac{43}{10}+1\right]$$

$$= 7842 \text{ IN-LB} = M_t$$

$$M_{TOT} = \sqrt{M_r^2+M_t^2} = \sqrt{7842^2+7842^2} = 11,090 \text{ IN-LB}$$

$$t = \sqrt{\frac{6M}{\sigma}} = \sqrt{\frac{(6)11090}{12000}} = \underline{\underline{2.35''}}$$

Checked by: W. H. Blissell
2/8/85

SIGNATURE E. P. Tsiatangelo DATE 2/8/85 TRB NO. EPF04MRS PAGE 18

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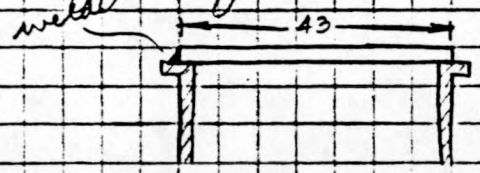
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Drywell lid weld size

Determine size of fillet weld around drywell lid.

Analyze largest diameter lid as worst case.



From Roark pg. 366, case 16

$$M_r = \frac{-W}{4\pi} = \frac{34200}{4\pi} = 2721 \text{ IN-LB MAX}$$

$$M_t = \frac{-\nu W}{4\pi} = \frac{-(.29)(34200)}{4\pi} = 783 \text{ IN-LB}$$

$$M_{TOT} = \sqrt{2721^2 + 783^2} = 2831 \text{ IN-LB/IN}$$

From design of welded structures page 7.4-7 Table 5

$S_W = \frac{\pi d^2}{4}$

$f = M/S_W$ – actual force on weld

weld size = $\frac{f}{\text{allowable weld strength}}$

$$S_W = \frac{\pi 43^2}{4} = 1452$$

$$f = \frac{2831}{1452} \approx 2$$

weld size = $\frac{2}{10000 \text{ PSI}}$ = .0002" weld size

assumed strength

i.e. – any weld size is acceptable, maybe even tack weld

Checked by: W. H. Blanc
2/8/85

SIGNATURE E.P. Iratorgel DATE 2/8/85 TRB NO. EPF04MRS PAGE 19

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W.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Temporary drywell cover DESIGN OK NIX CALCS

16" DRYWELL

Lid is designed to temporarily cover and also used to carry and place the liner in the drywell hole.

LINER WEIGHT

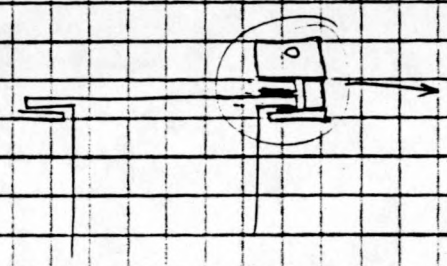
Stub end - $(.5)(\pi\ 20)(12)(.284) = 107$

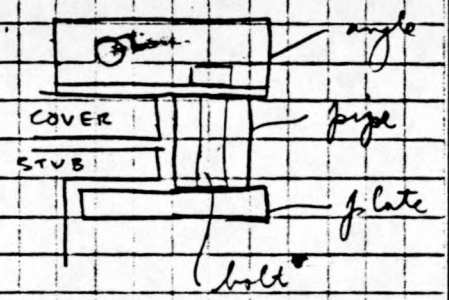
Reduc. - $(.5)(\pi\ 18_{AVG})(12)(.284) = 161$

Flg - 96

Pipe - $(.5)(\pi\ 16)(208)(.284) = 1484$

~ 1900 LBS assume 2000 LBS

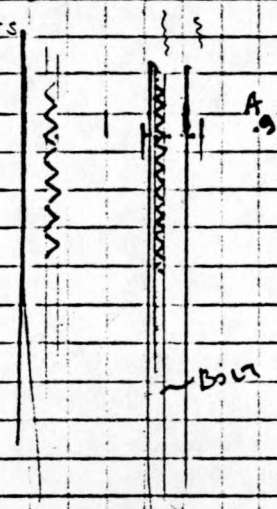




If only 2 "lugs" take the load, each bolt must support 1000 LBS.

Use 5/8 BOLTS

MIN. D. = .5135
MAJ. D = .6250



3/4 XXS PIPE ~ 5/8

OR

3/4 SCH 160 ~ 3/4

Checked by: W.H. Rhines 2/4/85

SIGNATURE Eric P. Trotangelo DATE 8/31/84 TRB NO. EPFO/MRS PAGE 63

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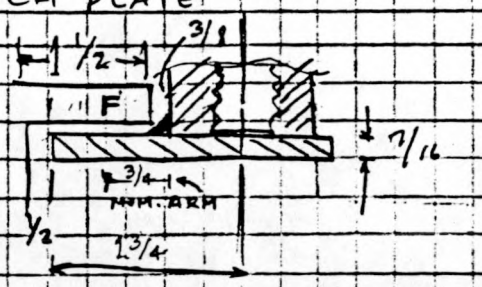
X + 3/8 + X + 1/2 + 4

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

SIZE "CATCH" PLATE



$M = (1000\ LB)(1\ 7/8) = \cancel{1000}\ 750\ 525$ LB · IN

$\sigma = \frac{Mc}{I} = \frac{(\cancel{1000}\ 750)(7/32)}{\frac{1}{12}\, b\, (7/16)^3}$

~~b = 3.5"~~ (5 b yield)

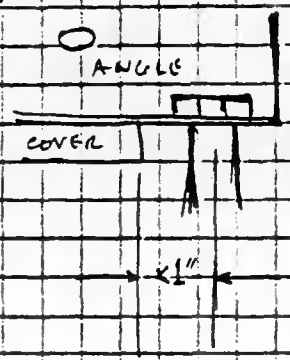
~~b = 2.67"~~

~~b ≥ 2.00~~ 2.6

b ≥ 2.25

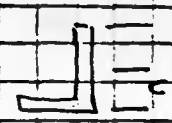
PL no 2 1/4" WIDE x 7/16 THK x 2 7/8" long

SIZE ANGLE



$M = (1000)(1") = 1000$ IN LB

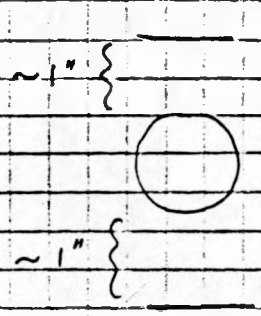
$\sigma = \frac{Mc}{I}$



Determine height

$\frac{Mc}{I} = \sigma \quad \frac{(1000)c}{\frac{1}{12} b (2c)^3} = \sigma \quad \frac{1000}{\frac{2}{3} b c^2} = \sigma \quad .125 = bc^2$

Any angle will the work



calc. shear

$\frac{F}{\tau} = A = \frac{1000}{6000} = 1/6\ IN^2$

okay

3/8" angle 3 x 2"

Checked by: W. H. Blair 2/6/85

SIGNATURE G. P. Fratangelo DATE 8/31/84 TRB NO. EP103MES PAGE 37

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4/8 + 3/8 + 14/8

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Temporary drywell cover

SIZE BOLTS — 30" DRYWELL

Lin. Weight

Stub = (.5)(π 36)(12)(.284) = 193
Red. = 360
Cap = 175
Pipe = (.5)(π 36)(207.5)(.284) = 2777

≈ 3600 LBS

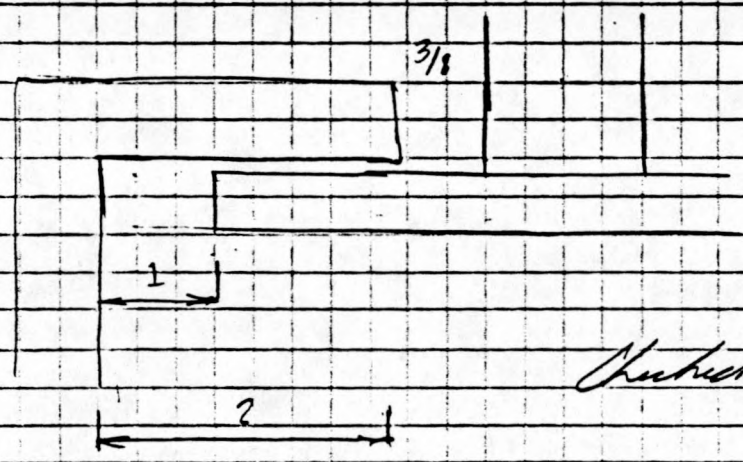
Again, assume 2 carry load, 1800 LBS each

Use 3/4" BOLT in 3/4 SCH 160 PIPE

SIZE "CATCH" PLATE

$$\sigma = \frac{Mc}{I} = \frac{M\ 7/32}{\frac{1}{12}(4)(7/16)^3} = 12000$$

M = 1531
M = Fr
$r = \frac{1531}{1800} = .85$



Checked by: W. H. Blanchard
2/6/85

SIGNATURE E. P. Tratanych DATE 8/31/84 TRB NO. EP1703MRS PAGE 65

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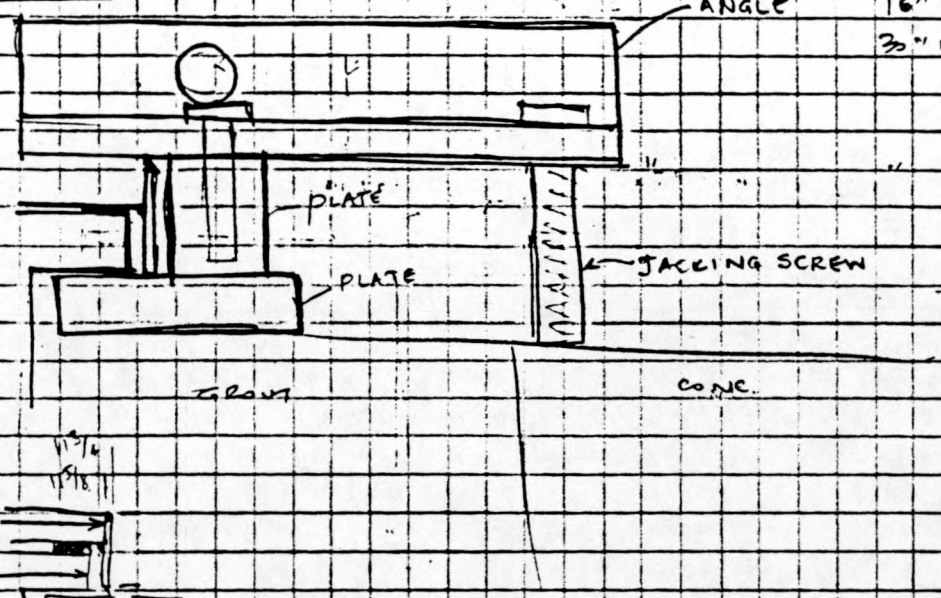
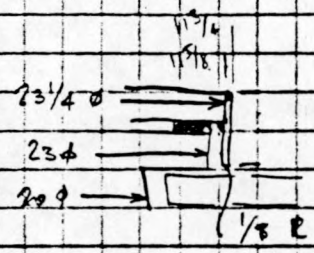
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Drywell Lifting and Positioning device

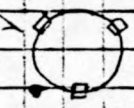
16" WELL



16" LINER WT = 2000
30" LINER = 36[illegible]

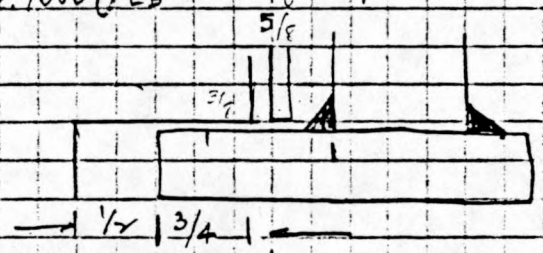


Drywells are laying down when the lifting device is placed on it. Assume workmen place lid on lift shown



When lifted 1/2 of weight will be supported by one ~~pt~~ lug.

For 16" drywell weighing approx 2000 LB, One lug will support approx. 1000 LB



$1 + 1/8 + 1/8 + 3/8$

$1\frac{5}{8}$

1 INCH MOMENT ARM

$$\sigma = \frac{Mc}{I} = \frac{Mc}{\frac{1}{12}b(2c)^3} = \frac{Mc}{\frac{2}{3}bc^3} = \frac{3M}{2bc^2}$$

$b = 2.75$ w/ $t = 7/16"$
$b = 3.5$ w/ $t = 3/8"$
$b = 2.0$ w/ $t = 1/2"$

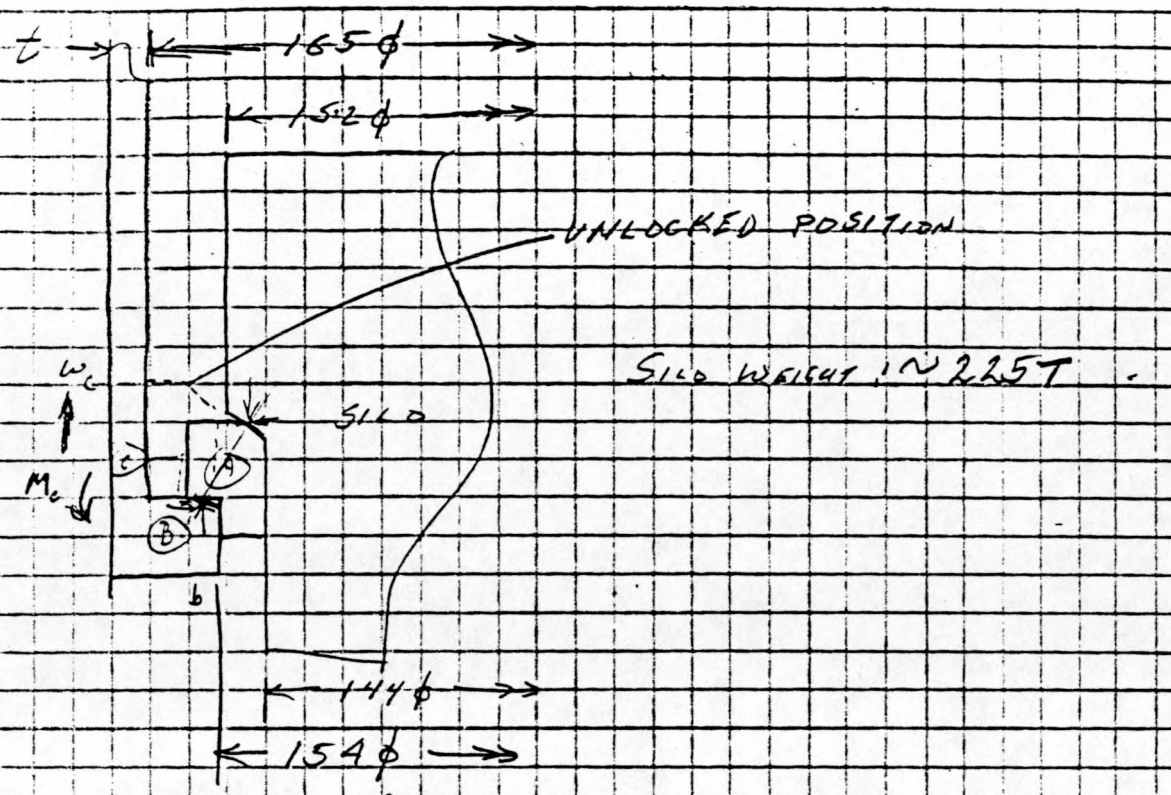
Checked by: W.H. Blessell
2/6/85

SIGNATURE E.P. Fratangelo DATE 9/4/84 TRB NO. EPF03MRS PAGE 66

Pr 192

G.O. or CHARGE NO. SB1239-05 PROJECT MRS - SILO LIFTER

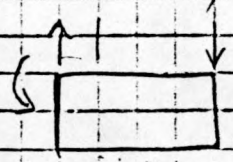
SUBJECT MRS - CONCRETE SILO LIFTING DEVICE



M & w in free body C (M_c & w_c) must support weight of silo plus act of lifting eq. say ans the 5T. use S.F. of 5. so, at b: $w = (225+5)(2000 \times 5) \div (154\pi)$

$w_b = 4753.98$ lb/in

for the free body, B, assume simple support at outer edge with lin load at inner edge (Roark, case 1a, p 334) and uniform moment (from reaction with "C") at outer edge. (Case 5a, p 351)



$a = 82.5 + t$ $b = 77$

cont →

Checked: E.P. Stratanoff 7/1/95

SIGNATURE [illegible] DATE 17 July 95 TRB NO. SH031 PAGE 17

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G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

cont from P 17

the OD of the ring (radius a) is dependent upon reactions in the supporting shell, free body "c". This shell is loaded by the weight of the site & ring plus the moment due to the ring reactions. For the moment reactions see Roark, Case 3, p 460, & Case 10, p 462. In either event $M_{max} = M_o$ for $x = 0$.

In (B) the moment load must produce the same slope at the outer edge (θ_a) as the lateral load, thus:

$$\theta_{a(1)} = \theta_{a(5)}$$

for 1a

$$\theta_a = \frac{wa^3}{D}\left(\frac{C_4 L_9}{C_7} - L_6\right) = F(1a)\frac{wa^2}{D}$$

and for 5a

$$\theta_a = \frac{-M_o a}{D}\left(\frac{C_4 L_8}{C_7} - L_5\right) = F(5a)\frac{-M_o a}{D}$$

so

$$M_o = wa\left(\frac{\frac{C_4 L_9}{C_7} - L_6}{\frac{C_4 L_8}{C_7} - L_5}\right) = wa\left(\frac{F(1a)}{F(5a)}\right)$$

where C_4, C_7, L_5, L_6, L_8 & L_9 depend on a

& $a = 82.5 + t$

$$\frac{6M_o}{t^2} + \frac{w_r}{t} = 30000 \text{ (max)}$$

cont →

Checked: G.P. Tatangelo 2/1/85

SIGNATURE JWB/HCI DATE 17 July 84 TRB NO. 001 PAGE 18

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT

from p 18

$C_4 = .5\left[(1+\nu)\frac{b}{a} + (1+\nu)\frac{a}{b}\right]$ $\qquad w = \frac{230 \times 2000 \times 5}{154\pi}$

$C_7 = .5(1-\nu^2)\left(\frac{a}{b} - \frac{b}{a}\right)$ $\qquad w = 4754$ lb/in

$L_5 = .5\left[1-\left(\frac{r_0}{a}\right)^2\right]$ where $r_0 = a$, thus $L_5 = 0$

$L_6 = \frac{b}{4a}\left[\left(\frac{b}{a}\right)^2 - 1 + 2\ln\frac{a}{b}\right]$

$L_8 = .5\left[(1+\nu) - (1-\nu)\left(\frac{a}{a}\right)^2\right]$, thus $L_8 = 1$

$L_9 = \frac{b}{a}\left\{\frac{1+\nu}{2}\ln\frac{a}{b} + \frac{1-\nu}{4}\left[1-\left(\frac{b}{a}\right)^2\right]\right\}$

	2.5	2.75	3.00	3.0556	
C_4	.9752	.9746	.9740	.9739	
C_7	.0901	.0928	.0955	.0961	
L_5	0	0	0	0	
L_6	.0041	.0044	.0046	.0047	
L_8	1	1	1	1	
L_9	.0866	.0889	.0911	.0916	
b/a	.9059	.9032	.9006	0.900	
$F(a)$	.9336	.9291	.9246	.9237	
$F(sa)$	10.8238	10.5041	10.2033	10.1388	
x	.0863	.0885	.0906	.0911	
$M_0(a)$	34855	35848	36835	37053	RINGS + SHELL LOADS
$w(a)$	4307	4294	4281	4297	
σ_m	1723	1561	1427	1400	shell stresses
σ_b	33461	28441	24557	23812	
$\sigma_m + \sigma_b$	35183	30003	25984	25212	
b =	77	77	77	77	
a =	87.5	88	88.5	88.611	

cont →

Checked E.A. Fratangelo 2/1/85

SIGNATURE [illegible] DATE 17 Aug 84 TRB NO. 001 PAGE 19

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G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

cont

using $t = 3$ for the shell:

$M_o = 36835$ in lb/in

& $\omega = 4281$ #/in, tension

$$\lambda = \left[\frac{3(1-\nu^2)}{R^2 t^2}\right]^{1/4} = \left[\frac{3(1-.3^2)}{84^2 \times 3^2}\right]^{1/4} = 0.08097 \quad (28)$$

$$D = \frac{E t^3}{12(1-\nu^2)} = \frac{29\times10^6 \times 3^3}{10.92} = 71.703E6 \quad (27)$$

at $l = 0$ $\cosh \lambda l = 1$ $\sinh \lambda l = 0$

$\cos \lambda l = 1$ $\sin \lambda l = 0$

$\therefore C_1 = 1,\ C_2 = 0,\ C_3 = 0,\ C_4 = 0$

$C_{11} = 0,\ C_{12} = 0,\ C_{13} = 0,\ C_{14} = 0$

let $\bar{x} = 0$, then

$F_1 = 1,\ F_2 = 0,\ F_3 = 0,\ F_4 = 0$

in TaCo 30, case 3, p 460

$LT_x = LT_y = LT_z = 0$

$LT_m = M_o$

in TaCo 30, case 10, p 462, for $x = 0$

$M_A = M_o = 36835$ $V_A = 0$ max $V = 962$ #/in @ $x = 9.7$"

$\psi_A = .0063$ rad $(.363°)$

$y_A = .0392$

$\sigma_1 = \frac{4281}{3} = 1427 \therefore \sigma_2 = \frac{\nu E}{R} + .3\sigma_1 = 13961$

$\sigma_1' = -\frac{6M}{t^2} = \frac{6\times36835}{3^2} = 24557,\ \sigma_2' = .3\sigma_1' = 7367$

cont →

Checked: GO Spotangels 7/1/85

SIGNATURE WHC [illegible] DATE 8/7/85 TRB NO. 001 PAGE 20

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G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

Cont:

in the ring (for body B): $b = 77$, $a = 85.5$ $\frac{b}{a} = .9006$

Avg 0.900

$$y = \frac{K_{y1} w a^3 - K_{y5} M_o a^2}{D} \qquad D = \frac{E t^3}{12(1-\nu^2)}$$

for t:	D:
4	169.9E6
~~4~~ 6	573.6E6
8	1359.7E6

$$y = \frac{.0938 \times 85.5^3 - .4754 + 1.0263 \times 36835 \times 85.5^2}{573.6E6}$$

$y = -0.0041$ in

$$\theta_b = \frac{.9532 \times 4754 \times 85.5^2 - 10.1388 \times 36835 \times 85.5}{573.6E6}$$

$\theta_b = 0.0021$ rad

$$\theta_a = \frac{.1237 \times 4754 \times 85.5^2 - 10.41 \times 36835 \times 85.5}{573.6E6}$$

$\theta_a = -0.0012$ rad

$M_t(b) = .9638 \times 4754 \times 85.5 - 10.5263 \times 36835$

$M_t(b) = 4014.9$ in lb/in

$Q_A = Q_b\left(\frac{b}{a}\right) = 4281$ lb/in

Checked: S.A. Fratangelo 7/1/85

SIGNATURE George B. Hall DATE 17 July 84 TRB NO. 001 PAGE 21

p. 197

$\frac{\pi d^2}{4}$

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete Cask Weights

31 11, 162, 1.5

Find loaded / unloaded weights 15'3" 183"

Spent Fuel Cask

Rebar

90 vertical	@ 252"	× 1/2	=	4453
45 radial hoop × 33	@ 28 1/2"	× 5/8	=	12984
45 vertical	@ 252"	5/8	=	3479
43 hoops (in)	@ 251"	1/2	=	2119
43 hoops (out)	@ 431"	1/2	=	3639
				26,674 in³ = 7575 LB REBAR

Concrete

$$228\,\frac{144^2\pi}{4} - 194\,\frac{72^2\pi}{4} + 36\,\frac{152^2\pi}{4} - 36\,\frac{72^2\pi}{4} + 36.5\,\frac{73.76^2\pi}{4} = 3,569,742$$

BOT LINER TOP PLUG L. PLUG CONC.

REBAR −26674 = 3,542,568

$(3,542,568)(.087) = 308,203$ LB

Liner

$$\left((2)(70\pi)(194) + (.5)(75.5\pi)(38) + (.5)\frac{\pi\,72^2}{4}\right) \cdot .284 = 26091\text{ LB}$$

LINER UN TOP BOT

Lids $\left(2\left(\frac{86^2\pi}{4}\right) + .5\left(\frac{74.76^2\pi}{4}\right)\right)(.284) = 3478$ LB

Plug Liner $\left[.5(74.26\pi)(36.5) + .5\,(74.76^2\pi/4)\right](.284) = 1932$ LB

Ribs $(3.5)(.75)(188)(16)(.1) = 790$ LB

Dividers $\left[(4)(31) + (4)(11)\right](1.5)(167)(.1) = 4208$ LB

Plates $(2)\left(68^2 - (12)(13.12^2)\right)\frac{\pi}{4}(1)(.1) = 401$

TOTAL = 352,578

Checked by: W.T. Rhymes 9/8/85

SIGNATURE Eric P. Fratangelo DATE 10/4/84 TRB NO. EPFO4MCS PAGE 1

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete Cask Heights

HLW

Same rebar cage as spent fuel canister 7575 LB 26673

Concrete

$(144^2 \frac{\pi}{4})\ 221.5 + -(152^2 \frac{\pi}{4})(42.5) - (182.5)(60^2 \frac{\pi}{4}) - (42.5)(67^2 \frac{\pi}{4}) +$ N^3

BOT TOP $+ 42.5(65^2 \frac{\pi}{4}) =$ 3,853,732

− REBAR 26673

3827059

$(3827059)(.087) =$ 332,954

Liner

$[2(58\pi)(182) + .5(66.5\pi)(42.5) + 1(59^2 \frac{\pi}{4})]\ .284 =$ 20874 LB

LIN LIN TOP

Lids

$[(2)\ \frac{71^2\pi}{4} + 1\ 65.76^2 \frac{\pi}{4}]\ .284 =$ 3213

LID PLUG LID

Plughlies

$[(.5)(65.76)(42.5) + (1)(64.76^2 \frac{\pi}{4})](.284) =$ 2173

LIN BOT

Ribs $(9.5)(.75)(179)(16)(.1) =$ 2040

Dividers $(8)(19)(1.5)(94)(.1) =$ 2143

Plates $2[56^2 - (9)(13.12)^2]\ \frac{\pi}{4}(1)(.1) =$ 249

371 221

TOTAL = ~~374,377~~ empty

20,700

~~395,7~~ " ed

391,921

Checked by W.H. Blessed 2/6/85

SIGNATURE E.P. Tratangelo DATE 10/4/84 TRB NO. EPROGRESS PAGE 2

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete Cask Weights

Non-fuel Components

Rebar cage is assumed to weigh 1/2 that of the spent fuel rebar cage.

Rebar weighs 3788 LB (13336 IN³)

Concrete

$$224\left(144^2\frac{\pi}{4}\right) - 188\left(63^2\frac{\pi}{4}\right) + 40\left(152^2\frac{\pi}{4}\right) - 40\left(67^2\frac{\pi}{4}\right) + \left(64.75^2\frac{\pi}{4}\right)40 =$$

BOT TOP PLUG

3778.546
− 13336
(3765210)(.087) = 327,573 LB

Liner $\left[2(61\pi)188 + (.5)(66.5\pi)40 + 2\left(59^2\frac{\pi}{4}\right)\right].284 = 234480$ LB

LIN TOP LIN BOT

Lids $\left[2\left(71^2\frac{\pi}{4}\right) + 1\left(65^2\frac{\pi}{4}\right)\right].284 = 3224$ LB

Plug liner $\left[1\left(65^2\frac{\pi}{4}\right) + (.25)(40)(65.25\pi)\right].284 = 1540$ LB

BOT

359,573 LB empty
12,000
371,573 loaded

	EMPTY		LOADED	
Spent Fuel	352,600	177 TONS	412,600	207
HLW	371,300	186	392,000	196
Non-fuel	359,600	180	371,600	186
WV HLW	318,900	159	344,900	174

Checked by: W. H. Blair
2/8/85

SIGNATURE C. P. Tratangelo DATE 10/5/84 TRB NO. EPFO 4MRS PAGE 3

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Cask Weights

West Valley HLW Canister (see sketch)

Rebar weighs the same as spent fuel cask. (3788) -- 13337

Concrete

$$\left(144^2\tfrac{\pi}{4}\right)224 - \left(78^2\tfrac{\pi}{4}\right)189.5 + \left(152^2\tfrac{\pi}{4}\right)41 - \left(84^2\tfrac{\pi}{4}\right)41 + \left(82.25^2\tfrac{\pi}{4}\right)38 =$$

3,461,239

REBAR − 13337

3,447,902

(3,447902.)(.087) = (299967)

Liners

$$\left[(78.5\pi).5(189.5) + (83.5\pi).5(41) + .5\left(\tfrac{78^2\pi}{4}\right)\right].284 = (8842)$$

BOT LIN TOP LIN BOT

Lids $\left[\left(58^2\tfrac{\pi}{4}\right)1 + \left(83.75^2\tfrac{\pi}{4}\right)1\right].284$ = (3255)

Chuglines $\left[(82.25\pi)(.5)\,40 + \left(82.75^2\tfrac{\pi}{4}\right).5\right].284$ = (2231)

318847

5 @ (6000) 30000

344296

Checked by: W. H. Blindt

2/8/85

SIGNATURE L. P. Fratangelo DATE 11/16/82 TRB NO. EPROFILES PAGE 7

page 201

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete cask weight

RHTRU cask 50 – 1000 R/HR

Relaw weight of RHTRU cask is nearly the same as the HLW cask.

Relaw weight = 3788 LB volume = 13337 LB

Concrete

$$\frac{\pi}{4}\left[(144^2)(228) + (36)(152^2) - (206)(84^2) - (32.5)(91^2) + (31)(88^2)\right] = 3{,}202{,}027 \text{ IN}^3$$

$$- \quad 13337$$

$$3{,}188{,}690$$

$$(3{,}188{,}690)(.087) = 277{,}416 \text{ LB}$$

Liner

$$\left[\underbrace{(83.5)\pi(.5)(206)}_{\text{BOT LIN}} + \underbrace{\left(84^2\tfrac{\pi}{4}\right)(.5)}_{\text{BOT}} + \underbrace{(90.5)\pi(.5)(32.5)}_{\text{TOP LINER}}\right].284 = 9773 \text{ LB}$$

Lids

$$\left[\underbrace{\left(95^2\tfrac{\pi}{4}\right)(1)}_{\text{CASK}} + \underbrace{\left(89^2\tfrac{\pi}{4}\right)(.5)}_{\text{PLUG}}\right].284 = 2896 \text{ LB}$$

Plug Liner

$$\left[\pi(88.5)(.5)(31.5) + 89^2\tfrac{\pi}{4}\right](.284) = 3010 \text{ LB}$$

TOTAL 296,883 LB

149 TONS

+ (7)(11000)

374,883 = 187 TONS

Checked by: M. H. Blanco
2/8/85

SIGNATURE L. P. Fratangeli DATE 11/16/84 TRB NO. EPF0PM25 PAGE 8

p. 202

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete Cask Weight

RHTRU cask <50 R/HR

Rebar wt. = 3788 LB 10333 = WK

Concrete

$\frac{\pi}{4}\left[(228)(144^2) + (36)(152^2) - (212)(102^2) - (26)(109^2) + (25)(106^2)\right] = 2612154$
$- 13337$
$(2598817)(.087) = 226097$

Liner

$\left[\pi(101.5)(.5)(212) + \pi(108.5)(.5)(26.5) + (102^2\frac{\pi}{4})(.5)\right](.284) = 12042$ LB
BOT LIN TOP LIN

Lids

$\left[(113^2\frac{\pi}{4})(1) + 107^2\frac{\pi}{4}(.5)\right](.284) = 4125$ LB

Alng liner

$\left[(107^2\frac{\pi}{4})(.5) + 106.5\pi(.5)(25)\right](.284) = 2465$ LB

248,516 LB = 125 TONS

+ 9 (11,000)

347,517 = 174 TONS

Checked by: W. H. Blanch
2/8/85

SIGNATURE E. J. Fratangelo DATE 11/17/84 TRB NO. EMFOGANES PAGE 9

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete and rebar measurements

SPENT FUEL CASK

		LENGTH		VOL (in³)
#4 hoops up side (in)	$[(.38)(137.5)+(6)(145.5)]\pi$	= 19157.4	✓	3762
#6 hoops " " (in)	$(31)(79.75)\pi$	= 7767	✓	3431
#4 " " " (in)	$[(2)(80)+(4)(89.5)]\pi$	= 1627	✓	319.5
#4 vert.	(90)(258)	= 23220	✓	4559
#6 vert.	(45)(258)	= 11,610	✓	5129
top #4 hoop mid	$(1)(117.5)\pi$	= 369.14	✓	72.5
top #4 rad.	(90)(18)	= 1620	✓	318.1
top #6 rad.	(45)(18)	= 810	✓	358
#5 rad	(45)(30)(52)	= 70200	✓	21537
#4 under + rad	$\pi[(1)(25.0+(57)(1)]+(16)(34)$	= 801	✓	158
bot. rads #4	(1.5)(45)+(17)(45)+(41)(22)+(58)(12)+(65)(11)	= 3595.5	✓	706
bot hoops #4	$(121.5+105.5+89.5+73.5+57.5+41.5+25.5+9.5)\pi$	= 1646.2	✓	323.
				40,673

#4	52,036	LENGTH	=	4336
#5	70,200"		=	5850
#6	20,187"		=	1687

Concrete-cask

$(144^2 \frac{\pi}{4})(228)+(152^2 \frac{\pi}{4})(36)-(83^2 \frac{\pi}{4})(38)-(72^2 \frac{\pi}{4})(94-(16)(3.5)(.75)(187)$ FINS $= 3,363,133$ in³

$3,363,133 - 40673$ REBAR $= 3,322,459$ in³ $=$ 71.21 yd³

Concrete-plug

$(80^2 \frac{\pi}{4})36.5 = 183,469$ in³ $=$ 3.9 yd³

Checked by: W. H. Rhoades
2/8/85

SIGNATURE E. P. Fratangelo DATE 12/5/84 TRB NO. EDF0 PM-25 PAGE 10

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete and Rebar Measurements

NON-FUEL BEARING COMPONENT CASK

			IN	IN³
#4 loops up side (out)			9,157.4	3762
#4 " " " (in)	$[(4)(66.5)+3(80.5)]\pi$	=	1594.4	313
#4 vert.	(90)(258)	=	23,220	4559
#4 top loop mid	$(108)\pi(1)$	=	339.3	66.6
#4 rad top	(90)(24) + (45)(24)	=	3240	636
#4 vert in	(45)(48) + (45)(26)	=	3330	653.8
#4 under rads	(16)(33)	=	528	103.7
#4 loop under	$\pi(53.5 + 21.5)$	=	235.6	46.3
#4 bot rads			3595.5	706
#4 bot loops			1646.2	323
			56,886"	11,169 IN³
			4740'	

Concrete-cask

$(144^2\frac{\pi}{4})228 + (152^2\frac{\pi}{4})36 - (60^2\frac{\pi}{4})198 - (63.2^2 - 60^2)\frac{\pi}{4}168 - (74^2\frac{\pi}{4})40.5 - (48^2\frac{\pi}{4})1.5 =$

3,605,987 IN³

3,605,987 − 11169 = 3,594,818 IN³ = 77.05 YD³

Concrete-plug

$(71.5^2\frac{\pi}{4})38 = 152,576$ IN³ = 3.27 YD³

WEST VALLEY CASK

#4 loops up side (out)			19,157	
#4 " " " (in)	$[(4)(84.5) + 3(91.5)]\pi$	=	1924	
#4 vert.			23220	
#4 top loop mid	$(1)(116.5)\pi$	=	366	
#4 rad top	(90)(12.5) + (45)(18)	=	2565	
#4 vert. in	(45)(56) + (45)(24)	=	3600	
#4 under rad	(16)(36)	=	576	
#4 loop under	$[(58.5) + (26.5)]\pi$	=	267	
#4 bot rad			3595.5	
#4 bot loop			1646.	
			56916.5	11176 IN³
			4743'	

Concrete-cask

$(144^2\frac{\pi}{4})228 + (152^2\frac{\pi}{4})36 - (78^2\frac{\pi}{4})190 - (85^2\frac{\pi}{4})40 = 3,231,593$ IN³ − 11176 = 3,220,417

= 69.02 YD

Concrete-plug

$(82.5^2\frac{\pi}{4})38 = 203,133$ IN³ = 4.35 YD³

Checked by W.H. Blair 2/6/85

SIGNATURE E.P. Fratangelo DATE 12/6/84 TRB NO. EPF09MRS PAGE 11

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete cask weights and measures

COMMERCIAL H.L.W. CASK

All Groups		IN	IN³
#4 loops up side (out)		19157	3761
#6 loops up side (in)		7767	3431
#4 loops up side (in)	(6)(80)π =	1508	296
#4 vert.	(90)(258) =	23220	4559
#6 vert.	(45)(258) =	11610	5129
top #4 mid	(111)π =	349	68.5
top #4 rad	(14)(90) =	1260	247
top #6 rad	(18)(45) =	810	360
#5 rad	(24)(30)(45) =	32400	9940
#4 under + rad	(16)(42) + [58 + 26]π =	935	183
bot hds #4		3595.5	706
bot loops #4		1642	322
			29003

#4 - 51667 4306'
#5 - 32400 2700'
#6 - 20187 = 1682'

Concrete - cask

$(144^2 \frac{\pi}{4})228 + (152^2 \frac{\pi}{4})36 - (60^2 \frac{\pi}{4})182 - (74^2 \frac{\pi}{4})43.5 - (47^2 \frac{\pi}{4}).5 - 16(9.5)(.25)175 =$

3643,965

3,643,965 - 29,003 = 3,614,962 IN³ = 77.5 YD³

Concrete - plug

$(40.5^2 \frac{\pi}{4})71.5 = 92,109 = 1.97$ YD³

Checked by: W.H. Blount 2/8/85

SIGNATURE E. P. Fratangelo DATE 12/7/84 TRB NO. EPFO&M125 PAGE 12

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Concrete Cask Weights and Measures

RHTRU CASK 50-1000 R/HR GR. 1

#4 loops up side	(out)		19157	3761
#4 loops up side	(in)	$[(4)(88)+(3)(96)]\pi$	2010	394
#4 vert			23220	4559
#4 top hoop mid		$(120.75)\pi$	379	74.4
#4 rad top			2565	503
#4 vert in		$(45)(48)+(45)(24)=$	3240	636
#4 under rad		$(16)(36)$	576	113
#4 " hoop		$\pi[(56)(1)+(24)(1)]=$	251	49.2
#4 bot rad			3595.5	706
#4 bot hoop			1646	323
			56641	11121
			4720	

Concrete — cask

$(144^2\frac{\pi}{4})228+(152^2\frac{\pi}{4})36-(84^2\frac{\pi}{4})206-(91^2\frac{\pi}{4})33=3{,}010{,}229-11121$

$2{,}999{,}108\ IN^3 = \underline{64.28\ YD^3}$

Concrete — plug (5)

$(88.5^2\frac{\pi}{4})31 = 190{,}694\ IN^3 = 4.09$

RHTRU CASK <50 R/HR GR. 2

#4 loops up side	(out)		19157	3761
#4 loops up side	(in)	$[(4)(106)+(3)(114)]\pi=$	2406	472
#4 vert			23220	4559
#4 top hoop mid		$(129.75)\pi$ =	407.6	80
#4 rad top			2565	503
#4 vert in		$(45)(48+18)$ =	2970	583
#4 under rad		$(16)(56)$ =	896	176
#4 " hoop		$[74+42+10]\pi$ =	396	77.8
#4 bot rad			3595.5	706
#4 bot hoop			1646	323
			57259	11242
			4772'	

Concrete — cask

$(144^2\frac{\pi}{4})228+(152^2\frac{\pi}{4})36-(102^2\frac{\pi}{4})212-(109^2\frac{\pi}{4})27=2{,}382{,}204\ IN^3$

$2{,}382{,}204-11242=2{,}370{,}962\ IN^3$

$=\underline{50.8\ YD^3}$

Concrete — plug GR. 2

$(106.5^2\frac{\pi}{4})25=222{,}704=\underline{4.77}$

Checked by: W.H. Flanigan 2/8/85

SIGNATURE E. P. Tratangelo DATE 12/8/84 TRB NO. EPROMES PAGE 13

P 207

G.O. or CHARGE NO. _____ PROJECT MRS

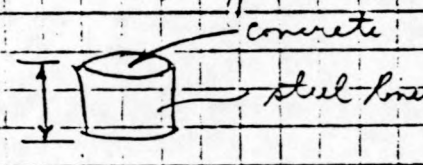
SUBJECT Concrete cask pouring

When pouring the concrete, will the inner shell collapse?

RHTRU liner is largest, it will be investigated.

$p = \rho g h = (.087 \frac{LB}{IN^3})(213 in) = 18.53 \frac{LB}{IN^2}$ NO EFFECT

For shield plug



$(.087)(30") = 2.6$ PSI AT BOT. NO BIG DEAL!

assume uniform pressure dist.

$\sigma_H = \frac{pR}{t} = \frac{(2.6)(\sim 45)}{(.5)} = 234$ PSI

Checked by: W. H. Blume
2/8/85

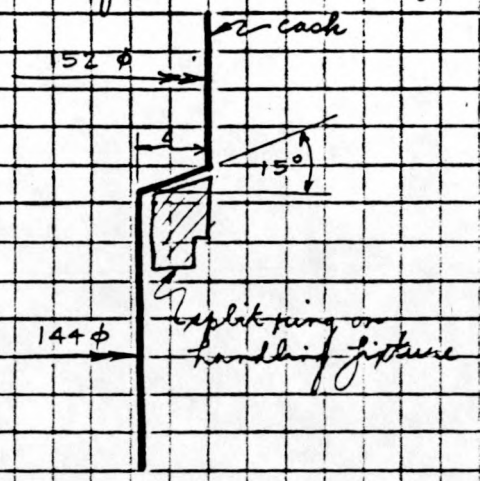
SIGNATURE L P Tratangelo DATE 10/12/84 TRB NO. _____ PAGE 6

p. 208

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Analysis of Storage Cask Lifting Face

See drawing H-3-54986 for details on handling surface



Largest cask weight ≈ 210 TON
≈ 420,000 LB

Estimate compression stress on handling surface

From Design of Concrete Structures

LOAD = 1.4 DL + 1.7 LL

DEAD LOAD LIVE LOAD

LOAD = (1.4)(420,000) + (1.7)(0) = 588,000 LB

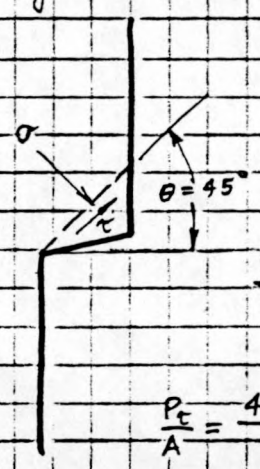
$f_c = .85\,\phi\, f_c'$
$= (.85)(.7)(4000\text{ PSI})$
$= 2380\text{ PSI}$

ϕ = strength factor ≈ .7 for compression load
f_c' = yield strength in compression ≈ 4000 PSI

$\sigma = \frac{\text{LOAD}}{A} = \frac{588{,}000\text{ LB}}{(148\pi)(4\cos 15°)} = 327\text{ PSI} \ll 2380$ allowed. okay

ave. circumference of face

What if corner cracks at angle = θ



Pick θ = 45°
Resolve LOAD into τ and σ components on 45° angle

$P_\tau = (588{,}000)\sin 45° = 415{,}779\text{ LB}$
Shear area $= (148\pi)\left(\frac{4}{\cos 45°}\right) = 2630\text{ IN}^2$

From same source, f_c for concrete in shear without bending $= 3.5\,\phi\sqrt{f_c'}$
$= (3.5)(.85)\sqrt{4000} = 188\text{ PSI}$

$\frac{P_\tau}{A} = \frac{415{,}779}{2630} = 158\text{ PSI} < 188$ allowed okay

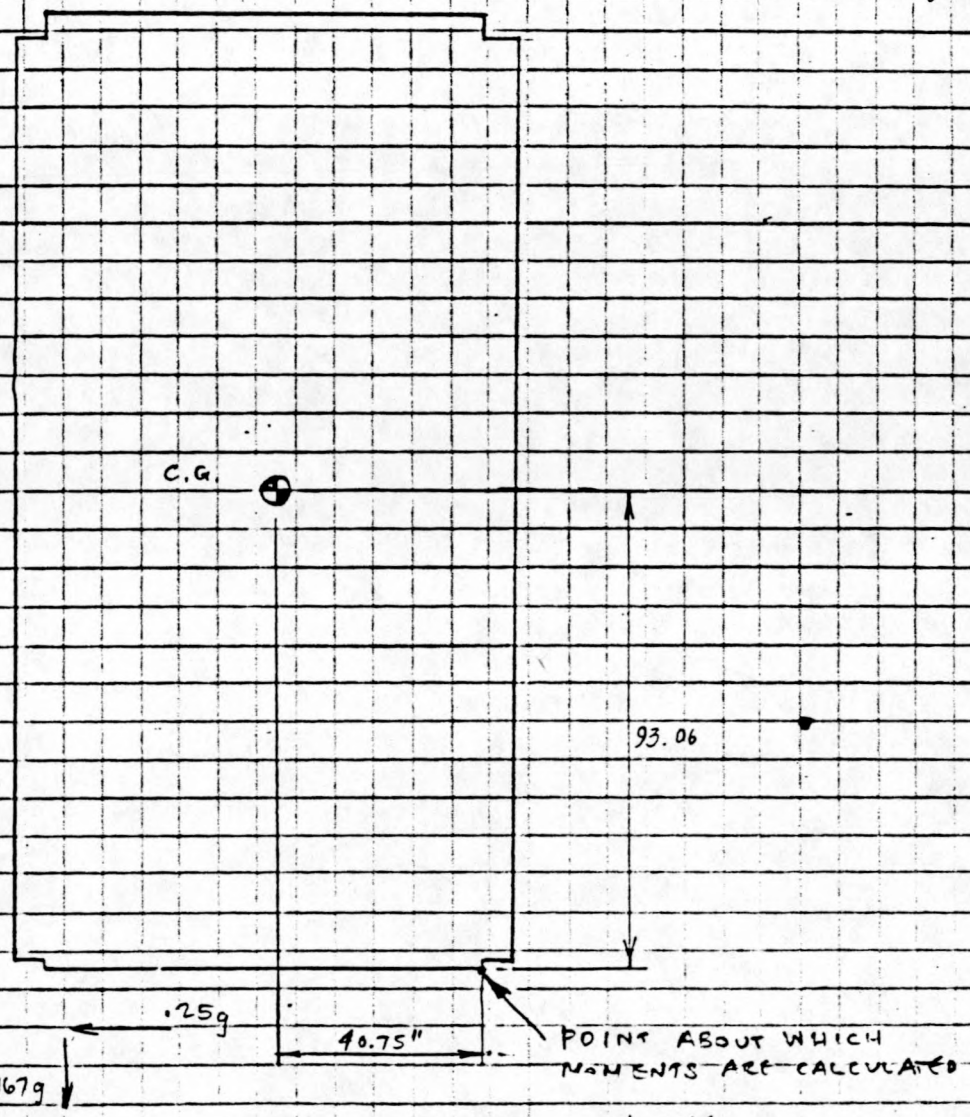
Checked by W. H. Blanch 2/8/85

SIGNATURE E. P. Fratangelo DATE 2/8/85 TRB NO. EDF04MRS PAGE 20

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Stability analysis on Cask (REA)

Assuming cask is stored vertically, is the cask stable under a .25 g. horizontal and .167g vertical earthquake loading.



C.G. is assumed centered in the cask even though it may actually be slightly lower.

If ground drops at .167g simultaneously with moving horizontally at .25g, the most unstable condition will be developed.

Also, μ (friction coefficient) will = 1

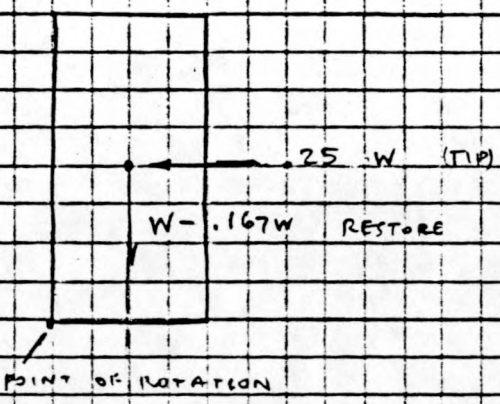
Checked by: W. H. Blount 2/6/85

SIGNATURE E. P. Fratangelo DATE 6/29/84 TRB NO. EPF03MRS PAGE 24

p-210

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Cask stability analysis



TIP RESTORE

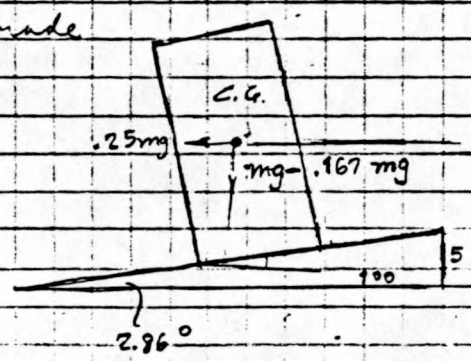
$(.25\,mg)(93.06'') : mg\,(1-.167)(40.75)$

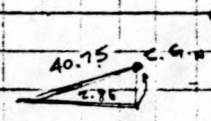
$23.3\,mg : 33.9\,mg$

1.46 to keep upright

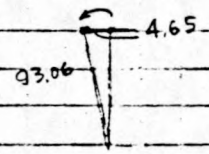
For $\mu < 1$, the tipping moment imparted to the cask will be less and it will remain more stable.

With a 5% grade





C.G. moves up 2.04" higher than point of rotation



TOPPLE RESTORE

$(.25\,mg)(93.06 + 2.04) : (1-.167)\,mg\,(40.75 - 4.65)$. CG moves over 4.65"

$23.8\,mg : 30.1\,mg$

1.25

Since there will be a stainless steel plate between the under the cask which is also stainless, μ will be reduced to 0.75 from 1.0. This will decrease the likelyhood of toppling by ~25%.

Checked by: W. W. Bhandari 3/5/65

SIGNATURE E. P. Fiatangelo DATE 6/29/64 TRB NO. EPF03MRS PAGE 25

G.O. or CHARGE NO. _____ PROJECT MRS

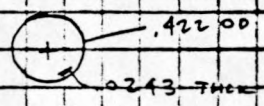
SUBJECT Zircaloy weight

Calculate amount of Zircaloy in fuel rods.

All information from DOE/ET/47912-3 NAC-C-8129

(W) 15×15 PWR

225 spaces − 21 tubes = 204 rods



.3734 I.D.

ρ from personal communication with H. D. Berkiek 7/18/84

→ Clad wgt. = (vol) ρ = $\frac{\pi}{4}(.422^2 - .3734^2)(\overset{149.7 -}{2(.47)})(.235\ lb/in^3)$ = 1.0614 LB/ROD

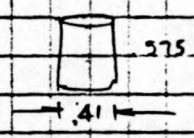
$d_o^2 - d_i^2$ ρ

dimensions from TABLE 4-2

(1.061)(204 RODS) = 216.5 LB

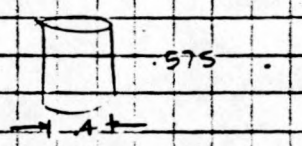
→ Top plug (sizes are estimated) from fig. 4-2

Assume cylinder



Wt = $(204)\frac{\pi}{4}(.41^2)(.575)(.235)$ = 3.64 LB

→ Bottom plug (sizes are est.) from fig 4-2



Wt. = $(204)(\frac{\pi}{4}\ .4^2)(.575)(.235)$ = 3.46

Total = 216.5 + 3.64 + 3.46 ≈ 223 LB

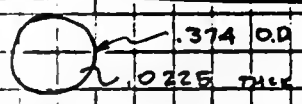
Checked by W. H. Rhodes 2/6/85

SIGNATURE L. P. Tratangelo DATE 7/18/84 TRB NO. EPF03MRS PAGE 48

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Finishing weight

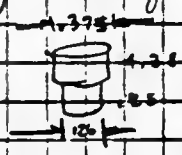
(W) 17×17 264 rods



→ Clad wgt = $(264)(.374^2 - .3290^2)\frac{\pi}{4}(150.75)(.235) = 232.$ LB

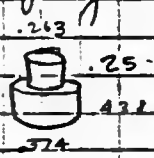
dimensions from TABLE 4-2

→ Top plug (sizes are est.) from fig 4-8



Top wt = $264\left(\left(.374^2\frac{\pi}{4}\right)(.438) + \left(.26^2\frac{\pi}{4}\right)(.25)\right)(.235) = 3.8$

→ Bottom plug (sizes are est.) from fig 4-2

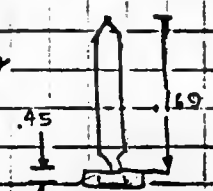


$(264)\left([(.26^2)(.25) + (.374^2)(.438)]\pi/4\right)(.235) = 3.8$

Total = 232. + 3.8 = 239 LB

(Gb) 7×7 BWR 49 rods

Top plug



from GE 731E614 drawing and TABLE 5-3

$Wt. = (49)\left(\frac{\pi}{4}\right)\left[(.25^2)(.169) + (.499)^2(.45)\right](.235) = 1.1$

Checked by: W. H. Blanc 2/6/85

SIGNATURE E. P. Fratangelo DATE 7/18/84 TRB NO. EPF03MRS PAGE 49

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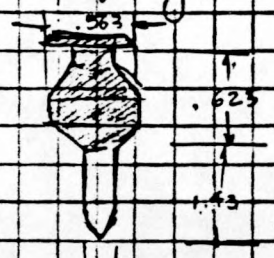
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Zircaloy weight

Bottom plug



from GE 731E614 and fig. 5-7

Assume $\left(\frac{.563+.28}{2}\right)$ (AVG) for average diameter of .65" length

$$Wt. = 49\left(\frac{\pi}{4}\right)\left(\left(\frac{.563+.28}{2}\right)^2(.65) + (.28^2)(1.43)\right)(.235) = 2.05 \text{ LB}$$

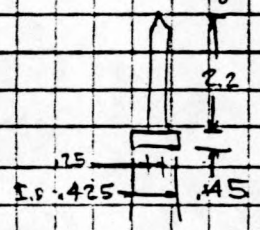
→ Cladding

$$Wt = (49)\left(\frac{\pi}{4}\right)(.563^2 - .499^2)(161)(.235) = 99.9$$ from TABLE 5-3

Total = 99.9 + 1.1 + 2.05 = 102 LB

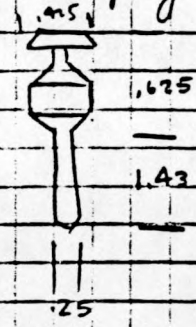
GE 8×8 62 rods

→ Top plug dimensions from 829E433 and TABLE 5-3



$$Wt. = (62)\frac{\pi}{4}\left((.25^2)(2.2) + (.425^2)(.45)\right)(.235) = 2.5 \text{ LB}$$

→ Bottom plug



$$Wt. = (62)\frac{\pi}{4}\left(\left(\frac{.425+.25}{2}\right)^2(.625) + (.25^2)(1.43)\right)(.235) = 1.84 \text{ LB}$$

from TABLE 5-3 and same as above

Checked by: W. H. Blanes 2/4/85

SIGNATURE E. P. Frutangels DATE 7/19/84 TRB NO. EPF03MRS PAGE 51

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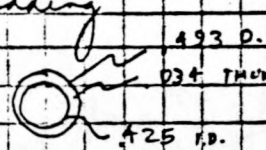
or CHARGE NO. _____ PROJECT MRS

SUBJECT Typical weights

→ Cladding



$W_{lt.} = (62)(.493^2 - .425^2)\frac{\pi}{4}(162)(.235) = 115.7$

length from 829E433 dwg

Total = 115.7 + 1.84 + 2.5 = 120 LB

ZIRC TABULATION OF WEIGHTS (LB)

	Top	Bot	Clad	Total
5x15	3.6	3.5	216.5	223
7x17	3.8	3.8	232	239
7x7	1.1	2.1	99	102
8x8	2.5	1.84	115.7	120

These represent the largest expected population of fuels to be processed at a MRS. The fact is recognized that many other PWR FA designs exist.

Checked by: W. H. Blair 2/8/85

SIGNATURE E. P. Gratangelo DATE 7/19/84 TRB NO. EAF13MRS PAGE 57

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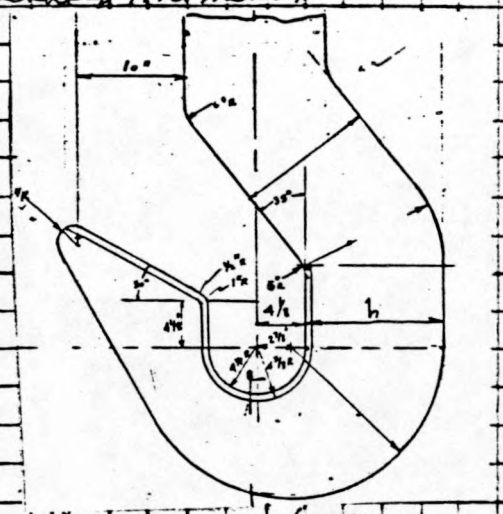
.O. or CHARGE NO. _____ PROJECT MRS

-JBJECT Yoke Design REA 2023

SIZE HOOK (FROM PG 47)

Size hook to resist bending moment.



$\frac{\frac{1}{6} b h^2 P}{b}$

$\sigma = \frac{Mc}{I} + \frac{P}{A}$ on inside fiber (refer to page 30)

$$\sigma = \frac{(P)(4\tfrac{1}{8} + h/2)(h/2)}{\frac{1}{12} b h^3} + \frac{P}{bh} = \frac{4\tfrac{1}{8}P + \frac{Ph}{2}}{\frac{1}{6} b h^2} + \frac{P}{bh}$$

$$\frac{1}{6} b h^2 \sigma = 4\tfrac{1}{8}P + \frac{3Ph}{6} + \frac{1}{6}Ph$$

$$\frac{1}{6} b \sigma h^2 - \frac{2}{3}Ph - 4\tfrac{1}{8}P = 0$$

$$h = \frac{\frac{2}{3}P \pm \sqrt{(\frac{2}{3}P)^2 + 4(\frac{1}{6}b\sigma)(4\tfrac{1}{8}P)}}{\frac{1}{3} b \sigma}$$

= 12.6 KSI
= 125 K

b	h
4	14.23
3	17.82
5	12.02
6	10.51

This is a preliminary sizing calculation. Additional detailed analysis will be performed in the definitive design phase.

Checked by: W. W. Schmidt 2/8/85

NATURE J. P. Stratangels DATE 7/21/84 TRB NO. EP-03-MRS PAGE 53

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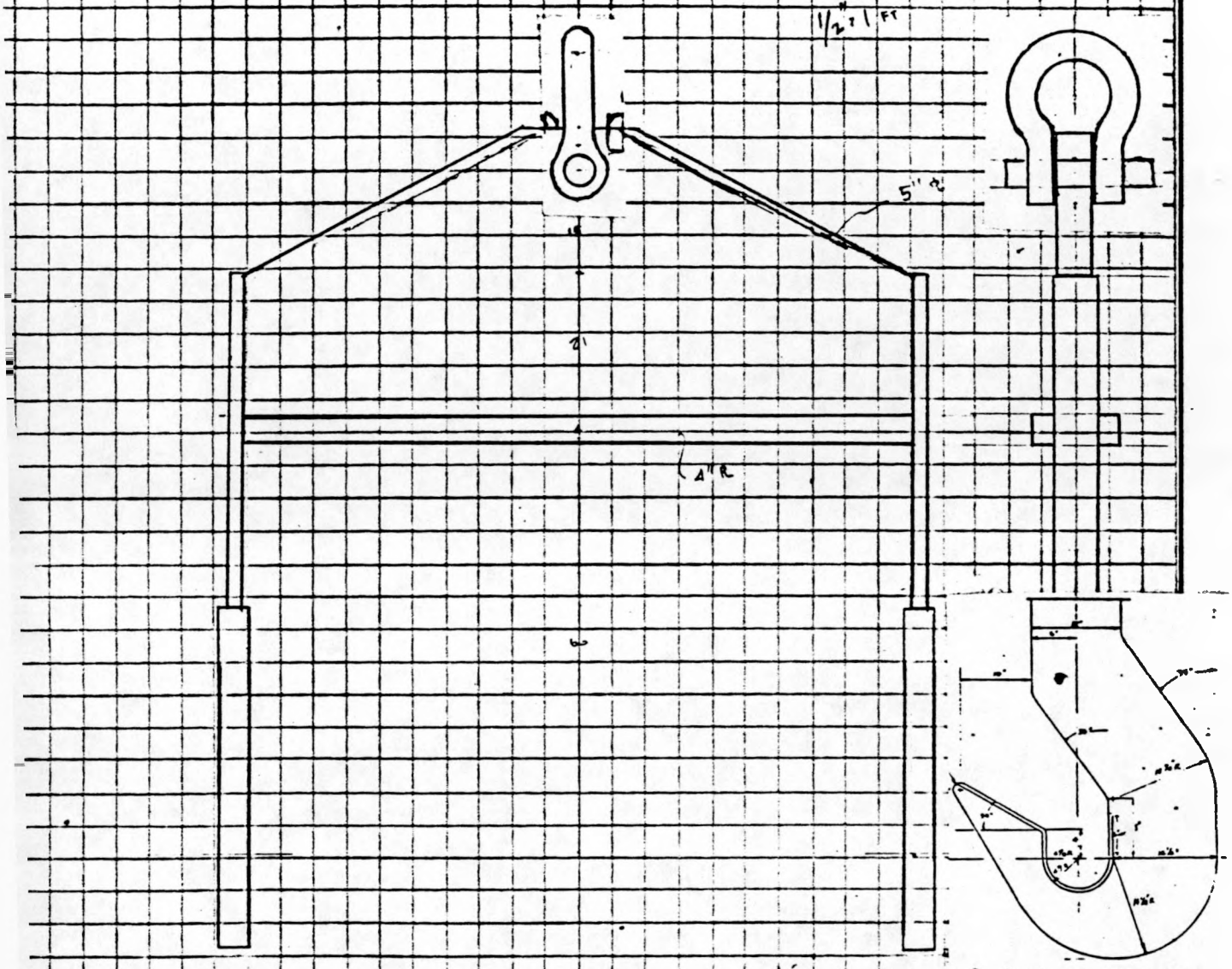
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Yoke Design REA-2023

SIZE HOOK ARM

$\sigma = P/A \qquad A = P/\sigma = \frac{129000}{12600} = 9.92 \text{ IN}^2$



Checked by: W. H. Blanchard
2/6/85

SIGNATURE E. A. Frutangelo DATE 7/23/84 TRB NO. EPF03MRS PAGE 54

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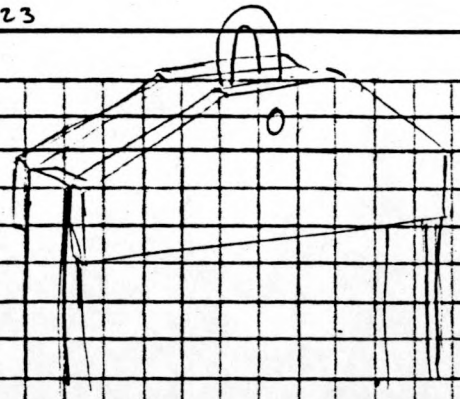
.O. or CHARGE NO. _____ PROJECT MRS

-JECT Yoke design REA - 2023

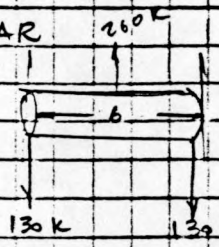
Double plate design

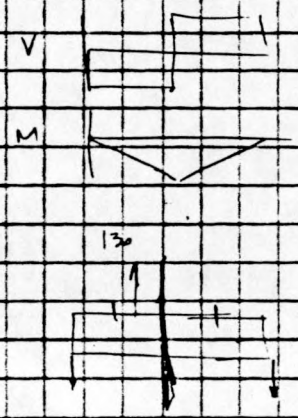
Using A - 242 with this design



Assuming a lifting ring of approximately 5" Dia. cross section.

SIZE BAR





$M = (125\,K\,LB)(3\,IN) = 375\,K$ IN.LB

$\sigma = \frac{32M}{\pi d^3}$

$12.6\,K = \frac{(32)(375\,K)}{\pi\, d^3}$

$d = 6.72$

USE 7" BAR

Check bearing stress

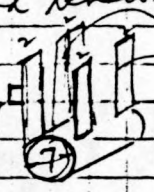
bearing areas

$\sigma = 12.6$ KSI

$A = \frac{P}{\sigma} = \frac{260K}{12.6} = 20.6\ IN^2$

$\frac{20.6\ IN^2}{(2\ PL)(7\ IN)} \approx 1.5\ IN$ each plate must be > 1.5" wide for bearing stress.

eck shear and tension tear-out)



shear areas

element to be analyzed

FOR 2" PL

For tension → $A = \frac{P}{\sigma} = \frac{130K}{12.6} = 10.3\ IN^2$

ctr of pin should be > 2.75" from ctr of plate

For shear → $A = \frac{P}{\tau} = \frac{260K}{42K/(3\times2)} = 37.14\ IN^2$

42K is σ_y and $42/6 = \tau_{ALL} = \sigma_y/3(2)$

$\frac{37.14\ IN^2}{(4\ PL\ AREA)(2\ IN)} = 4.64\ IN$ > 4.75' from ctr of plate.

of pin will be 4.75' from ctr of plates

Checked by: W. H. Blines 2/6/85

SIGNATURE E. P. Fritzenzels DATE 7/26/84 TRB NO. EPF03MRS PAGE 55

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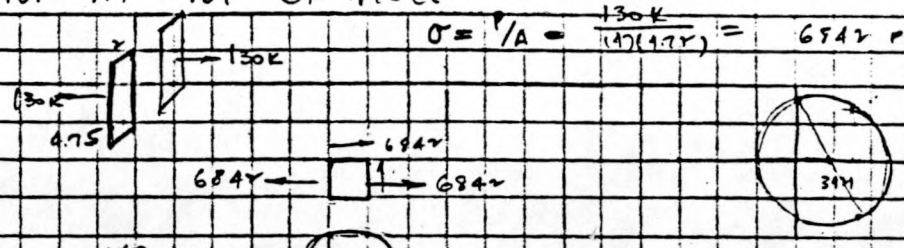
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Yoke Design

CHECK TENSION AT TOP OF HOLE

If 4.75"

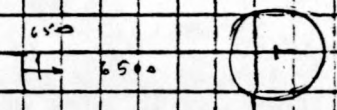
$\sigma = P/A = \frac{130K}{(4)(4.75")} = 6842$ psi



15.3 KSI

No

If 5.0"

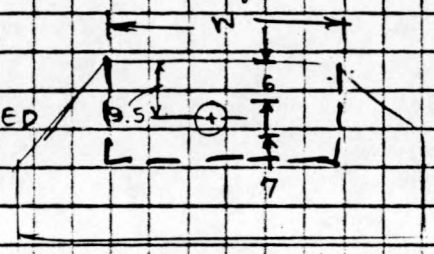


14.5 KSI

If 5.75"

Make pin 6" deep principal stress = 12.1 KSI okay which is conservative because of extra material along sides of pin.

SIZE SECTION IN RED



Check stress Concentration

with K_t = 2.5 5.8 KSI

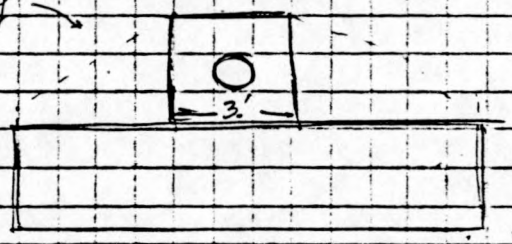
K_t = 2.2 18.1

K_t = 2.35 10.3 KSI

W ≥ 24"

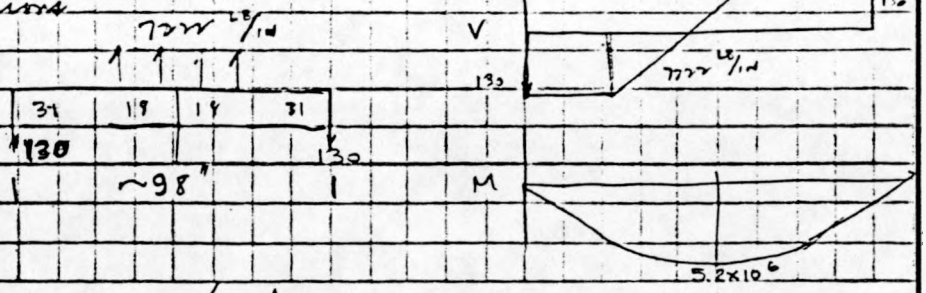
SIZE PLATES

Assume plate shape of



to simplify calculations

For a beam =



SIGNATURE E. P. Fratanelo DATE 7/26/84 TRB NO. EPF03MRS PAGE 56

Checked by: W. H. Blanch 2/6/85

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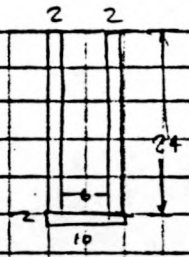
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Yoke design

$M = 5200000$



Centroid

$(96 + 20)x = (20)(25) + (4)(24)(12)$ $\quad x = 14.24$ IN

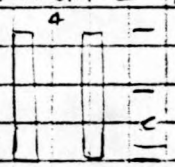
$I = \frac{1}{12}(4)\,24^3 + \frac{1}{12}(10)\,2^3 + (16) \times 10.76 = 6467$

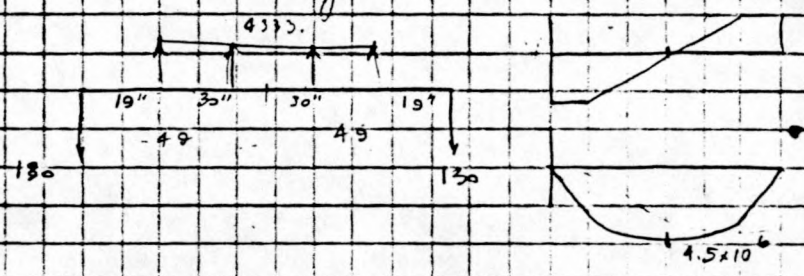
$\sigma = \frac{Mc}{I} = \frac{(5.2 \times 10^6)(14.24)}{6467} = 11.5$ KSI okay

$\longrightarrow$ Can even use crane hook directly if it can fit between 7", and has a mouth > 9"

With no crosspiece and assuming load distribution as such

MAX MOMENT $= 4.5 \times 10^6$





$\sigma = \frac{Mc}{I} = \frac{Mc}{\frac{1}{3}\,4\,8c^3} = \frac{3M}{8c^2}$ $\quad c = 11$

$h \geq 23"$ which is min height to bottom of bail pin.

SIZE RING

From Mark's handbook, page 10.7, with steel of 100,000 yield strength "d" of an oblong shaped ring d — is given as $\sqrt{WLL/20K}$ INCHES

where WLL is the working load limit. A normal safety factor for lifting devices is assumed.

$d = \sqrt{WLL/20K} = \sqrt{260K/20K} = 3.6$

$d_{RING} = 3.75$ $\quad$ Inside length = 28"

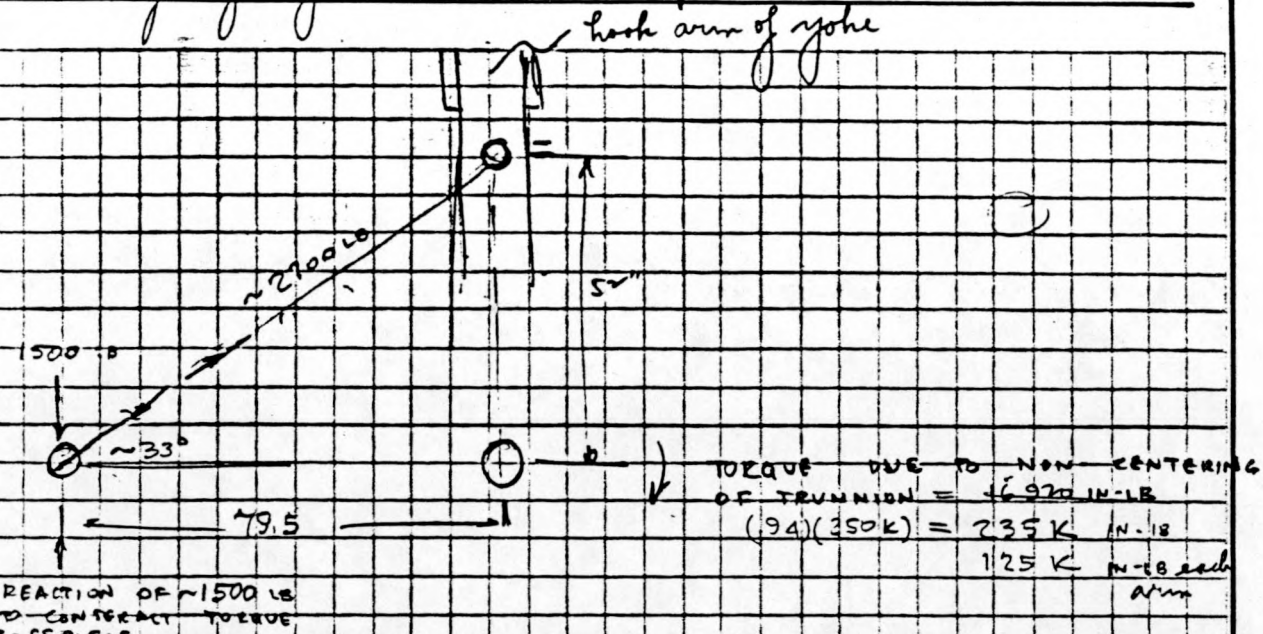
Inside width = 13.5"

SIGNATURE E.G. Fratangelo DATE 7/27/84 TRB NO. EPF03 MRS PAGE 57

Checked by: W. H. Bennett 7/6/85 p. 220

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Crash lifting yoke – additional fixed counterbalance arm



TORQUE DUE TO NON-CENTERING OF TRUNNION = 16920 IN-LB

(.94)(350K) = 235K IN-LB

125K IN-LB each arm

SIZE CROSSPIECE

Estimate load in crosspiece as 2700 lb. Compression

With A-242 steel and 63 KSI U.T.S., $\sigma_v = 63/5 = 12.6$ KSI

$A = \frac{F}{\sigma} = \frac{2700}{12600} \geq .215$ IN² X-sect. area of crosspiece (choose 2 x 5 x .18 tube steel)

Buckling analysis indicated no problem

SIZE:

$M = (2000\ LB)(\ )$ = [illegible] IN/LB $\quad \sigma = \frac{Mc}{I} = \frac{Mc}{\frac{1}{4}\pi c^4} = \frac{4M}{\pi c^3}$ $\quad c > .58$

$d = 1.17$

choose 3" dia pivot pin at top $\quad d > 1.75"$

Checked by: W. H. Blood 2/6/85

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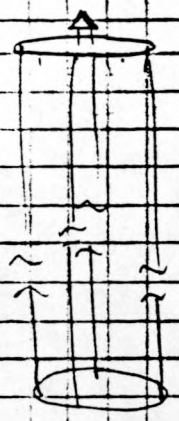
pr 221

$\frac{\pi d^2}{4} = A$

.O. or CHARGE NO. _____ PROJECT MRS

JBJECT Drum cage for Skeletons



General configuration

SIZE BARS

Drum weight 900# each, 5 drums in cage

4000# for drums + weight of top and bottom plate

TOTAL ≈ 4500# assumed.

4500/3 = 1500 #/bar

Using A-36 steel XX pipe.

$\frac{1500}{36000/3} = .125$ to hold axial load. Use any pipe > 1/4" nom.

S.F.

Out of Mark's Handbook, page 9-28, Use 3/4" BOLT (4)

$D_{MIN} = .6273$ $D_{MAX} = .7500$

Pipe I.D. is < D_{MIN} and > D_{MAX}

~~EXTRA STRONG~~	~~I.D.~~	~~.546~~	~~O.D.~~	~~.840~~	~~NO~~
DOUBLE X-STRONG –	I.D.	.599	O.D.	1.315	1" XX

Use 1" XX pipe, tap for 3/4" bolt, use 3/4" bolt.

Barrels are 23 27/32" wide.

Leave ~1/2" clearance

Make center of pipes on a 26 3/16" DIA circle

1 1/4" XX → .896 I.D. 1.660 O.D. 1 1/8 BOLTS

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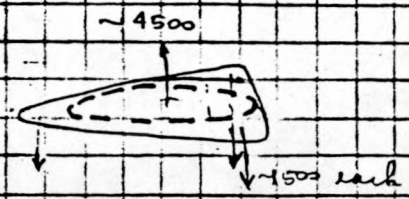
8/17/84 Checked by: W. H. Blair 2/5/85 p. 222

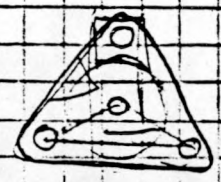
C.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Skeleton Drum Cage MRS

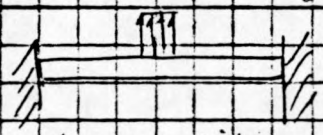
Thread outside of bottom of pipes 1 5/16" thread

Size top plate.
Loaded as shown.





Idealize section outlined in red by:



circular plate, fixed on edge

In Roark and Young try condition 1e, pg 336

$L_9\ C_7\ L_6\ C_5$

$$L_9 = \frac{1.25}{6}\left\{\frac{1+.3}{2}\ln\frac{6}{1.25} + \frac{1-.3}{4}\left[1-\left(\frac{1.25}{6}\right)^2\right]\right\} = .2973$$

$$C_7 = .5\left[1+.3+(1-.3)\left(\frac{1.25}{6}\right)^2\right] = .6652$$

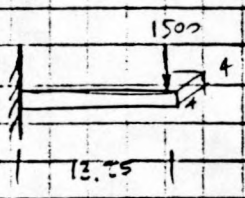
$M = 573$ LB IN

$$L_6 = \frac{1.25}{4\cdot 6}\left[\left(\frac{1.25}{6}\right)^2 - 1 + 2\ln\frac{6}{1.25}\right] = .1136$$

$\sigma = 1000$ PSI

$$C_5 = .5\left[1-\left(\frac{1.25}{6}\right)^2\right] = .4793$$

Assume area in red is a beam, cantilevered



12875

$$\sigma = \frac{Mc}{I} = \frac{Mc}{\frac{1}{12}b\cdot 8c^3} = \frac{12Mc}{8bc^3} = \frac{3M}{2bc^2}$$

2" top, 1" bottom

Checked by: W.H. Schmid
2/6/85

SIGNATURE [illegible] DATE 8/20/84 TRB NO. EPF03MRS PAGE 59

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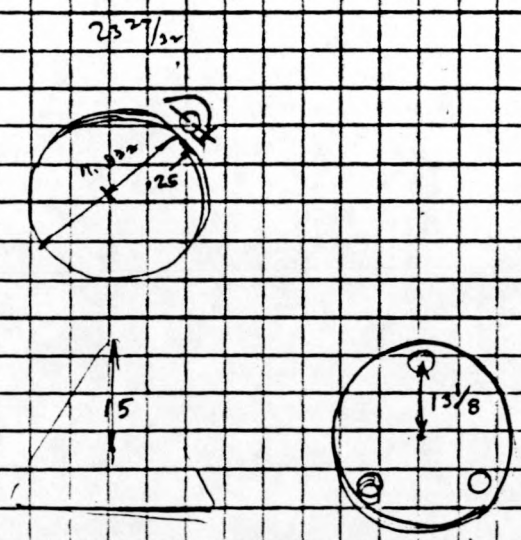
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Drum cage for skeletons

Use 1½ sched 40 pipe for separator plates - has 1.61 I.D and 1.9 O.D.



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2/6/85

SIGNATURE G.P. Fratangelo DATE 8/21/86 TRB NO. EPF03MRS PAGE 60

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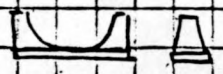
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Cask "saddles" for REA-2023

Soil strength in compression is 4000 PSI (R.U.)

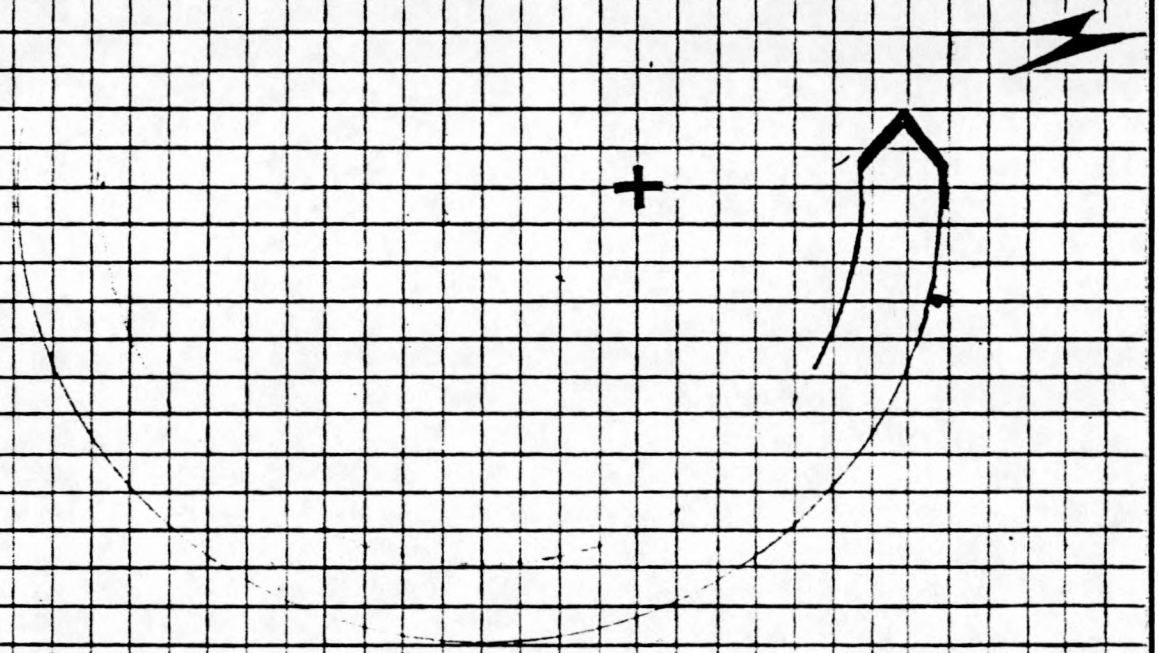
Cask weighs 250,000 LB $\frac{250000}{4000}\frac{LB}{}\frac{1}{LB}\frac{IN^2}{} = 62.5\ IN^2 \approx 31\ IN^2$ each saddle

General saddle shape



Assume concrete to have 3000 PSI capacity w/ safety factor of 3 = 1000 PSI

Need a total of 125 IN^2 on each saddle.



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SIGNATURE E.P. Gratangelo DATE 8/28/84 TRB NO. EFFOSMER PAGE 6

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Drywell cover size // Crack lid size

If full track is assumed

16" well $t \geq 1.43"$
36" well $t \geq 1.76"$

The thickness of the concrete crack lid is to be determined. It will be sized such that a missile will not penetrate it.

The method by which the lid size will be calculated is described in the MRS Basis for Design pages 1-27 4

Tornado-generated missiles will be considered in the design. The following missiles and associated impact velocities shall be considered.

Missile	Velocity (ft/sec) Horizontal	mv/A	Vertical	mv
(1) Wood plank, 4 in. x 12 in. x 12 ft long, wt 115 lbs	~~272~~	455	190	71850
(2) Steel pipe, 6 in. diameter, Schedule 40, 15 ft long, wt 287 lbs	~~170~~	1208	119	34153
(3) Steel Rod 1 in. diameter x 3 ft long	~~167~~	6010	167	*4721
(4) *Utility pole, 13-1/2 in. diameter, 35 ft long, wt 1,125 lbs	~~180~~	990	126	141750
(5) Steel pipe, 12 in. diameter, Schedule 40, 15 ft long, wt 750 lbs	~~154~~	716	108	81000
(6) *Automobile (20 sq ft frontal area) wt 4,000 lbs	~~193~~	187.5	135	540000

*Missiles to be considered at elevations up to 30 ft abovegrade.

The largest crack lid is 110.25" ϕ
Spent fuel crack lid is 72.00" ϕ

Only a direct vertical hit will be considered, thus horizontal velocities will be discounted.

Checked by: W. H. Thomas 2/8/85

SIGNATURE J. P. Tratangelo DATE 9/24/84 TRB NO. EPF03MRS PAGE 69

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Cask lid size

The equation to find the lid thickness is

$$T = \frac{\left(\frac{MV^2}{2}\right)^{2/3}}{672\,D}$$

Projectile ① Assumed diameter is one inch nearly equal area (x-sect)
For wood 8"

$$T = \frac{\left(\frac{115}{32.2}\,190^2\right)^{2/3}}{672\,(8)} = .47''$$

② $$T = \frac{\left(\frac{297}{32.2}\,119^2\right)^{2/3}}{672\,(60)} = .62''$$

③ $$\frac{\left(\frac{8}{32.2}\,167^2\right)^{2/3}}{672\,(5)} = .54$$

④ $$\frac{\left(\frac{1125}{32.2}\,126^2\right)^{2/3}}{672\,(13.5)} = .74''$$ ← TELEPHONE POLE IS DETERMINING SIZE

⑤ $$\frac{\left(\frac{750}{32.2}\,108^2\right)^{2/3}}{672\,(12)} = .52''$$

⑥ $$\frac{\left(\frac{4000}{32.2}\,135^2\right)^{2/3}}{672\,(60)} = .42$$

.74 + 25% = .925 ≈ 15/16"

Checked by: W. H. Blanch
2/8/85

SIGNATURE E. P. Trutanych DATE 9/24/84 TRB NO. EFF03MRS PAGE 70

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G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT UPENDER, MODULE F/A CLAMP

TOOLING REQD

1.) BASE PLATFORM G
2.) POWER SCREW DRIVE G
3.) HYDRAULIC SYSTEM G/S
4.) STONE CUTTER G
5.) COMB S
6.) GENERAL STRUCTURE G
7.) COLLECTION SYSTEM G
8.) VISUAL (KEY LOCATIONS G/S
9.) MODULES (BWR, PWR) S
10.) CLAMPING S
11.) CONTROL SYSTEM G/S
12.) STORAGE FOR MODULES G

DESIGN PARAMETERS

1.) ACCEPTS ALL FUEL TYPES
2.) NOZZLE REMOVAL, UPENDING, CLAMPING, CRUD COLLECTION, VISUAL & CONTROL SYSTEMS.
3.) MINIMIZES RAD WASTE
4.) MODULAR
5.) CONSOLIDATED INTO SAME CANISTER.
6.) NOZZLES & GRIDS INTO 55 GAL. DRUM FOR DISPOSAL
7.) MECHANIZED & AUTOMATED
8.) ROUND CANISTERS
9.) 3PWR/7BWR... 12" SCH 20 CAN.
(REF WTSD D. WATERBURER)

CONSIDERATIONS

A.) OFF-NORMAL
B.) MODULAR
C.) REPLACEMENT
D.) MAINTANCE
E.) WEIGHT
F.) TEMPERATURE EFFECTS
G.) RADIATION EFFECTS
H.) LIFTING SCREWS... SELF LOCKING

Checked by: E.O. Tortangelo

Date: 2/6/85

SIGNATURE W.H. Bunnell DATE 5/22/84 TRB NO. WHB-001 PAGE 1

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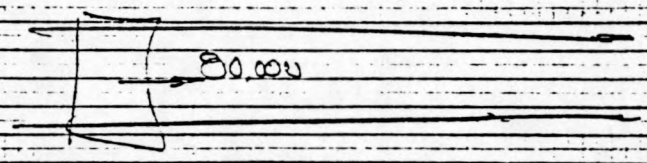
G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT GRIPPER DRIVE

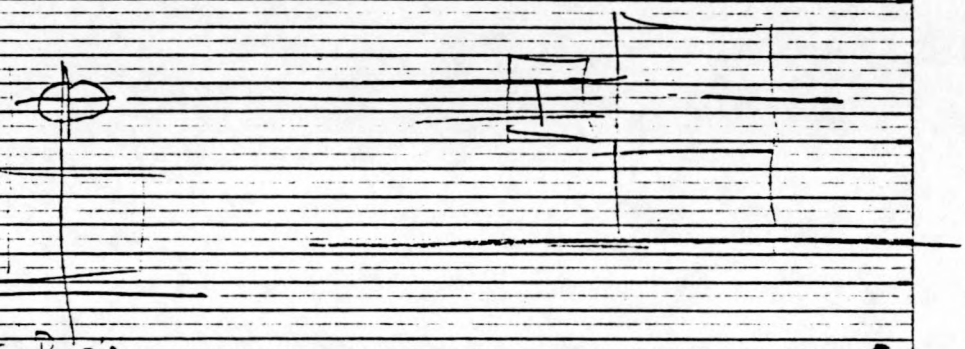
5/23/84

DRIVE DESIGN:

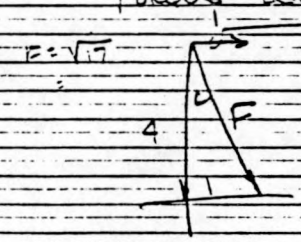
TORQUE



4" ϕ BALL SCREW



TORQUE ROD



40,000

LEAD = 1"

$\tan^{-1}\theta = \frac{1}{4}$ $\theta = 14.04°$

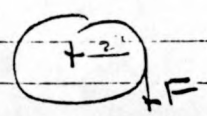
$F \tan\theta = 40{,}000$

$F = 40000 / .25 = 100{,}000$ lbf

$\cos 14.04 \times F = T_{max} \times 2$

$= \frac{97{,}014}{2} = 48{,}507$ lbf

OUTPUT SHAFT



Date: 5/23/84

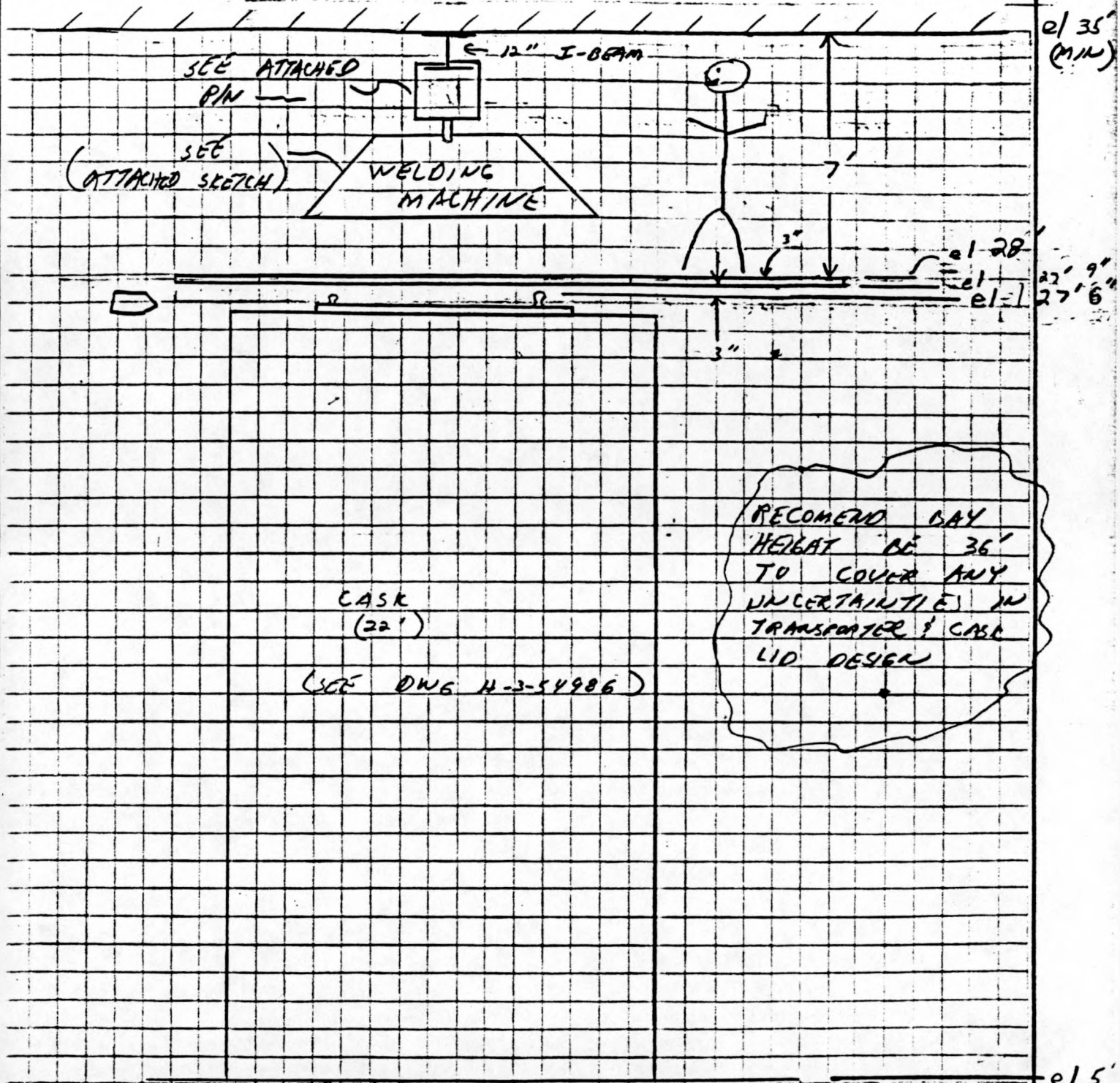
Date:

SIGNATURE WHB for T.J. Kramer DATE 5/23/84 TRB NO. 00 ¢ PAGE 1

Checked by: J.P. Spatangelo
Date: 7/6/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT TRANSPORTER MONORAIL



SIGNATURE Jeff Mitchell DATE 8-15-89 TRB NO. 1 PAGE 107

Checked by: W.H.B. for L.P. Pollons 8/21/89

el 0

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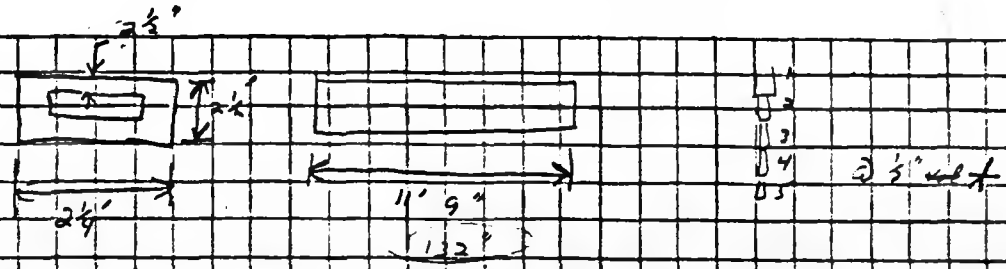
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT WEIGHT CHECK ON TROLLEY

1. POWER MAST



$[(27)(30) - (22)(25)](132)(.28) = 9609$ lbs

2. PAR MAST

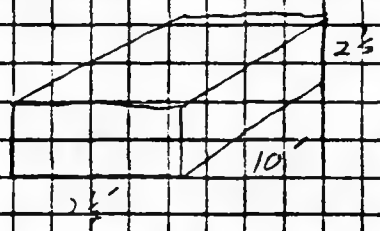
$[(18)(24) - (13)(19)](132)(.28) = 6837$ lbs

3. PAR ARM 550 lbs

4. BEARING 6½ ft. O.D.

$\frac{\pi}{4}(79^2 - 68^2)(5)(.28) = 1065$ lbs

5. TROLLEY STRUCTURE



ASSUME 10% VOLUME

$(7.5)(10)(2.5)(12)^3(.28)(.1) = 9072$ lbs

9609
6837
550
1065
9072
27133 lbs
= 13.5 TON

∴ 17 TON ESTIMATE IS GOOD BALL PARK #

SIGNATURE J.Y. Mitchell DATE 8-10-84 TRB NO. 1 PAGE 102

Checked by: WHB for L.P. Pellono 8/7/85

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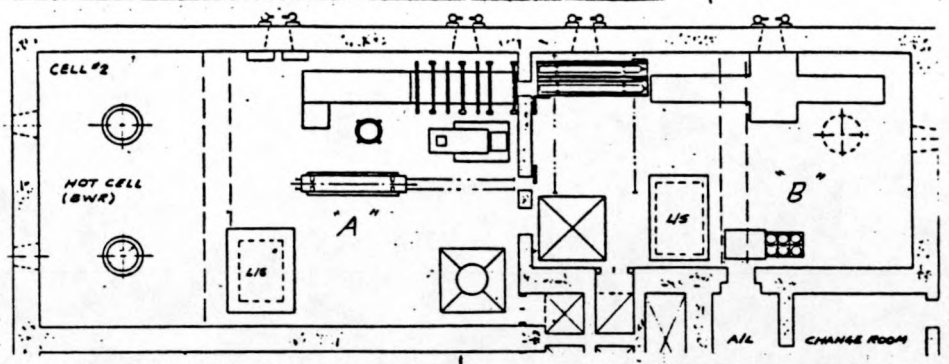
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT PARSONS PRESENTATION MAT'L

CRANE LIFTS



"A" CELL

ROUTINE LIFTS:

1. CHANGEOUT OPENDER MODULE (<5T)
2. REMOVE & REPLACE INLET PORTS (15.3 & 14.6 T)
3. REMOVE & REPLACE SHIPPING CASK LIDS (5 T)
4. REMOVE & REPLACE LAG STORAGE COVERS (TBD)
5. LIFT FUEL ASSY. TO A) LAG STORAGE (3/4 T) B) CONSOLIDATOR
6. LIFT FUEL ASSY FROM L/S TO CONSOLIDATOR (3/4 T)

MAINTENANCE LIFTS

1. REMOVE & REPLACE MAINTENANCE PORTS (<15T)
2. LIGHT REPLACEMENT (PAR)
3. ASSIST WITH MISC MAINTENANCE
   - MASTER SLAVES
   - PNEUMATIC HOOK UPS
   - CAMERAS
   - ELECTRICAL CONNECTIONS
   - CONSOLIDATOR

"B" CELL

ROUTINE LIFTS:

1. REMOVE & REPLACE OUTLET PORTS (15.3 & 14.6 T)
2. REMOVE & REPLACE SILO COVERS (<15T)
3. LIFT CANISTERS TO WELD STATION (≤1T)
4. LIFT LIDS TO WELD STATION (TBD)
5. LIFT WELDED CANISTERS TO A) L/S (2.5 T) B) OUTLET PORTS
6. LIFT WELDED CANISTERS FROM L/S TO OUTLET (2.5 T)

MAINTENANCE PORTS

1. LIGHT REPLACEMENT (PAR)
2. ASSIST WITH MISC. MAINT.
   - MASTER SLAVES
   - PNEUMATIC HOOK UPS
   - CAMERAS
   - ELECTRICAL CONNECTIONS
   - CONSOLIDATOR

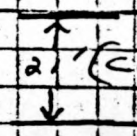
SIGNATURE Jeff Mitchell DATE 7-30-84 TRB NO. 1 PAGE 86

Checked by: WHA for L. P. Pollono 8/7/85 p. 232

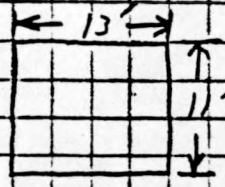
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT DIMENSIONAL AGREEMENTS W/ PARSONS WORKING MEETING

I. THIRD FLOOR & ROOF PLAN INCLUDING NON-CATAGORY 1 SERVICE CORRIDOR

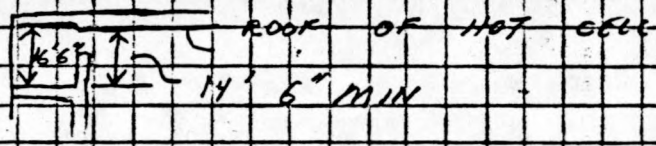


II. HATCH SIZE (1 PER CELL)

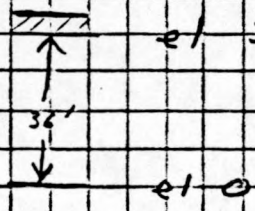


III. WIDTH OF CRANE MAINT BAY 16' → 14'
(PARSONS WILL TRY TO PROVIDE 16')

IV. ELEVATION OF FLOOR IN CRANE MAINT. BAY.



V. TRANSFER DISCHARGE CORRIDOR BAY HEIGHT



VI. ALL HOT CELLS ISOLATED FROM EACH OTHER IN THE CRANE MAINT. BAYS

VII. THIRD LEVEL SERVICE GALLERY WILL BE USED FOR CRANE MAINT & STORAGE OF SPARE TROLLEY

VIII. WIDTH OF NON-CATAGORY 1 SERVICE CORRIDOR 18' TO ALLOW PERSONEL TO PASS BY HATCHES WHEN OPEN.

SIGNATURE Jeff Mitchell DATE 8-15-84 TRB NO. 1 PAGE 111

Checked by: W.H.B for L.P. Pollard 8/7/85

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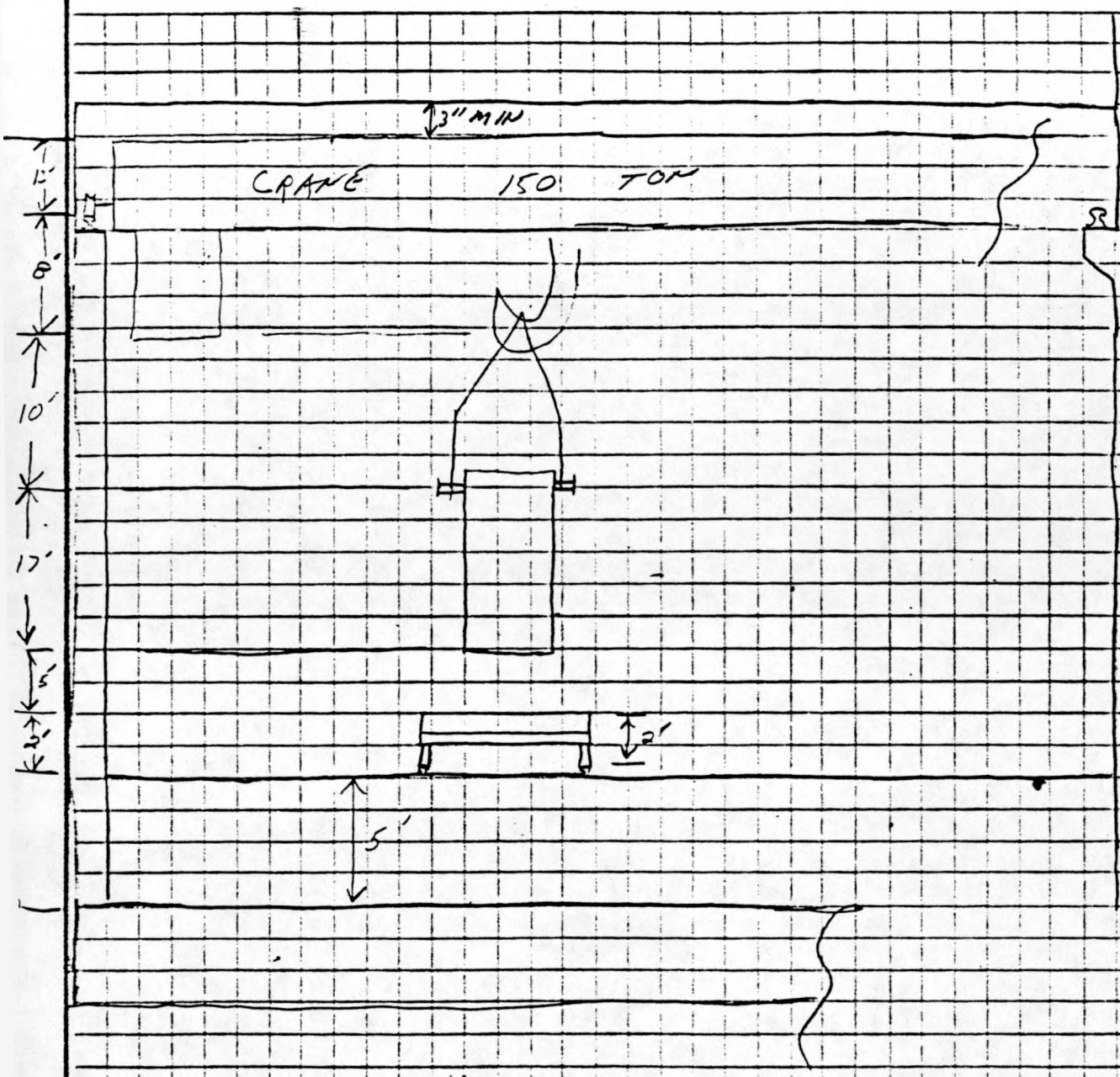
G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT RESIZE CASK BAY FOR SINGLE 150 TON



CRANE	21'	← CONSER. BY ~ 5'
YOKE	10'	
CASK	17'	
CLEARANCE	5'	
CART	2'	
5' ELEVATION	5'	
	60'	

SIGNATURE Jeff Mitchell DATE 7-9-84 TRB NO. 1 PAGE 50

Checked by: WHB for L.P. Perkins 6/7/85

p. 23.4

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT RECEIVING (NORTH) END HANDLING & WORKING PLATFORMS

- Covers and lids - Outer cover: 81.5 inch diameter weighing 3,000 lbs.

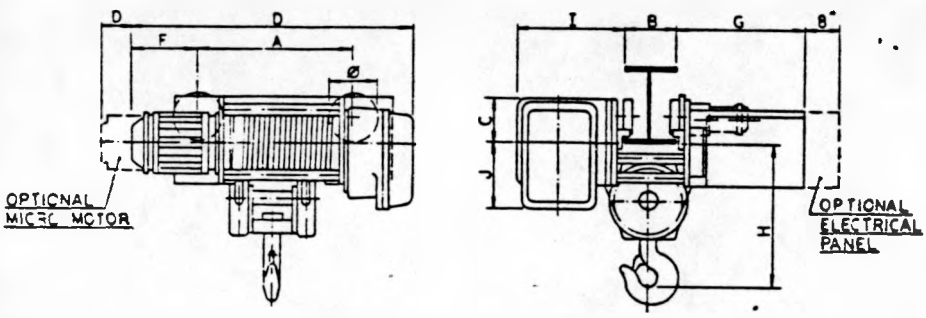
REA 8023

- Inner lid: 77.5 inch diameter weighing 8,000 lbs.

- NLI-1/2 has two closure lids. The outer lid is 28 inches in diameter and weighs TBD lbs. The inner lid is 18 inches in diameter and weighs TBD lbs.
- TN-12 has two closure lids. The outer cover is 98 inches in diameter and weighs approximately 8,000 lbs. The inner lid is approximately 64 inches in diameter and weighs approximately 9,000 lbs.

- NEED A 5 TON MONO RAIL

LOW HEADROOM MONORAIL HOIST MODEL 23



1. 2 speed motor for 2821- hoist series.
2. The H dimension does not increase with under B.

Cap. Ton	Hoist/ Trolley Type	Hoist Speed F/M	Height Of Lift	Hoist Reeving Rope-Dia.	Hoist/ Trolley Wt.-Lbs.	A	C	D'	E	F	G	H	I	J	Ø	No. Of Wheels
1½	222-5223	40	39'-4"	2 ps - 5/16"	850	6"	6¾"	8"	32"	11"	24"	21"	16"	13"	5"	4
	222-6223	40	57'-4"	2 ps - 5/16"	900	13"	6¾"	8"	37"	11"	24"	21"	16"	13"	5"	4
3	222-5423	20	19'-6"	4 ps - 5/16"	950	15"	7"	8"	32"	8"	24"	18"	17"	13"	5"	4
	222-6423	20	28'-6"	4 ps - 5/16"	1000	20"	7"	8"	37"	8"	24"	18"	17"	13"	5"	4
	2821B-1223	32	26'-3"	2 ps - 3/8"	1000	26"	8"	6"	50"	20"	23"	24"	17"	11"	6¼"	4
	2821B-2223	32	52'-6"	2 ps - 3/8"	1050	36"	8"	6"	56"	20"	23"	24"	17"	11"	6¼"	4
	223-1223	40	32'-8"	2 ps - 1/2"	1800	27"	8"	18"	38"	7"	31"	26"	20"	16"	6¼"	4
	223-2223	40	50'-10"	2 ps - 1/2"	2000	27"	8"	18"	44"	7"	31"	26"	20"	16"	6¼"	4
5	222-6623	13	19'-1"	6 ps - 5/16"	1100	26"	10"	7"	38"	8"	26-5/2	31"	17"-5/2	16"	7⅝"	4
	223-6223	27	50'-10"	2 ps - 1/2"	2100	27"	8"	18"	44"	7"	38"	38"	21"	16"	7⅝"	4

- BEAM NEEDS TO CLEAR "C" DIMENSION OF 9" to 10" ∴ NEED A 12" I BEAM → ENVELOPE = 28 + 12 = 40" ~ 3' 4"

SIGNATURE Jeff Mitchell DATE 8-29-84 TRB NO. 2 PAGE 31

Checked by: WHS for L.P. Pellino
Date

SPENT FUEL CANISTER VES 950 H-3-54903

S.O. or CHARGE NO. PROJECT

SUBJECT Canister Design to Hold Consolidated Fuel

Determine the smallest circular enclosure that will include certain number of circles

Ref. Machinery Handbook, 17th Edition

Page 79

Diameter of Circle Enclosing a Given Number of Smaller Circles. — Four of many possible compact arrangements of circles within a circle are shown at A, B, C, and D in Fig. 1. To determine the diameter of the smallest enclosing circle for a particular number of enclosing circles all of the same size, three factors that influence the size of the enclosing circle should be considered. These are discussed in the paragraphs that follow which are based on the article, *How Many Wires Can be Pushed into a Circular Conduit*, by Jacques Dutka, Machinery, October 1956.

1. *Arrangement of Center or Core Circles:* The four most common arrangements of center or core circles are shown cross-sectioned in Fig. 1. It may seem, offhand, that the "A" pattern would require the smallest enclosing circle for a given number of enclosed circles, but this is not always the case since the most compact arrangement will, in part, depend on the number of circles to be enclosed.

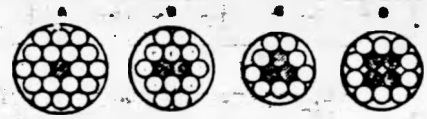


Fig. 1. Arrangements of Circles Within a Circle

2. *Diameter of Enclosing Circle When Outer Layer of Circles is Complete:* Successive complete "layers" of circles may be placed around each of the central cores, Fig. 1, of 1, 2, 3, or 4 circles as the case may be. The number of circles contained in arrangements of complete "layers" around a central core of circles, as well as the diameter of the enclosing circle, may be obtained using the data in Table 1. Thus, for example, the "A" pattern in Fig. 1 shows, by actual count, a total of 19 circles arranged in two complete "layers" around a central core consisting of one circle; this agrees with the data shown in the left half of Table 1 for $n = 2$.

To determine the diameter of the enclosing circle, the data in the right half of Table 1 is used. Thus, for $n = 2$ and an "A" pattern, the diameter D is 5 times the diameter d of the enclosed circles.

3. *Diameter of Enclosing Circle When Outer Layer of Circles is not Complete:* In most cases it is possible to reduce the size of the enclosing circle from that required if the outer layer were complete. Thus, for example, the "B" pattern in Fig. 1 shows that the central core consisting of 2 circles is surrounded by 1 complete layer of 8 circles and 1 partial, outer layer of 4 circles so that the total number of circles enclosed is 14. If the outer layer was complete then (from Table 1) the total number of enclosed circles would be 24 and the diameter of the enclosing circle would be $6d$; however, when the outer layer is composed of only 4 circles out of a possible 12 for a complete second layer, a smaller diameter of enclosing circle may be used. Table 2 shows that for a total of 14 enclosed circles arranged in a "B" pattern with the outer layer of circles incomplete, the diameter for the enclosing circle is $4.6d$.

Table 2 can be used to determine the smallest enclosing circle for a given number of circles to be enclosed by direct comparison of the "A," "B," and "C" columns. For data outside the range of Table 2, use the formulas in Dr. Dutka's article.

4. *Approximate Formula When Number of Enclosed Circles is Large:* When a large number of circles are to be enclosed, the arrangement of the outer circles has little effect on the diameter of enclosing circle. For numbers of circles greater than 20,000 the diameter of the enclosing circle may be calculated within 2 per cent from the formula: $D = d(1 + \sqrt{N} \times 0.907)$. In this formula, D = diameter of enclosing circle; d = diameter of enclosed circles; and N is the number of enclosed circles.

SIGNATURE [signature] DATE 5/6/91 TRB NO. PAGE 2

Cost of Pipe

10" (Sch. 20) = $64.50/ft

12" (Sch. 20) = $78.00/ft

Per 14' length

10" (Sch. 20) = $64.50 ft (14 ft) = $903 / canister body

12" (Sch. 20) = $78.00 ft (14 ft) = $1092 / canister body

At: 15000 MTU Storage

(285) 16,333 canisters needed: 10" cost is -- $14,748,489

(387) 11,202 canisters needed: 12" cost is -- $12,232,984

Difference: $2,516,495
Saved using 12"

At: 30,000 MTU Storage

(285) 30,209 canisters needed: 10" cost is -- $48,296,727

(387) 22,201 canisters needed: 12" cost is -- $53,803,492

Difference: $11,312,235
Saved using 12"

Difference in 1' foot of length between PWR & BWR Canister

At 15,000 MTU Storage:
If 10" Std Pipe cost ($64.50/ft) $620,230
If 12" Std Pipe cost ($78/ft) $500,984

At 30,000 MTU Storage:
If 10" 45,308 Pipe cost ($64.50/ft) $2,922,000
If 12" 30,253 Pipe cost ($78/ft) $2,300,000

25A

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Canister Envelope Size to Enclose Fuel Rods

Equation used: $D_e = d_r\left(1 + \sqrt{N + .907}\right)$

N = # of rods
d_r = diam. of rods
D_e = diam. of envelope

Fuel Type				Dia. of Envelope
2 PWR	CE 14x14	325 rods @ 0.398" dia.	157.6" long	8.70"
2 PWR	CE 15x15	432 rods @ 0.385" dia.		9.57"
2 PWR	CE 16x16	472 rods @ 0.382 dia.	162.6" long	9.09"
2 PWR	BW 15x15	416 rods @ 0.430 dia.	156.4" long	9.65"
2 PWR	WE 14x14	300 rods @ 0.422 dia.	152.3" long	8.85"
2 PWR	WE 15x15	408 rods @ 0.422 dia.	151.4" long	9.37"
2 PWR	WE 17x17	528 rods @ 0.374 dia.	153.0" long (179.1" width)	9.39"
5 BWR	GE 7x7	245 rods @ 0.563 dia.	137.2" long	9.31"
5 BWR	GE 8x8 (14,0)	315 rods @ 0.493 dia.	161.0" long	9.68"
5 BWR	GE 8x8 (24,0)	330 rods @ 0.493 dia.	162.0" long	9.61"

∴ All PWR & BWR consolidated assemblies will fit a 10" Sch. 20 S.S. pipe

SIGNATURE [signature] DATE May 16, 81 TRB NO. _____ PAGE 31

G.O. or CHARGE NO. PROJECT

SUBJECT: Canister Envelope Size

Type of Fuel	Envelope Size
3 PWR's CE 14x14 308 mm @ 0.440" dia.	10.84"
3 PWR's CE 15x15 [illegible] @ 0.411" dia.	11.50"
3 PWR CE 16x16 308 mm @ 0.381" dia.	11.06"
3 PWR Bw 15x15 [illegible] @ 0.434" dia.	11.70"
3 PWR W 14x14 [illegible] @ 0.422" dia.	10.74"
3 PWR W 15x15 [illegible] @ 0.422" dia.	11.30"
3 PWR W 17x17 792 mm @ 0.374" dia.	11.42"
7 PWR GE 7x7 [illegible] @ 0.563" dia.	11.51"
7 PWR GE 8x8 (1) [illegible] @ 0.493" dia.	11.36"
7 BWR GE 8x8 (2) [illegible] @ 0.480" dia.	11.17"

So According to calculation sheet, a 12" Sch. 20 S.S. pipe (12.25" I.D.)

SIGNATURE [illegible] DATE 5/7 TRB NO. PAGE 32

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cask Envelop to Enclose N # Canisters

Determine what number of 12" canisters can fit into cask of 48 1/4" internal diameter.

Referring back to "Machinery's Handbook, 17th Edition" p. 79

Using Patterns A, B, C & D & Table #2

For Pattern A (with one canister at center core)

D = 48.25"
d = 12.75"

D = Kd (Limiting Equation)

48.25 = K(12.75")

K = 3.78

∴ The maximum # of canisters is 7

For Pattern B (with two canisters as core)

K = 3.78

∴ The maximum # of canisters is 8

For Pattern C (with 3 canisters as core)

K = 3.78

∴ The maximum # of canisters is 6

SIGNATURE [signature] DATE _____ TRB NO. _____ PAGE 35

G.O. or CHARGE NO. PROJECT

SUBJECT

Defendant:

Question #1. Why is the canister made of stainless steel?

- The material chosen for the canister was 304 stainless steel on the basis of its good oxidation and corrosion resistance for the projected storage conditions at the ISFS.

- 304L stainless steel not be a viable option because of the reduction of precipitation of carbides resulting from the welding of the various sections of the canister body. This precipitation of carbides in and near the weld zones results in a reduction of chromium in portion grain boundaries rendering the weld zone more susceptible to intergranular corrosion. Further inspection be necessary.

- Using 304L eliminates the necessary preparation of a carbon steel canister, e.g. sandblasting, painting, etc., painting.

- Lower emissivity constant of 304L could not adversely affect the dissipation of heat from the enclosed assemblies.

SIGNATURE [signature] DATE 5/17/84 TRB NO. PAGE 36

Eric P. Fratangelo 1/21/85

G.O. or CHARGE NO. PROJECT

SUBJECT

QUESTION #2 WHY IS THE CANISTER ONE LENGTH?

- THE CANISTER IS DESIGNED TO BE ONE LENGTH TO HOUSE BOTH PWR & BWR FUEL ASSEMBLIES.

- WHY WOULD A CANISTER OF THE SAME LENGTH?
  - WELDING OPERATIONS ARE SIMPLIFIED
  - CONSOLIDATION OPERATIONS ARE SIMPLIFIED
  - THE ADDITIONAL COST OF THE EXTRA FOOT OF PIPING DOES NOT OFFSET THE ADDITIONS THAT WOULD NEED TO BE CONSIDERED IN THE WELDING & CONSOLIDATION HANDLING OPERATIONS.

REFERRING TO PAGE 25 & 25A WITHIN THIS BOOK, THE DIFFERENCE SAVED USING 12" PIPE INSTEAD OF 10" PIPE IS EQUAL TO $2,594,485. SINCE THIS MUST JUSTIFY USING 12" PIPE, THE AMOUNT OF MONEY SAVED USING 12" PIPE AT 13' IN LENGTH TO PWR INSTEAD OF 14' IN LENGTH IS $506,454 FOR STORAGE CAPACITY OF 36,000 FSTU.

THIS SAVINGS OF $506,454 PROBABLY DOES NOT JUSTIFY USING 2 DIFFERENT LENGTH CANISTERS FOR PWR & BWR ASSEMBLIES. DUE TO MODIFICATIONS AND ADDITIONAL REQUIREMENTS THAT WOULD BE NECESSARY IN THE CONSOLIDATION & WELDING EQUIPMENT, THE 2 LENGTHS OF CANISTERS ARE NOT WORTHWHILE.

QUESTION #3 WHY ARE THE END CAPS ELLIPSOIDAL?

A FINAL REPORT (EXPERIMENTAL DEMONSTRATION POCKET PROGRAM) "CANISTER FINAL DESIGN REPORT, PREPARED FOR ROCKWELL HANFORD OPERATIONS DIVISION CONTRACT NO. CDFF-RSH WAS REVIEWED AND VERIFIED THE CANISTER END CAPS OF THE ELLIPSOIDAL CONFIGURATIONS. THE FOLLOWING CONCLUSIONS WERE REACHED".

DOE TEST FUEL REPORT 6.3

- THE SELECTED DESIGN IS INCONSPICUOUS FOR ROAD PLOT TRANSPORTATION USING A LICENSED UNIT 1/2 CASK
- THE VESSELS DOME END CAP CONTAINS FUEL SHEARING WITHIN NORMAL DROP TEST IMPACT LOADS THAT WOULD BE ELLIPSOIDAL CAP
- ELLIPSOIDAL CAP WITHSTANDS A SIGNIFICANT INTERNAL PRESSURE TO 100 @ 300°F

SIGNATURE [signature] DATE 5/7/85 TRB NO. PAGE 37

G.O. or CHARGE NO. PROJECT

SUBJECT

The lower end of the canister is a standard 1 inch diameter, 0 wall, 304 stainless steel ellipsoidal end cap. The ellipsoidal shape was chosen instead of a flat plate for reasons of a more uniform stress distribution. A flat plate welded to a pipe, resisting internal pressure, produces moments and interaction loads due to the discontinuity at what would be the weld area. The use of the ellipsoidal end cap greatly reduces these discontinuity stresses especially near the weld area. The use of the ellipsoidal end cap results in a design which is judged to be more suited for long term storage. Additionally the ellipsoidal shape acts as a large lead-in surface during emplacement operations ~~which improves the canister's handleability.~~

FURTHER STUDY WILL BE NECESSARY TO DETERMINE THE INTERNAL PRESSURE OF THE CANISTER IN ALL MODES (3 MAL ASSEMBLIES & 7 BWR'S) BOTH. THE CANISTER DESIGN NEEDS TO WITHSTAND THIS PRESSURE.

QUESTION #4 WHY IS THE PLATE INCLUDED IN THE TOP?

TO ALLOW FOR HORIZONTAL RETRIEVAL FROM THE CANISTER BODY, THE LIFTING SYSTEM WAS MOUNTED ON THE ELLIPSOIDAL CANISTER END.

WITHOUT THE PLATE, REMOVAL FROM THE CANISTER BODY:

- PACKING OF CANISTERS INTO A CASK IS SIMPLIFIED
- PLACING A CANISTER INTO A REPOSITORY AND RETRIEVAL IS SIMPLIFIED.
- ATTACHMENT IS SIMPLIFIED
- ATTACHMENT ANCHOR IS SIMPLER
- THERMAL-STRESSES ARE ELIMINATED ON CANISTER BODY IF THE TRUNNIONS WERE TO BE WELDED TO THE BODY.
- MECHANICAL STRESSES ARE ELIMINATED ON CANISTER BODY IF TRUNNIONS WERE TO BE MECHANICALLY ATTACHED TO THE BODY.

SIGNATURE DATE 5/18/84 TRB NO. PAGE

G.O. or CHA

SUBJECT

SIGNATURE

G.O. or CHARGE NO. PROJECT

SUBJECT

Δ Diametral Expansion = $\alpha T L$

$= (3.43 \times 10^{-6} \frac{in}{in\,°F})(700°F)(0.425\ in)$

$= 0.00102\ in$

Maximum Dia = 0.425 + 0.00102

Maximum Dia. = 0.426 in

Minimum I.D. = 0.371 + .00102

Maximum I.D. = 0.3720 in

Now Considering Irradiation Growth

For 3 cycle fuel ≈ 33,000 MWD/MTU

Irradiation Growth = .3%

so:

Max Dia = 0.426 (1.003) = 0.42728 in

Min I.D. = 0.372 (1.003) = 0.3731 in

Consider Fuel Pellets:

Pellet O.D. = 0.3669 ± .001

Max. Pellet O.D. = 0.3679 in

Min. Pellet O.D. = 0.3659 in

SIGNATURE [signature] DATE 5/22/81 TRB NO. PAGE 37

G.O. or CHARGE NO. PROJECT

SUBJECT

QUESTION #5 WHAT IS THE NEED FOR THE SEAL CAP IN THE LID?

THE SEAL CAP WILL BE INCLUDED IN A PELW CLOSURE LID FOR THE PURPOSE OF PROVIDING A MEANS TO SAMPLE INTERIOR GAS FOR ANALYSIS AT A LATER DATE. THE CAP WAS TESTED FOR REPEATABILITY & SEAL TIGHTNESS IN "CY 1977 SPENT FUEL HANDLING & PACKAGING DEMONSTRATION PROGRAM AT THE PACIFIC TEST SITE" REPORT. RESULTS CONCLUDED THE PENETRATION CAN BE REMOVED AND INSTALLED SEVERAL TIMES & STILL MAINTAIN ITS GAS-TIGHT SEAL. RESULTS ARE INCLUDED IN "ATTACHMENT #2" OF THE REPORT.

QUESTION #6 WHY ARE THE WELDS IN THE HORIZONTAL CONFIGURATION?

WELD CONFIGURATION STUDIES WERE PERFORMED BY FINITE ELEMENT ANALYSIS, AND THE RESULTS ARE INCLUDED IN THE "CANISTER FINAL DESIGN REPORT" PART 2 OF 2 IN BOEING HANFORD OPERATIONS DIVISION.

THE RESULTS ARE LISTED IN APPENDIX I "WELD PROCESS CONCEPT VERIFICATION TESTING REPORT" PAGES 6-24.

THE RESULTS CONCLUDED THAT STRESSES WERE THE SAME IN THE HORIZONTAL WELD CONFIGURATIONS. ALL MISSILE WELDS BELOW THE YIELD POINT OF THE CONTAINER MATERIAL WERE REDUCED BELOW OCCURED. WHERAS THE VERTICAL WELD CONFIGURATION HAD LOCALIZED YIELDING & HAD CONSIDERABLE MEMBRANE STRESS THROUGHOUT THE WELD.

SIGNATURE [signature] DATE 5/16/84 TRB NO. PAGE 39

JOB NO. | DEPARTMENT | AUTHOR | DATE

E. P. Spatangelo

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

QUESTION #7 WHY IS THE CANISTER 12" IN DIAMETER?

REFERRING BACK TO PAGES 25 - 25A, IT IS OBVIOUS THAT USING A 12" CANISTER VERSUS A 10" CANISTER WILL REQUIRE 5100 CANISTERS LESS FOR STORAGE OF 15,000 MTU AND 23,900 CANISTERS LESS FOR MAXIMUM STORAGE OF 30,000 MTU. THIS SAVINGS IN DOLLARS CORRESPONDS TO $2,916,000 FOR STORAGE OF 15,000 MTU AND $4,913,000 FOR STORAGE OF 30,000 MTU. THIS SAVINGS IS A SUBSTANTIAL AMOUNT AND SHOULD OUTWEIGH THE ADDITIONAL SIZES OF HARDWARE THAT MAY BE NECESSARY TO HANDLE THE LARGER CANISTER.

HOWEVER, BEFORE ACCEPTING THE LARGER DIAMETER CANISTER, EVALUATIONS OF INTERNAL PRESSURES AND IMPACT RESISTANCE WILL BE NECESSARY TO INCLUDE THREE PWR AND 7 BWR ASSEMBLIES.

QUESTION #8 HOW MUCH CLEARANCE ROOM IS LEFT IN THE CANISTER?

ACCORDING TO MY CALCULATIONS ON PAGE 32 OF THIS BOOK, TAKING THE WORST CASE WHICH IS BW 15x15 BUTBY 624 RODS D 0.430" DIA.

THE ENCLOSING DIAMETER NECESSARY IS 11.70". USING A 12" S.S. SCH. 20 PIPE, THE INTERNAL DIAMETER IS 12.25".

SUBTRACTING AND DIVIDING BY 2

12.25 - 11.70 = 0.55/2 = 0.275" DIAMETRAL CLEARANCE

∴ IF THE CONSOLIDATED RODS ARE FED INTO THE CANISTER IN AN APPROPRIATE FASHION, THIS CLEARANCE IS SUFFICIENT

SIGNATURE [signature] DATE 5/10/84 TRB NO. _____ PAGE 90

CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
						E.P. Fratangelo	1/21/8

G.O. or CHARGE NO. PROJECT

SUBJECT

QUESTION #9 WHAT IS THE WEIGHT OF AN EMPTY / FULL CANISTER?

EMPTY CANS 12" DIA, SCHEDULE 20

WT: 33.38 lbs/FT

33.38 lbs/FT (18 FT) = 467 lbs CANISTER BODY

PLUS

BOTTOM PLATE OF CONTAINMENT CAP 11.46 lbs/FT²

12.75 in DIA = 127.67 in² ÷ 144 in² = .886 FT²

@ .25" THICK .886 (11.46) = 10.27 lbs

PLUS BOTTOM OF DISPOSAL CAP THAT IS CYLINDRICAL (2 CAPS)

3" CYLINDRICAL (33.38 lbs / 12) = 8.34 lbs

PLUS 2 SUPPORT PLATES WELDED TO END CAPS

12.25 in DIA = 117.81 in² ÷ 144 in² = 0.82 FT²

2 x (.82) = 1.64 FT²

@ .50 in THICK 24.46 lbs/FT² (.82) = 20.45 lbs

PLUS BASTLE 10 lbs

∴ TOTAL EMPTY WEIGHT 550 lbs

SIGNATURE [signature] DATE 5/18/84 TRB NO. PAGE 12

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

A full canister is:

Empty canister 550 lbs

3 consolidated assemblies

THE 305 WGA For PWR fuel rod - 5.50 lbs

BWR fuel rod - 4.30 lbs

Taking the worst cases from page 32

3 PWR w 17x17 392 rods @ 0.374 lbs 4356 lbs

7 BWR GE 8x8 491 rods @ 0.385 lbs 4277 lbs

Total weights

Empty + consolidated rods

PWR -- 550 lbs + 4356 lbs = 4906 lbs

BWR -- 550 lbs + 4277 lbs = 4827 lbs

Using these weights and the results of the stress analysis as shown in the Experimental Demonstration Package Report "Canister Final Design Report" Page Rev 2, and multiplying the stresses by 2.30 (4906/1400) the maximum stress is 24,072 psi.

This stress is below yield and therefore the canister design is compatible to the fuel assembly.

SIGNATURE [signature] DATE 5/8/84 TRB NO. _____ PAGE 42

G.O. or CHARGE NO. PROJECT

SUBJECT

QUESTION #10 WHY ARE THE WELDS TO BE FULL PENETRATION WELDS?

THE WELD JOINTS ARE FULL PENETRATION STRUCTURAL WELDS DESIGNED TO MEET THE SUFFICIENT ASME BOILER AND PRESSURE VESSEL CODE, SECTION III, DIVISION I, CLASS 3. THE WELD JOINT DETAILS ARE ACCEPTABLE TYPE WELDS AND WILL SERVE A COMPLETE PRESSURE BOND. THE WELDS WILL SPECIFICALLY MEET THE ASME CODE ND-3351.2 "CATEGORY B WELDS", ND-3352.2 "JOINTS OF CATEGORY B WELDS", ND-4233 "ALUMINUM'S BEGGREMENTS WHEN INSIDE SURFACES ARE INACCESSIBLE", AND ND-4242 "CATEGORY B WELD JOINTS IN VESSELS".

QUESTION #11 IS THE CANISTER DESIGNED TO THE ASME BOILER & PRESSURE VESSEL CODE, SECTION II, DIVISION I?

THE CANISTER DESIGN WILL BE DETERMINED ACCORDING TO THE ASME CODE, SECTION III DIVISION I. OF THESE CONCERNS WILL BE THE WELD THICKNESS, DETERMINED WELDS 1 AND 2 ARE. A STUDY WILL BE REQUIRED TO BE PERFORMED TO DETERMINE THE CANISTER INTERIOR PRESSURE WITH 3 FUEL CONSOLIDATED ASSEMBLIES WITH. THE STUDY WILL YIELD RESULTS THAT ARE APPLICABLE TO VARIOUS CASES OF SECURED AND UNSECURED WILL BE REPORTED HERE.

SIGNATURE DATE 5/21/84 TRB NO. PAGE 35

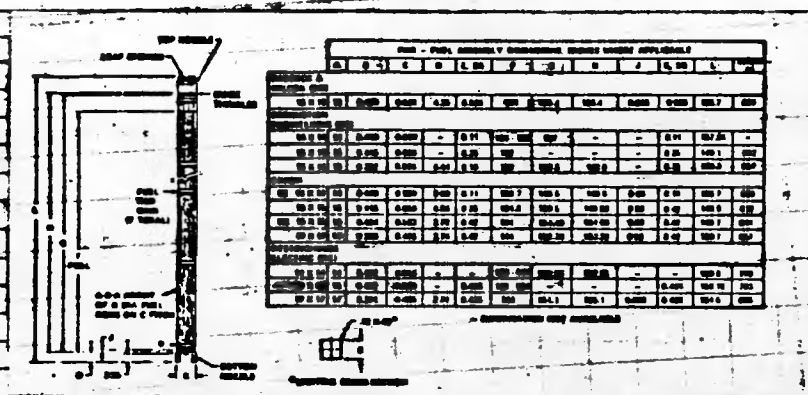
RMP-307 (2/78)

TITLE CANISTER DESIGN

JOB NO. DEPARTMENT AUTHOR DATE

G.O. or CHARGE NO. PROJECT MRS

SUBJECT DETERMINING THE INTERIOR PRESSURE OF THE CANISTER



OUR REFERENCE CASE WILL BE A 17x17 PWR 15x15 FUEL ASSEMBLY WITH CONSERVATISMS IN ALL PARTS OF THE CANISTER.

ASSUMPTIONS INCLUDE:

- FUEL ROD O.D. = 0.422 in
- CLAD THICKNESS = 0.0243 in
- FUEL ROD I.D. = 0.3734 nominal @ 68°F
- PELLET O.D. = 0.3668 in
- FUEL ROD O.D. TOLERANCE = MAX. 0.425 in AND MIN. 0.420 in.
- FUEL PELLET O.D. TOLERANCE IS ±.001 in

MAX. 0.3679 in. AND MIN. 0.3659 in

- CLAD THICKNESS VARIES BY ±10%

BECAUSE THE MINIMUM PELLET WILL BREAK WITH ALL FUEL RODS BREAKING AT THE MINIMUM POSSIBLE TEMPERATURE, 700°F, THIS IS LARGE THE PELLETS IS FOR.

SIGNATURE [signature] DATE 5/21/84 IRB NO. PAGE

G.O. or CHARGE NO. PROJECT

SUBJECT

I. DETERMINE FUEL O.D & I.D, SPENT FUEL PELLETS O.D. & I.D. @ 700°F AND 25% IRRADIATION GROWTH

FRESH FUEL RODS

FUEL ROD O.D. = 0.422 in NOMINAL @ 68°F

ADJUSTING FOR TOLERANCES

MAX. O.D. 0.425 in

MIN. O.D. 0.420 in

ADJUSTING FOR TOLERANCES IN WALL THICKNESS, DETERMINE FUEL I.D.

MAX. ROD O.D. = 0.425 in

MAX. ROD I.D. = 0.425 in − 2(.0243 in ± .00243 in) ± 10% TOLERANCE

= 0.381 in

MINIMUM ROD I.D. = 0.425 in − 2(.0243 ± .00243) ± 10% TOLERANCE

= 0.371 in

MINIMUM ROD O.D. = 0.420

MINIMUM ROD I.D. = 0.420 − 2(.0243 − .00243)

= 0.376 in

MAXIMUM ROD I.D. = 0.420 + 2(.0243 + .00243)

= 0.3[illegible] in

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G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

Using the limiting cases:

max O.D. = 0.425 in

max I.D. = 0.381 in

min I.D. = 0.371 in

min O.D. = 0.420

max I.D. = 0.376 in

min I.D. = 0.366 in

* Limiting case is largest O.D. and smallest I.D.
(However, the largest I.D. will also be investigated)

max. O.D. = 0.425 in

min. I.D. = 0.371

max I.D. = 0.381 in

Now consider thermal expansion

α = coefficient of thermal expansion for Zircaloy

α = 3.40 μin/in/°F Ref. (Steam and its Generation, Babcock & Wilcox, Table 6, p. 57-5)

Table 8
Some physical properties of Zircaloy-4

Temp. F	Density lb/ft³	Thermal Conductivity Btu/sq ft. hr. F/in.	Coefficient of Linear Expansion† (in./in. F) 10^6	Specific Heat	Modulus of Elasticity in Tension (Static Value) psi/10^6
70	412	98		0.070	14
200		101	3.24	0.073	13
400		107	3.33	0.077	12
600		113	3.43	0.081	11
800		120	3.53	0.085	9
1000		131	3.62	0.086	7
1200		142	3.72	0.086	5

†Between 70F and temperature shown.

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G.O. or CHARGE NO. PROJECT

SUBJECT

Δ Diametral Expansion = $\alpha T L$

$= (3.43 \times 10^{-6} \frac{in}{in\,°F})(700°F)(0.425\,in)$

$= 0.00102\,in$

Maximum Dia = 0.425 + 0.00102

Maximum Dia = 0.426 in

Minimum I.D. = 0.371 − .0010²

Minimum I.D. = 0.3720 in

Now Considering Irradiation Growth

For 3 cycle fuel ≈ 33,000 MWD/MTU

Irradiation Growth = .3%

so:

Max Dia = 0.426 (1.003) = 0.42728 in

Min I.D. = 0.372 (1.003) = 0.3731 in

Consider Fuel Pellets

Pellet O.D. = 0.3669 ± .001

Max. Pellet O.D. = 0.3679 in

Min. Pellet O.D. = 0.3659 in

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W.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

It is not decided which of the O.D.'s is the limiting case, so both will be investigated. We will use the maximum O.D.

Max. Pellet O.D. = 0.3679 in

Consider Diametral Expansion at 700°F (Ref. Steam B1W)

Table 3
Some physical properties of uranium dioxide

Temp, F	Thermal Conductivity* Btu/sq ft, hr, F/in.	Coefficient of Linear Expansion† (in./in. F) 10^{6}*	Specific Heat
300	43.8	5.67	0.056
1000	28.4	5.67	0.067
2000	18.7	5.73	0.072
3000	16.0	6.58	0.075
4000	16.6	7.42	0.081
5000	20.3	—	0.094

* Based on 95% density pellets.
† Between 70F and temperature shown.

$\alpha = 5.67 \times 10^{-6}$ in/in °F

$\Delta Dia = (5.67 \times 10^{-6})(700°F)(0.3679)$

$= 0.00 \cancel{5}\ 1 \times 10$

Max. Dia = 0.3693 in

Consider Irradiation Growth:

Growth is .3% at 20000 MWD/MTU

Max. Dia = 0.3693 in (1.003)

Max Pellet O.D. = 0.3705 in

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G.O. or CHARGE NO. PROJECT

SUBJECT

B. Summarizing

Max. Rod O.D. = 0.42728 in

Min. Rod I.D. = 0.3731 in

Max. Pellet O.D. = 0.3705 in

II. Determine length of rods and pellets at 700°F & Irradiated:

Rod Length = 152.4"

For Zircaloy $\alpha = 3.98 \times 10^{-6}$ in/in °F

$\Delta L = \alpha T L$

$= (3.98 \times 10^{-6})(700°F)(152.4)$

$= 0.3688$ in

Maximum Length = 152.768 in

Irradiation Growth = .3% for 22,000 MWD/MTU

Maximum Rod Length = (1.003)(152.768) = 152.22 in

Fuel Length = 144.0"

For UO_2 $\alpha = 5.67 \times 10^{-6}$ in/in °F

$\Delta L = \alpha T L$

$= (5.67 \times 10^{-6})(700)(144)$

$\Delta L = 0.571$ in

Max. Length = 144.571

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G.O. or CHARGE NO. PROJECT

SUBJECT

Subject to Irradiation Growth @ .3% for 30,000 MWD/MTU fuel

Max. 144.671 (1.003)

Max. Length = 145.00"

Or Summarizing:

Max. Rod Length = 152.22 in

Max. Fuel Length = 145.00 in

To determine the interior cavity length of the fuel rod, the two solid end caps must be subtracted from the overall length of the rod.

Solid end caps = 0.695 in

0.695 in x 2 = 1.390 in

Therefore

Max rod length = 152.22 - 1.390 in

Maximum Rod Interior Cavity = 150.83 in

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B.O. or CHARGE NO. PROJECT

SUBJECT

To Determine the Plenum Length, subtract active fuel length from the maximum internal cavity length of a fuel rod.

$L_{max\ rod} - L_{act\ fuel} = \text{Plenum}$

150.83 in − 145.0 in = 5.83 in = Plenum length

Plenum length = 5.83 in

III Determine the Interior Volume of the Canister

Assumptions made:

- For conservatism in our analysis, thermal expansion of the canister was omitted, thereby utilizing the smallest volume which would yield the highest pressure.
- The volume of the end caps is omitted due to the support plates being welded in them.

I.D. = 12.25 in

$\text{Volume} = \text{Tube length} \left(\frac{\pi (12.25)^2}{4}\right)$

$\text{Vol.} = 19.564\ \text{in}^3$

$\text{Vol.} = 11.32\ \text{ft}^3$

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G.O. or CHARGE NO. PROJECT

SUBJECT

Determine the Volume Displaced by the Intact Rods.

Maximum Rod Length = 152.22 in

Maximum Rod Dia. = 0.4278 in

$$\text{Volume} = \left(\frac{\pi(.4278)^2}{4}\right)(152.22\text{ in})$$

Vol/Rod = 21.89 in^3

Total Vol. = (21.89)(610)

= 13,350 in^3

Total Vol. = 7.749 ft^3

Determine the Total Volume Added to the Canister Volume Once all Fuel Rods Stretch.

- Volume to Plenum Length = 5.83 in

$$\text{Vol./Rod} = \frac{\pi(.3131)^2}{4}(5.83)$$

Vol./Rod = 0.637 in^3

- Volume due to Diametral Clearance between Fuel Pellet and I.D. of Rod for Active Fuel Length

$$\text{Vol./Active Length due to Clearance} = \frac{\pi(.3131 - .3105)^2}{4}(145.0)$$

= 0.00764 in^3

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G.O. or CHARGE NO. PROJECT

SUBJECT

TOTAL VOLUME PER ROD:

$V_{TOT/ROD}$ = VOL. OF PELLETS + VOL. DUE TO CLEARANCE

$= 0.637\ in^3 + 0.000769\ in^3$

$= 0.6377\ in^3$

$VOL/ROD = 0.000369\ ft^3$

$VOL/3\ PWRs = 0.000369\ ft^3\ (612)$

$= 0.226\ ft^3$

VOL/3 CONSOLIDATED PWR ASSEMBLIES = $0.226\ ft^3$ 0.458 ft^3/ROD

DETERMINE THE VOLUME OCCUPIED BY SOLID MATERIAL:

$VOL/SOLID$ = TOTAL VOL FOR INTACT RODS − TOTAL VOLUME OF FREE SPACE IN INTERIOR OF EACH ROD

$= 7.749\ ft^3 - 0.226\ ft^3$

$VOL/SOLID = 7.52\ ft^3$

VOLUME/SOLID MATERIAL IN CANISTER = $7.52\ ft^3$

VOL/TOTAL EMPTY SPACE = $11.32 - 7.52 = 3.79\ ft^3$

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G.O. or CHARGE NO. PROJECT

SUBJECT

Total Volume of Empty Space = 3.79 ft³

IV Determine the moles of gas in each fuel rod:

Assumptions: 1 According to 99/99 Statistical Max

Initial Pressurization P_o = 600 PSIA = 40.82 atm.

T = 60°F = 293.16°K

V = 0.6711 in³/rod = 0.0184 L

R_{Helium} = 0.0821

$PV = nRT$

$\frac{(40.82)(.0184)}{(.0821)(293.16)} = n$

n = moles of He = 0.0776 moles/rod

For 612 rods n = 18.79 moles of He

n = 18.79 moles He in original rods

V Determine moles of Helium in Canister

Assumptions:

Initial Pressurization = 1 atm

T = 120°F = 322.12°K

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JOB NO. DEPARTMENT AUTHOR DATE

G.O. or CHARGE NO. PROJECT

SUBJECT

V = Volume Stack − Vol. Fuel Rods = 3.57 ft³ = 101.13 L

R = .0821 Atm

PV = nRT

$\frac{PV}{RT} = n$

$\frac{(1)(101.13)}{(.0821)(322.15)} = n$

n = 3.620 moles of Argon

Total Moles of Gas in Canister = Helium in rods + Argon in Canister

= 10.79 moles He + 3.620 moles Argon

= 14.41 moles of Gas

Determine Once rods Breach and Temperature goes to 700°F, what is pressure.

Once rods Breach, Volume increases to = 3.79 ft³

Total gas supplied by pellets of gas diffused out = 2.47 moles/assembly

3 assemblies = 7.418 moles

Total Moles = 14.41 moles + 7.418 moles

Moles Tot = 22.03

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G.O. or CHARGE NO. PROJECT

SUBJECT

PLUGGING BACK INTO THE IDEAL GAS EQUATION AND ASSUMING TEMP = 300°F

$$PV = n\bar{R}T$$

$V = 3.79\ ft^3 = 107.12\ L$

$$P = \frac{n\bar{R}T}{V}$$

$$= \frac{(22.03)(.0821)(573.16)}{107.33\ L}$$

$P_{atm} = 10.85\ atm \times .0680\ \frac{psi}{atm}$

& $P = 160\ psi$ 160 psi

PLUGGING THIS PRESSURE INTO EQUATION FROM ASME VESSEL CODE, CLASS 3

FOR LONGITUDINAL JOINT WITH CIRCUMFERENTIAL STRESS

$$t = \frac{PR}{SE - .6P}$$

AT 300°F WELDED PIPE 304 $S = 15{,}900\ psi$ (ALLOWABLE STRESS)

$E = .60$ (WELD EFFICIENCY)

$$t = \frac{(160)(6.125)}{15{,}900(.60) - .6(160)}$$

$t = .103\ in$

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G.O. or CHARGE NO. PROJECT

SUBJECT

However if the analysis for pressure is done according to the "Origen" method:

Total moles of Gas = 14.65 + 3(21.66)

where 21.66 moles of gas is the 100% release of fission gases, multiplied by 3 for 3 assemblies

Total moles of Gas = 78.13 moles

Insertion into Ideal:

$$P = \frac{(78.13)(.0821)(644.26)}{107.33}$$

P = 38.60 atm

Psi = 567 psi

Inserting into stress equation:

$$t = \frac{(567)(6.125)}{15,900(.6) - .6(567)}$$

t = 0.381 ; D ≤ .60

t = 0.206 ; D ≤ .30

Cannot use Sch. 20

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RMP-307 (2/78)

SUBJECT ASME Code Acceptability (Continued from prev. sh.)

Using the Design Pressure of P = 160 psi and according to Design Considerations ND-3320.0

Specifically, ND-3324 Components under Internal Pressure:

A.) Circumferential Stress (Longitudinal Joints)

$$t = \frac{PR}{SE - 0.6P}$$

Pressure = 160 psi
Temp. = 700°F
R = 6.125"
Stress = 15,900 psi
E = .60 (Type III weld)

$$t = \frac{(160)(6.125)}{(15,900)(.60) - .6(160)}$$

$$\boxed{t = 0.103 \text{ in}}$$

B.) Longitudinal Stress (Circumferential Joints)

$$t = \frac{PR}{2SE + 0.4P}$$

$$t = \frac{(160)(6.125)}{2(15,900)(.60) + .4(160)}$$

$$\boxed{t = 0.052 \text{ in}}$$

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G.O. or CHARGE NO. PROJECT

SUBJECT

c.) For Ellipsoidal End Caps

$$t = \frac{PD}{2SE - 0.2P}$$

$$t = \frac{(100)(12.25)}{2(15,900)(.80) - 0.2(100)}$$

$$\boxed{t = 0.1034}$$

Insert Additional Pages Here

Analyze thickness required for the end caps to be flat

$$t = d\sqrt{CP/S}$$ (Refer p. 60 ND-3325.1)

Type (f)

$C = .33m$

$m = t_s/t_s$

$m = .209/.250$

$= .836$

So $C = .33(.836) = 0.275$

$d = 12.25$

$$t = (12.25)\sqrt{(.275)(100)/15,900}$$

$$\boxed{t = 0.644}$$

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TITLE CANISTER DESIGN

JOB NO. DEPARTMENT AUTHOR DATE

MUST ANALYZE COMBINED STRESS DUE TO PRESSURE + WEIGHT OF CANISTER

WORST SOLUTION

$\sigma_{allowable}$ at 700°F = 15,900 psi

For zinc vessel

A.) HOOP STRESS $\sigma_1 = \frac{Pr_i}{t}$

$15,300 = \frac{300(6.125)}{t}$

$t = 0.0385$ in

B.) LONGITUDINAL STRESS

$\sigma_2 = \frac{Pr}{2t}$

$= \frac{(300)(6.25)}{2(.25)}$

$= 2000$ psi

C.) LONGITUDINAL STRESS DUE WEIGHT

$\sigma_3 = \frac{F}{A}$

$= \frac{4904}{\frac{\pi(12.25)^2}{4} - \frac{\pi(12.25)^2}{4}}$

So $\sigma = 500$ psi

This is to high to meet code

Adding stresses of B & C

$\sigma_{tot} = 2000 + 500 = 2500$ psi

For 304L $\sigma_{all} = 15,900$ psi

USE 12" SCH. 20 $t_{wall} = 0.25$"

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G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

DESIGNING THE CANISTER ACCORDING TO THESE PARAMETERS IS IN ACCORDANCE WITH THE ASME CODE.

QUESTION # 12 WHAT MEANS ARE PROVIDED FOR IMPACT RESISTANCE?

THE BASIC MEANS PROVIDED FOR IMPACT RESISTANCE IS THE ADEQUATE WALL THICKNESS AND THE ELLIPSOIDAL END CAPS. THE CANISTER BODY IS OF SUFFICIENT SCHEDULE TO RESIST MINOR BUMPS & GOUGES WITHOUT EXTENSIVE OBVIOUS BENDING. THE ELLIPSOIDAL END CAPS WERE DELIBERATELY CHOSEN SOLELY FOR IMPACT RESISTANCE. THE CAPS WERE ATTACHED TO A 12" CANISTER BODY AND DROPPED TESTED FROM 41.7 FEET AT 117 PSIG (THIS IS REPRESENTATIVE OF A 30 FT. DROP AT AN ELEVATED TEMPERATURE OF 700°F) IN THE "EXPERIMENTAL DESIGN PACKAGE" PROPOSED FOR ROCKWELL MANIFOLD OPERATIONS. AND THE RESULTS ARE LISTED IN THE "CANISTER FINAL DESIGN REPORT" PART 1 OF 2. THE CANISTER WAS DROPPED FROM 30' IN A VERTICAL FASHION AND (3.3° ROTATED) A FLAGGED FASHION, WITH THE INTERNAL PRESSURE AT 100 PSI AND THE INTERNAL WEIGHT EQUAL TO 1600 LBS. THE GENERAL RESULTS SUMMARIZED IN THE REPORT ARE:

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G.O. or CHARGE NO. PROJECT

SUBJECT

- More canister impact energy was absorbed by the ellipsoidal end cap, as evidenced by the relative amount of end cap deformation, than was absorbed by the reversed-dished end cap.

- The angle drop test mode produced higher canister impact loads than did the straight end drop test mode.

Reversed-dished end cap canister assemblies sustained larger dummy fuel assembly impact accelerations (about 39% larger) during drop testing than did those of ellipsoidal end cap canister assemblies.

The reversed-dished end cap canisters were observed to sustain larger impact accelerations than did the ellipsoidal end cap canisters. The resulting canister instantaneous acceleration and equivalent average acceleration determined for the canister straight end drop tests are summarized as follows:

Analysis indicated that a canister at beginning-of-life (700°F canister with no corrosion and with 100 psig internal pressure) would sustain more drop test damage and therefore represents a more limiting set of design conditions than at end-of-life (fully corroded canister, original wall thickness less 0.020 inch, at 200°F and at 60 psig internal pressure).

The reversed-dished end cap canister design was subject to more localized end cap deformation during drop testing than was the ellipsoidal end cap canister design. Evidence of this was observed in the generated strain data as well as through examination of the deformed end cap. The localized end cap deformation was caused by interaction with the dummy fuel assembly support feet.

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G.O. or CHARGE NO. PROJECT

SUBJECT

The canister body diametral deformation sustained during drop testing was found to be 0.23 inch for the ellipsoidal end cap canister and 0.91 inch for the reversed-dished end cap canister. When consideration was given to post-drop handling and transportation of an EDP canister using a currently licensed truck mounted shipping cask such as the NLI 1/2, the reversed-dished end cap canister deformation was found to be unacceptably high. The ellipsoidal end cap canister deformation was judged to be acceptable.

Both candidate canister designs, the ellipsoidal end cap and the reversed-dished end cap, were found to be structurally leak tight after being subjected to drop testing.

THE ISSUES [illegible] WHETHER OR NOT THE ELLIPSOIDAL END CAP IS THE BEST METHOD FOR DISSIPATING ENERGY WHEN A FLAT PLATE OF REVERSED DISHED END CAP. THE TEMPERATURE AND PRESSURE OF THE INTERNAL PRESSURE OF CONTENTS OF THE CANISTER IS CHANGED. HOWEVER, BY DETERMINING THE CANISTER INTEGRITY AFTER VARIOUS PARAMETERS CHANGE, FAILURE DURATION IS [illegible].

IN OUR CASE, THE NEW PARAMETERS ARE:

INT. PRESSURE 320 PSIA
DEAD WEIGHT 4356 lbs
OVERALL WEIGHT 4900 lbs
2:1 ELLIPSOID + 36.25" DIA.

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G.O. or CHARGE NO. PROJECT

SUBJECT

QUESTION # 13 WHY ARE NO GUIDE BRACKETS INCLUDED IN THE INTERIOR OF THE CANISTER?

THE SIZE OF THE CANISTER HAS BEEN CHOSEN WITH AN I.D. THAT IS EXTREMELY CLOSE TO THE O.D. THAT IS NECESSARY TO CONTAIN ALL THE FUEL RODS (REFER TO PAGES 31-32). SINCE THE CLEARANCE BETWEEN THE I.D. OF THE CANISTER AND THE O.D. OF THE ENVELOPE OF THE RODS IS SO SMALL, NO ADDITIONAL INTERNAL CONSTRAINT IS NECESSARY TO HOLD THE RODS IN PLACE.

QUESTION # 14 WAS CRITICALITY CONSIDERED IN OUR DESIGN OF THE CANISTER?

CRITICALITY WAS CONSIDERED IN THE DESIGN AND IT WAS RULED OUT AS A POSSIBILITY BECAUSE:

- SINCE THERE IS NO WATER WITHIN THE CANISTER, NO MODERATION TAKES PLACE AND THE EFFECTIVE MULTIPLICATION FACTOR IS LESS THAN ONE.

- SINCE THE RODS ARE CLOSE PACKED, THE OPTIMUM CONFIGURATION FOR REACTION IS DISTURBED THEREBY RULING OUT CRITICALITY.

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G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT _____

QUESTION #15 CAN CANISTER INTEGRITY WITHSTAND 100 YEARS OF CORROSION?

UNDER THE CORROSION ALLOWANCE TABLE IN THE "NUCLEAR ENGINEERING HANDBOOK" EDITED BY, BY MCGRAW-HILL

Corrosion Allowance = 0.004724/ρ (in/year)

S.S. (300 series) ρ = 7.999 g/cm³

= 0.004724/7.999

= 0.00059 (in/year)

C.A. = 0.005 in / 10 YEARS

C.A. = 0.01 in / 20 YEARS

B. THEREFORE CORROSION IS NOT CONSIDERED A PROBLEM

QUESTION #16 WHY IS THE PUTTLE DESIGNED LIKE THIS?

WITH THE INNUMEROUS PUTTLE DESIGNS AVAILABLE IN THE MARKET, THERE WAS NO DISTINCT REASON FOR CHOOSING THAT PARTICULAR DESIGN. IT IS AVAILABLE, RELATIVELY INEXPENSIVE AND CAN BE ACCOMODATED BY A VARIETY OF AVAILABLE LIFTING GRAPPLES.

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G.O. or CHARGE NO. PROJECT

SUBJECT

QUESTION #17 IS THE CANISTER DESIGNED TO WITHSTAND SEISMIC EVENTS?

ACCORDING TO THE "CANISTER DESIGN REPORT" FOR ROCKWELL INTERNATIONAL APPENDIX L SEISMIC TEST REPORT, A 12.75 IN SCH 30 CARBON STEEL PIPE WITH DUMMY FUEL ASSEMBLY WAS SEISMIC TESTED. THE RESULTS OF THE TEST ARE INCLUDED WITHIN THAT SECTION AND BRIEFLY STATE THAT THE CANISTER WAS NOT EFFECTED BY SEISMIC IMPACTS.

WHILE IT IS PROBABLY SAFE TO ASSUME OUR CANISTER WOULD ALSO SURVIVE THE SEISMIC TEST, SINCE SO MANY INPUT CONDITIONS ARE IDENTICAL, THE SEISMIC TEST MAY HAVE TO BE RUN AGAIN FOR THE GREATER WEIGHT WITHIN OUR CANISTER AND THE HIGHER PRESSURE.

OLD CONDITIONS	NEW CONDITIONS
WEIGHT = 1960 lbs	WEIGHT = 4700 lbs
PSIA = 115 psi	PSIA = 320 psi

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RMP-307 (2/78)

AMP

THE ALCOA W. HARNISCHFEGER COMPANY

CALCULATION SHEET

TITLE WALL MOUNT HARNISCHFEGER LAYOUT

SHEET NO. 1 OF 1

JOB NO.

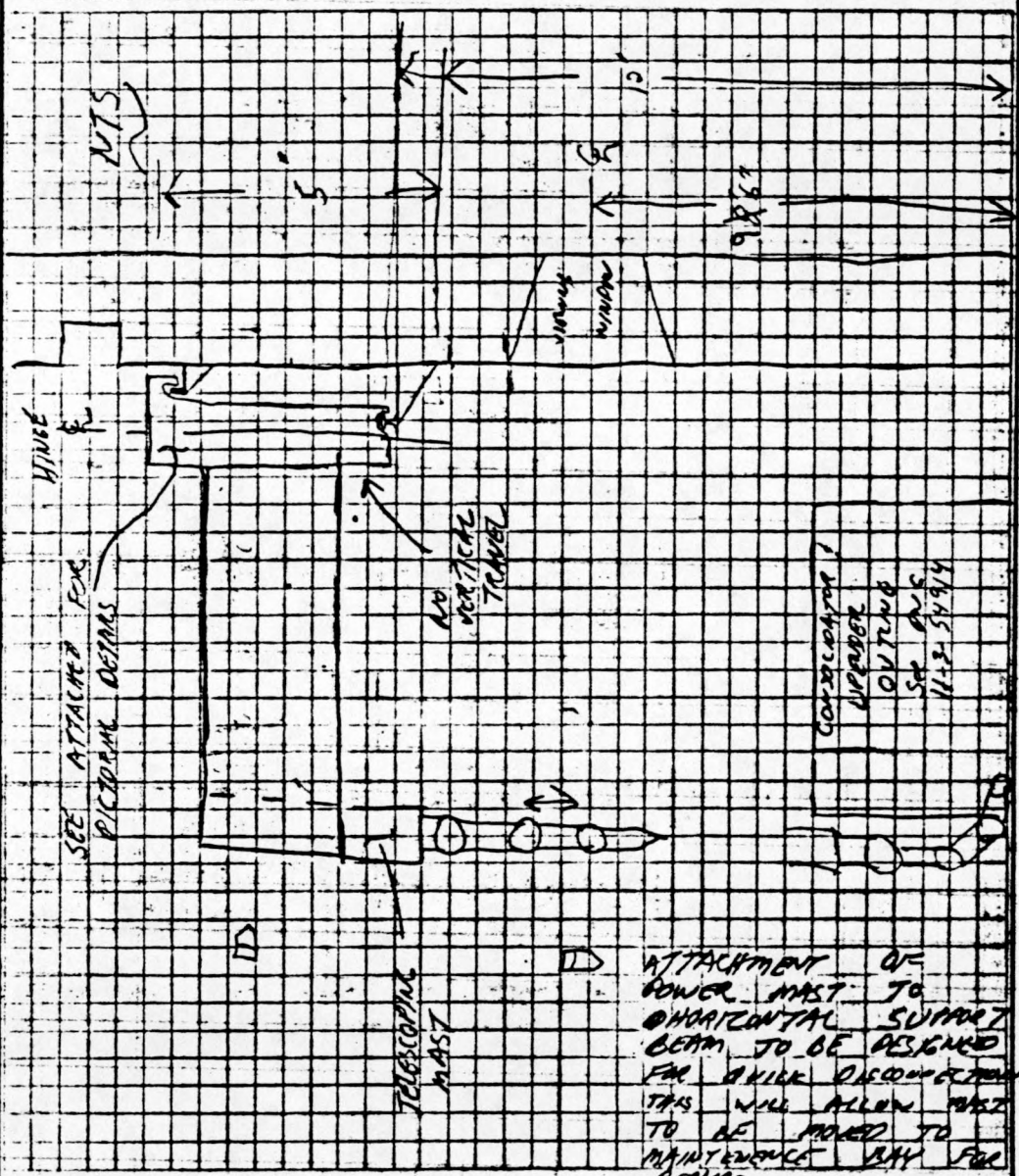
AUTHOR [illegible] DATE 1-12-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/2/85

EQUIP #: MOD-45-D DWG #: [illegible]

G.O. or CHARGE NO. PROJECT

SUBJECT



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307 (2/78)

RMP [illegible] COMPANY **CALCULATION SHEET**

TITLE CASE [illegible] MONORAIL HOIST SHEET NO. 1 OF 1

JOB NO. DEPARTMENT AUTHOR T. MICHAEL DATE 1-17-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
								[illegible]/30/85

5 TON MONO RAIL [illegible]

S.O. or CHARGE NO. ______ PROJECT ______

SUBJECT RECEIVING (NORTH) END HANDLING & WORKING PLATFORMS

- Covers and lids - Outer cover: 81.5 inch diameter weighing 3,000 lbs.

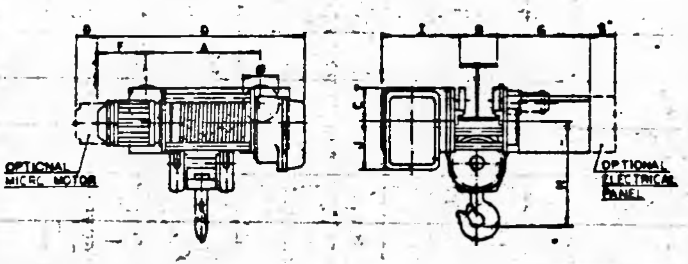
REA #023

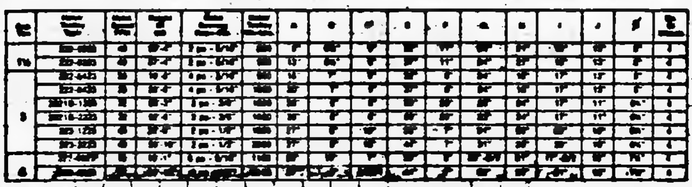
- Inner lid: 77.5 inch diameter weighing 8,000 lbs.

- NLI-1/2 has two closure lids. The outer lid is 28 inches in diameter and weighs TBD lbs. The inner lid is 18 inches in diameter and weighs TBD lbs.
- TN-12 has two closure lids. The outer cover is 98 inches in diameter and weighs approximately 8,000 lbs. The inner lid is approximately 64 inches in diameter and weighs approximately 9,000 lbs.

- NEED A 5 TON MONO RAIL

LOW HEADROOM MONORAIL HOIST MODEL 23





- BEAM NEEDS 7" CLEAR "C" DIMENSION OF 9" & 10" ∴ NEED A 12" I BEAM → ENVELOPE ≈ 28 + 12 = 40" ~ 3' 4"

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PAGE [illegible]

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Cask Cart Conceptual Design H3-54901 SHEET NO. 1 OF 13

JOB NO. DEPARTMENT AUTHOR L. P. Pollono DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

EQUIP # TD-950

G.O. or CHARGE NO. PROJECT Dwg SK-MH-011

SUBJECT Shipping Cask Cart Design

1.0 From FDC. Weight of Largest cask is 125 Tons 250,000 Pounds

2.0 Assume Cask similar To NL-10/24

Body dia max 96" 8'-0" dia

Body Length 204" 17'-0" long

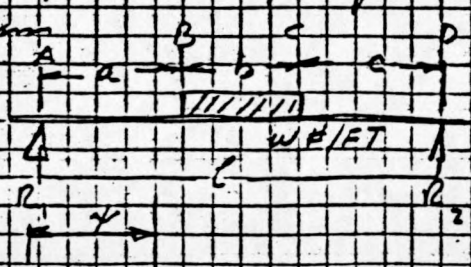
Loaded weight 195,000#

3.0 Design Concept

Steel construction, Flat Bed cart with steel Rail wheels, with self contained motive power, capable of supporting 250,000#s Dead Weight

Use A-36 Structural Steel Body structure

General Equation for partially loaded Simple Beam



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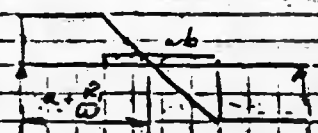
G.O. or CHARGE NO. PROJECT

SUBJECT Shipping Cask cart design

Shear diagram



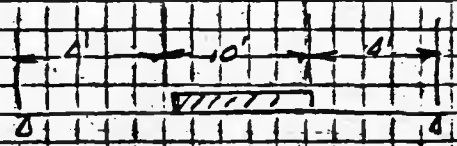
Moment diagram

$M_{max} = R_1\left(a + \frac{R_1}{2w}\right)$

$$R_1 = \frac{wb(2c+b)}{2l}$$

$$R_2 = \frac{wb(2a+b)}{2l}$$

$$M = \frac{wb(2c+b)[4al + b(2c+b)]}{8l^2}$$



Loading - cask is 250,000 # DW

assume 1.5 x DW to account for shock loading

$250{,}000 \times 1.5 = 375{,}000$ #

$$w = \frac{375{,}000}{10} = 37{,}500 \text{ \#/FT}$$

no max moment

SIGNATURE L.P. Pollono DATE 1/15/86 TRB NO. PAGE 96

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								1/21/85

G.O. or CHARGE NO. PROJECT

SUBJECT Shipping Crate CHRT design

$$M_{max} = \frac{wb(2c+b)[4ac + b(2c+b)]}{8 \times c^2}$$

$$M_{max} = \frac{37{,}500 \times 10(18)[288 + 180]}{8 \times 18 \times 18}$$

$$M_{max} = 1{,}218{,}750 \text{ in\#}$$

Assuming A-36 structural steel

the allowable bending load

$F_b = .66 F_y$ appendix A AISC

$\therefore F_b = .66 \times 36{,}000$

$F_b = 24{,}000$ PSI

$\therefore f_b = \frac{M}{Z}$

where the required $Z = \frac{M}{f_b}$

$$Z = \frac{1218{,}750 \times 12 \text{ in\#}}{24{,}000 \text{ PSI}}$$

SIGNATURE L. P. Pollono DATE 6/5/84 TRB NO. PAGE 97

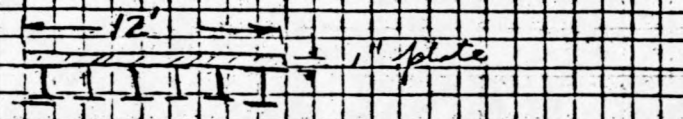
REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Shipping Cask Cart Design

$Z = 609 \text{ in}^3$

Assume



6 I beams on 2'-0" centers

Size of I Beam - assume wide flange Beam

$\therefore Z_{beam} = \frac{Z}{6}$

$Z_{beam} = \frac{609}{6} = 101 \text{ in}^3 / \text{Beam}$

From AISC Manual

Use W 12x 85 wide flange Beam

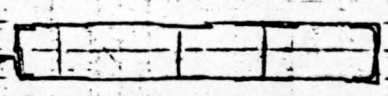
$I = 723 \text{ in}^4 \quad S = 116 \text{ in}^3$

$\sigma_b = \frac{M}{Z} = \frac{1,215,750}{6 \times 116} \quad c = 6.23 \text{ in}$

$\sigma_b = 1751 \text{ PSI}$

Use Channel Beam skirt

12" Channel

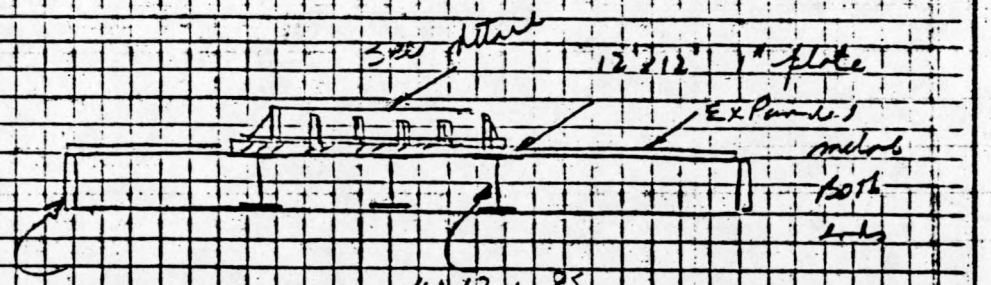


SIGNATURE L. P. Pollono DATE 1/18/85 TRB NO. _____ PAGE 8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT — Cost Cost Design



8" Channel
all around

# of Bolts for Hold down

$\sigma_b = F_v = .45 F_y = .45 \times 36000 = 16,200$ PSI

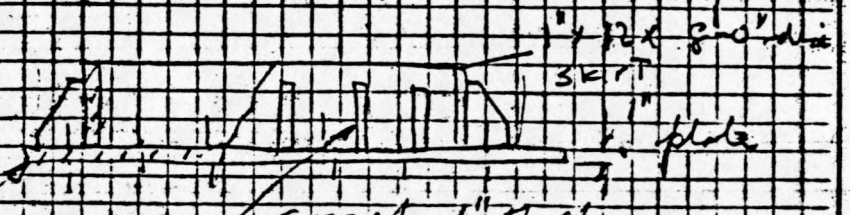
Assume if load Horizontal Friction Force excessive

$\therefore \sigma_b = \frac{P}{A} \quad A = \frac{P}{\sigma_b} = \frac{250,000^{\#}}{16,200}$

$A = 15.4 \text{ in}^2$ 1½ Bolt = 1.76 in²

use 9 1½" A307 Bolts or 12 1½ bolts

Bottom Guide plate



SIGNATURE L P Pollono DATE 6/5/84 TRB NO. _____ PAGE 5

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cask Cart Design

Shear plates

Compressive strain

For A36 $F_a = .60 F_y$

$F_a = .60 \times 36{,}000$

$F_a = 21{,}600$ psi

O Wt of cask 375,000 #

Req supporting Area =

$f_c = \frac{P}{A}$, $A = \frac{P}{f_c} = \frac{375{,}000}{21{,}600}$

$A = 17.36 \text{ in}^2$ min.

SIGNATURE [illegible] DATE 6/5/6 TRB NO. _____ PAGE 1022

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

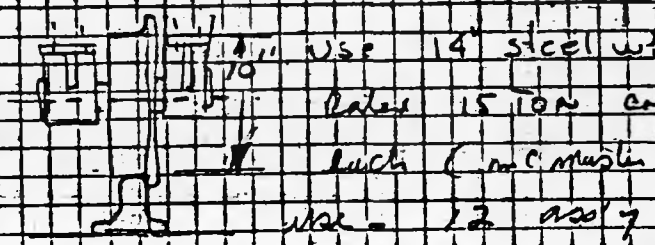
TITLE _____ SHEET NO. 7 OF 13

JOB NO. _____ DEPARTMENT _____ AUTHOR L. P. POLLONO DATE 1/18/85

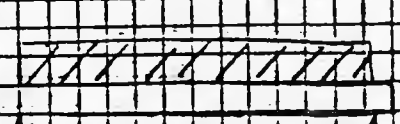
REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT See Sponge III for d/t cuts



Use 14" steel wheel
Rates 15 TON capacity
Lucki (no c musler cure)
use - 12 ASSY



375,000# QUET
9'-6"
9'-6" → Rail width OK with Pressor mayet

$W = \frac{375,000}{9.5} = 39,474$ #/ft

$M = \frac{wl^2}{8} = \frac{39,474 \times 9.5 \times 9.5}{8}$

$M = 445316$ FT#

$Z = \frac{445316 \times 12}{24,000} = 18 \text{ in}^3$

SIGNATURE [illegible] DATE 6/5/84 TRB NO. _____ PAGE 101

RMP-307 (2/78)

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

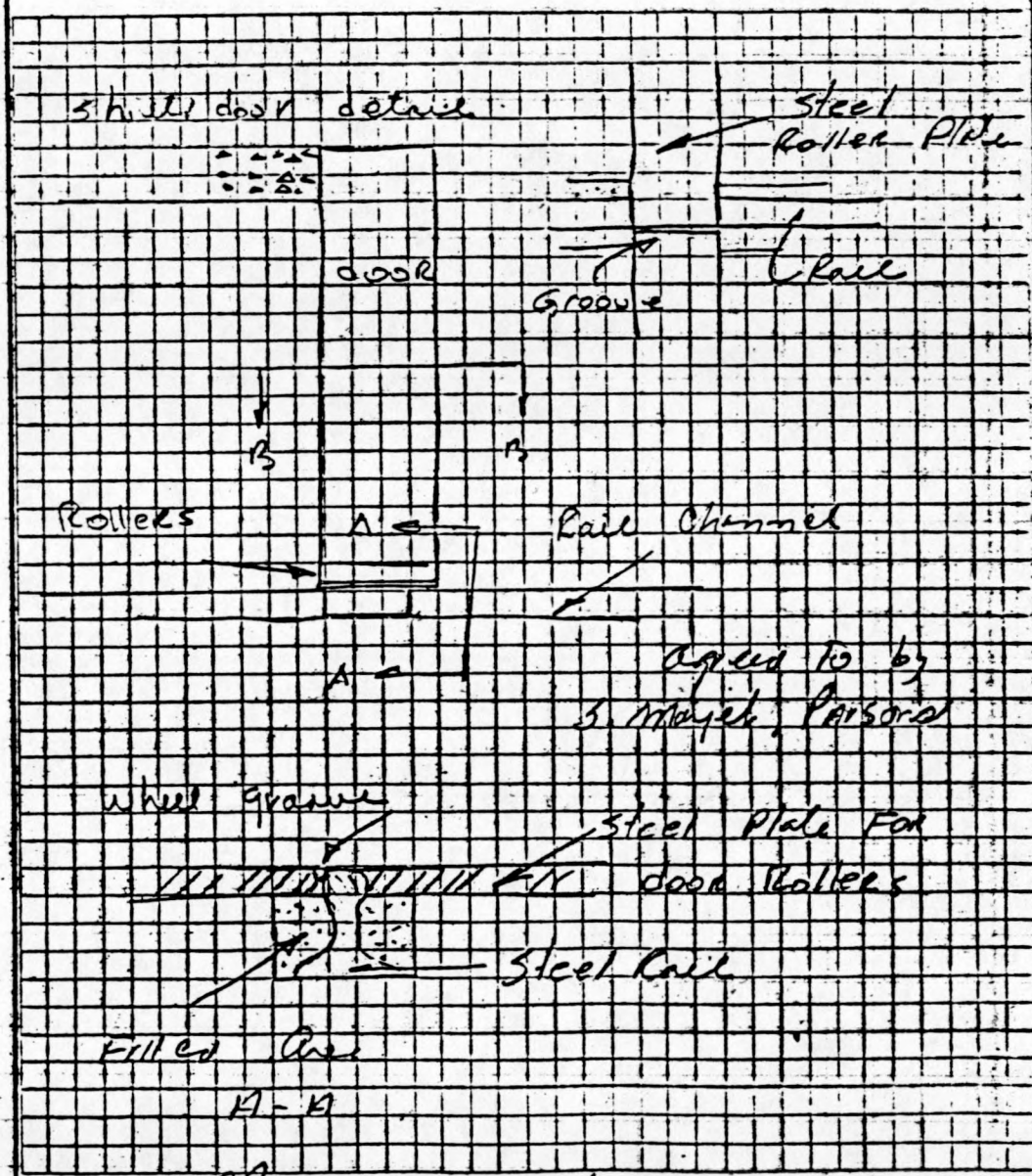
TITLE _____ SHEET NO. 58 OF 13

JOB NO. _____ DEPARTMENT _____ AUTHOR L. P. POLLONO DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT R-11 Bldg. Shield door outline



SIGNATURE [illegible] DATE 6/21/84 TRB NO. _____ PAGE 108

RMP-307 (2/78)

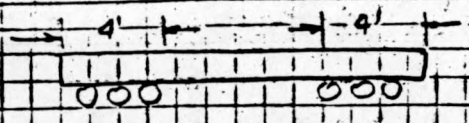
TITLE _____ SHEET NO. 9 OF 13

JOB NO. _____ DEPARTMENT _____ AUTHOR L. P. POKLONO DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Beam d/t Calculation



assume $\frac{375,000}{4} = 93,750$ # / wheel end

load carried by two beam
over 4'-0" length

compressive load on web = f_a

$$f_a = \frac{93,750}{(4 \times .796 \times 17) \times 2}$$

$$f_a = 1226 \text{ psi}$$

d/t = Not exceed $412\left(1 - 2.33\frac{f_a}{F_y}\right)/\sqrt{F_y}$

$$d/t = 412\left(1 - 2.33 \times \frac{1226}{36,000}\right)/\sqrt{36}$$

$$d/t = \frac{412(.966)}{\sqrt{36}} = 66$$

d/t Bar $\frac{12}{.796} = 15$ OK < 66

SIGNATURE [illegible] DATE 6/4/84 TRB NO. _____ PAGE 111

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE _____ SHEET NO. 10 OF 13

JOB NO. _____ DEPARTMENT _____ AUTHOR L. P. POLLONO DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/24/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Cask CART Power Drive

12 wheels at 400# each

Wt = 12 x 400 = 4800#

10,710 Beams

5100 Beam

8640 Steel plate

27,800 Steel plates

12,000 Steel plates

4800 wheels

Wt Total 35 Tons

Total weight on Wheels

Wt of Cask 125 Tons

Wt of CART 35 Tons

Total Wt 160 Tons

Load per wheel

L = 160 / 12 = 13.3 Tons

SIGNATURE L. P. Pollono DATE 1/18/85 TRB NO. _____ PAGE 122

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page ~~58~~ 284 PAGE NUMBER ~~58~~

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Check over Power Drive

P = Friction Resistance

L = load

r = Radius of wheel inches

K = Rolling friction

$P = \frac{KL}{r}$

$P = \frac{.002 \times 160 \text{ Tons}}{7}$

.002 Rolling
.242 Static

P = 91.4 # Rolling

$P = \frac{.242 \times 160 \times 2000}{7}$

P = 11,063 # Static Resistance

with 4 wheels driving each wheel must overcome

$P_{wheel} = \frac{11,063}{4} = 2766$ #

Torque = $P \frac{r}{12}$ FT #

$T = \frac{2766 \times 7}{12} = 1613$ FT #

SIGNATURE L P Pollono DATE 7/3/78 TRB NO. _____ PAGE R1

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Power Drive for Crane Hoist

Maximum vixen speed as 2 mile/hr

$V = \frac{2 \times 5280}{60} = 176$ FT/min

To make 176'/min a 16" wheel must turn

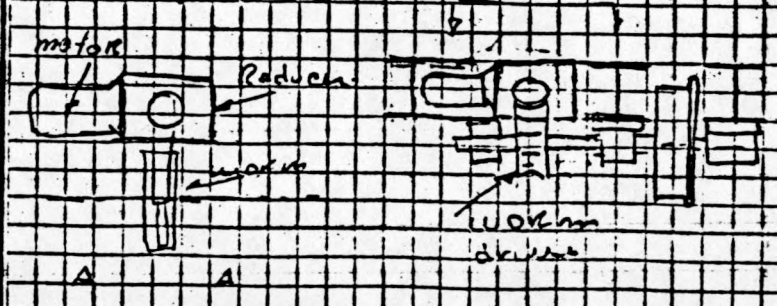
$RPM = \frac{176}{\pi \frac{D}{12}} = \frac{176 \times 12}{\pi D''} = 48$ RPM

HP req for each wheel wheel be (From Shigley)

$HP = \frac{RPM \times Torque \times 2\pi}{33{,}000}$

$HP = \frac{48 \times 1613 \times 2\pi}{33{,}000} = 1.73$ HP/wheel

Use Worm Drive gear, Double reduction gear box on DC motor mounted on reducer



SIGNATURE L P Pollono DATE 7/3 TRB NO. _____ PAGE 122

TITLE _____ SHEET NO. 13 OF 13

JOB NO. _____ DEPARTMENT _____ AUTHOR L. P. POLLONO DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/21/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT Power Drive

Assume time to crew 40' (Fkr unstacking Deck to Cook pump area) in two man

$\therefore$ Travel Rate $= \frac{40}{2} = 20'/min$

$\therefore$ RPM of wheel $= \frac{20' \times 12}{\pi \times 14} = 5.5$ RPM

$\therefore$ HP req at each wheel =

$$HP = \frac{RPM \times Torque \times 2\pi}{33{,}000}$$

$$HP = \frac{5.5 \times 1613 \times 2\pi}{33{,}000} = 1.7 \text{ HP at wheel}$$

SIGNATURE _____ DATE _____ TRB NO. _____ PAGE 12

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

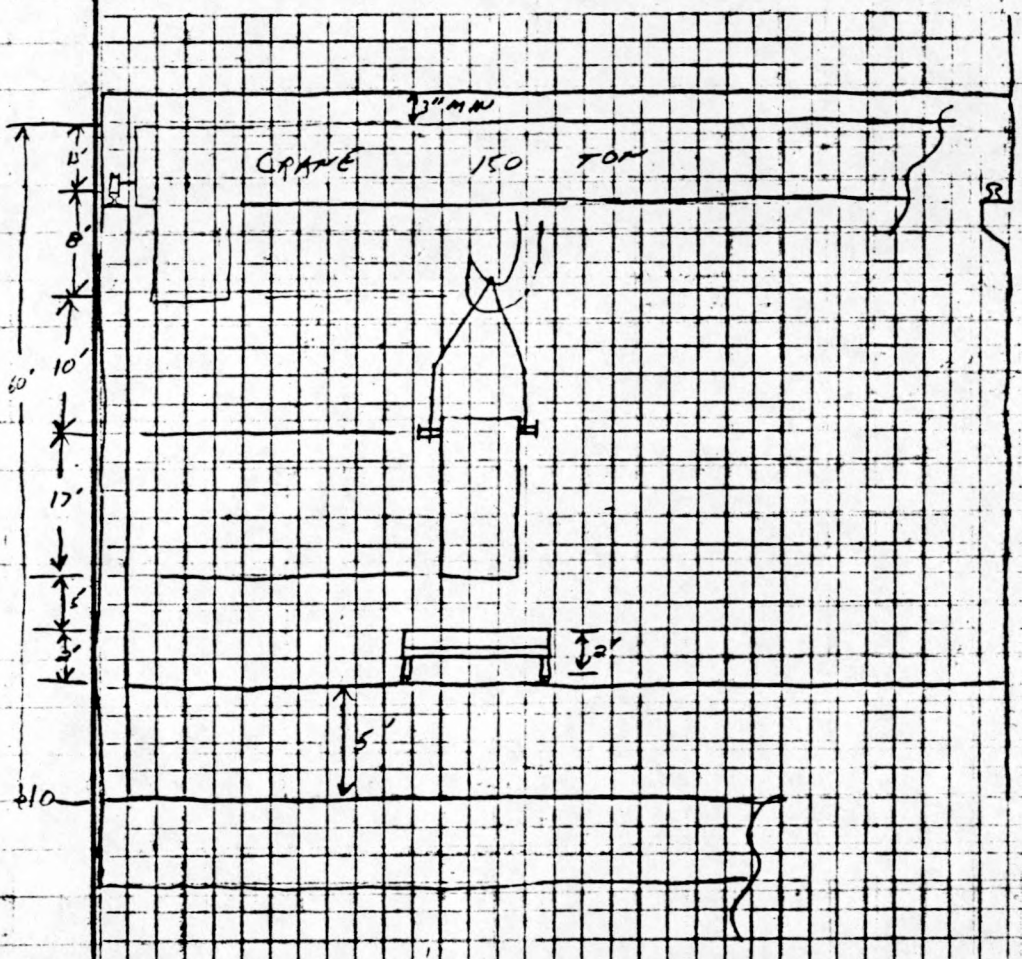
TITLE HOT CELL RECEIVING BAY HEIGHTS SHEET NO. 1 OF 2

JOB NO. DEPARTMENT AUTHOR J. MITCHELL DATE 1-17-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/30/85

G.O. or CHARGE NO. PROJECT

SUBJECT RESIZE CASK BAY FOR SINGLE 150 TON



CRANE	21'	← CONSIST. BY ~ 5'
YOKE	10'	
CASK	17'	
CLEARANCE	5'	
CART	2'	
5' ELEVATION	5'	
	60'	

SIGNATURE Jeff Mitchell DATE 9-9-84 TRB NO. PAGE 50

RMP 307 (2/78)

p. 28B

PAGE NUMBER

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

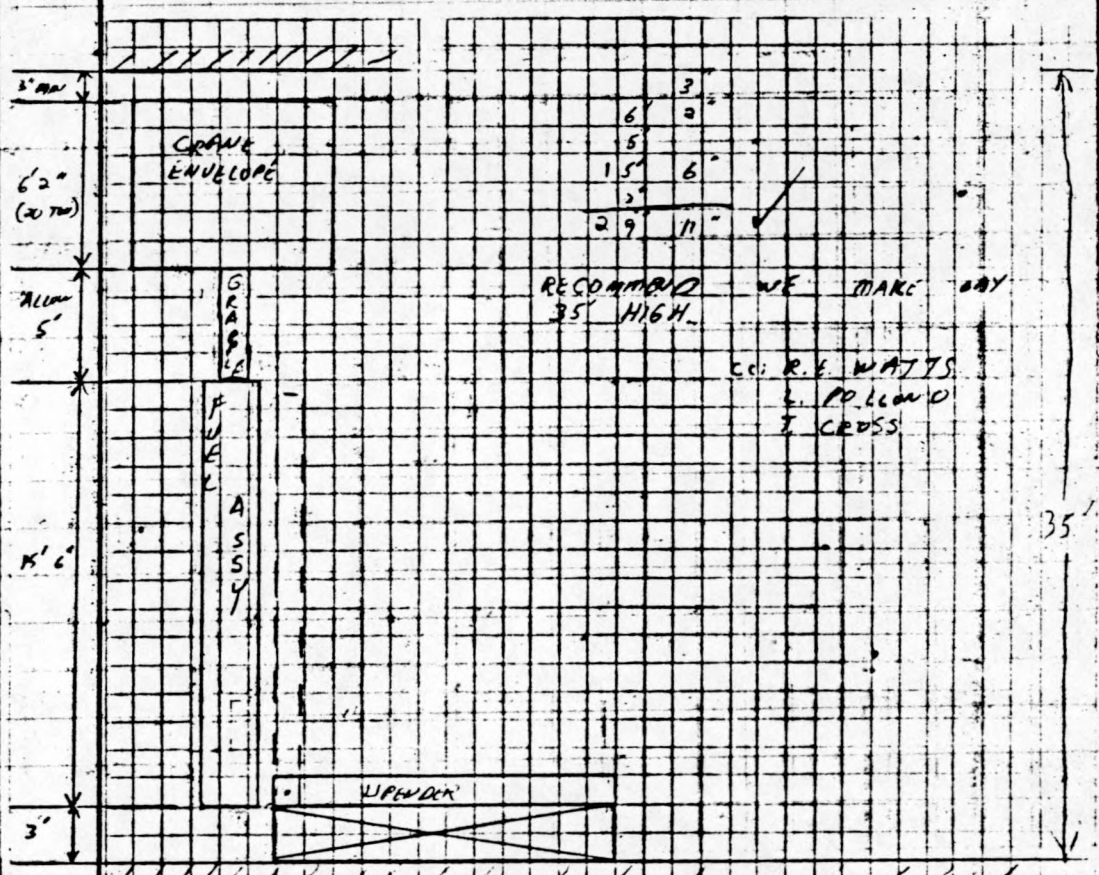
TITLE HOT CELL & RECEIVING BAY HEIGHT SHEET NO. 2 OF 2

JOB NO. DEPARTMENT AUTHOR J. MITCHELL DATE 1-17-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	4/21/85

G.O. or CHARGE NO. PROJECT

SUBJECT RECOMMENDATION ON BAY HEIGHT



3'2"
6'
5'
15' 6"
3"
29' 11"

RECOMMEND WE MAKE BAY 35' HIGH.

cc: R.E. WATTS
L. POLLARD
T. CROSS

SIGNATURE [illegible] DATE 6-12-84 TRB NO. PAGE 16

RMP 307 (2/78)

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PAGE NUMBER 63

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

AMP

TITLE WEIGHT CALCULATIONS FOR Power mast & Shield door — SHEET NO. 1 OF 2

JOB NO. — DEPARTMENT — AUTHOR J. MITCHELL — DATE 1-17-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
								1/24/85

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT WEIGHT CHECK ON TROLLEY

1. POWER MAST

$[(27)(30) - (22)(25)](132)(.28) = 9609$ lbs

2. PAR MAST

$[(18)(24) - (13)(19)](132)(.28) = 6837$ lbs

3. PAR ARM 550 lbs

4. BEARING 6½ FS O.D.

$\frac{\pi}{4}(28^2 - 6.5^2)(5)(.28) = 1065$ lbs

5. TROLLEY STRUCTURE

ASSUME 10% VOLUME

$(7.5)(10)(2.5)(12)^3(.28)(.1) = 9072$ lbs

9609
6837
550
1065
9072
27133 lbs
= 13.5 TON

6. 27 TON ESTIMATE IS GOOD BALL PARK #

SIGNATURE J. Y. Mitchell DATE 8-10-84 TRB NO. _____ PAGE 102

G.O. or CHARGE NO. _____ PROJECT _____

SUBJECT UPDATE ON SHIELD DOOR WEIGHTS

	CELL A	CELL B
a	44'	34'
b	10'	10'
c	6'	6'
d	10'	10'
f	1.5 (START)	1.5 (START)

wt cell A

$(44)(10)(1.5)(12)(.28) + (6)(10)(1.5)(12)(.28) =$

$319,334 + 42,546 = 361,879$

$= \boxed{181 \text{ TON}}$

wt cell B.

$319,334 \left(\frac{34}{44}\right) + 42,546 = 290,304$ $\boxed{145 \text{ TON}}$

SIGNATURE Jeff Mitchell DATE _____ TRB NO. _____ PAGE 44

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PAGE NUM

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE MRS Crow Canister Supply System Fuel SHEET NO. 1 OF 4

JOB NO. _____ DEPARTMENT _____ AUTHOR J.W. Wells DATE 1/19/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mohinder Kali	1/22/85

EQUIP No CVR 954, CVR 955, CVR 956 H-3-54924

G.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS

SUBJECT CANISTER SUPPLY SYSTEM (CSS) Drawing-H-3-54924

DISCUSSION: DURING THE CONSOLIDATION PROCESS, FUEL WILL BE REMOVED FROM SPENT FUEL ASSEMBLIES (SFA) AND PUSHED INTO THE EMPTY STORAGE CONTAINERS AND SEALED BY SOME WELDING PROCESS. THE CANISTER SUPPLY SYSTEM MUST BE CAPABLE OF PROVIDING AN ADEQUATE NUMBER OF CANISTERS FOR THE CURRENT PRODUCTION RATE OF 1800 MTU*/YR. THIS IS BASED ON 50% EFFICIENCY, WITH A 60/40 SPLIT OF PWR TO BWR FUEL ASSEMBLIES.

THEREFORE, 2338 PWR AND 3871 BWR ASSEMBLIES MUST BE PROCESSED PER YEAR.

• BASED ON DISCUSSION WITH B. BUSSER ON 7/3/84, HE INDICATED THAT 3-PWR ASSEMBLIES COULD BE PROCESSED INTO 1 CANISTER, WHERE 7-BWR SFA COULD BE PROCESSED INTO 1-CANISTER.

∴ FOR 1 year @ 1800 MTU/year 6.4 PWR & 10.6 BWR SFA are to be processed per day.

At peak capacity of 3600 MTU/year

* MTU = METRIC TON OF URANIUM

SIGNATURE J.W. Wells DATE 7/3/84 TRB NO. RH-TWW-01 PAGE 1

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE MRS Clean Canister Supply System

SHEET NO. 2 OF 4

JOB NO. DEPARTMENT AUTHOR J.W. WILLIS DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Michael Krali	1/22/85

G.O. or CHANGE NO. 58-1239-04-011 PROJECT MRS

SUBJECT CSS

13 PWR & 22 BWR STA CAN BE PROCESSED.

USING THE CONSOLIDATION RATIO OF 3:1 FOR PWR AND 7:1 FOR BWR, THE FOLLOWING NUMBER OF CANISTERS ARE REQUIRED PER DAY

- 1800 MTU → 3 FOR PWR
  2 FOR BWR
- 3600 MTU → 5 FOR PWR
  4 FOR BWR

SINCE THE MAXIMUM OF 3600 MTU WILL PROBABLY OCCUR USING BOTH CELLS 1 & 2 PRIMARILY, A SUPPLY OF 5 CANISTERS PER CELL/DAY IS ALL THAT WOULD BE REQUIRED FOR NORMAL OPERATION.

ASSUMPTIONS:
- MAXIMUM OF 5 CANISTERS PER CELL PER DAY REQUIRED (ASSUMED TO BE 12" CANISTERS FOR NORMAL CONSOLIDATION & DECONTAMINATION)
- PER DISCUSSION WITH LOU POLCONO ON 7/3/84, PROVISIONS MUST BE MADE TO PROVIDE AT LEAST 1 - 14" DIA CANISTER PER DAY IF NECESSARY TO OVERPACK A LEAKING OR DEFECTIVE CANISTER. SINCE THIS IS ANTICIPATED TO BE A LOW PROBABILITY SITUATION ONLY ONE WILL BE PROVIDED PER CELL PER DAY.

SIGNATURE J.W. Willis DATE 7/5/84 TRB NO. RH-JWW-01 PAGE 2

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE MRS Clean Canister Supply System SHEET NO. 3 OF 4

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mahinal Kali	1/22/85

G.O. or CHARGE NO. SB-1239-04-11 PROJECT MRS

SUBJECT (CSS)

- ALL CANISTER ARE ASSUMED TO OPEN ON ONE END. THIS OPEN END CAP MUST ALSO BE PROVIDED TO THE CELL WITH THE CANISTERS DURING THE NORMAL LOADING OPERATION. CURRENTLY EITHER END COULD BE OPEN. PINTLE END ATTACHED PROVIDE EASIER HANDLING OF CANISTER IN CELL AREA.
- 12" SCH 20 CANISTER WITH 12.75 OD / 12.25 ID FROM PARSONS DRAWING NO. SK-MH-015 WITH OVERALL LENGTH OF 192.00 INCHES.
- 14" SCH 10 CANISTER WITH 14.00 OD / 13.50 ID FROM PARSONS DRAWING NO. SK-MH-016 SHEET 1 OF 2. OVERALL LENGTH 16'-9". (201.00 INCHES)
- CANISTER STORAGE RACK WILL BE CAPABLE OF HANDLING EITHER 12" OR 14" CANISTERS. AS WELL AS THE ASSOCIATED END CAPS.
- CANISTERS WILL BE LOADED ONTO THE CANISTER STORAGE RACK (CSR) FROM THE SPECIFIED STORAGE AREA AND TRANSFER VIA THE GROUND OPERATING GALLERY. EITHER BY FORK LIFT TRUCK OF EQUIVALENT.
- CSR PLACED ON CANISTER STORAGE RACK LIFT MECHANISM/ELEVATOR PRIOR TO BEING PROVIDED TO THE CELL INTERFACE. LIFTING MECHANISM MUST BE CAPABLE OF LIFTING THE CSR WITH 5-12" CANISTERS & 1-14"-CANISTER AND 6 END CAPS.
- IT IS ALSO ASSUMED THAT IN ORDER TO LIMIT THE AMOUNT OF RADIATION EXPOSURE AND CONTAMINATION TO THE CANISTER STORAGE

SIGNATURE J.W. Willis DATE 7/5/84 TRB NO. RH-JWW-01 PAGE 3

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE ACS Clean Canister Supply System SHEET NO. 4 OF 4

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/10/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Original Calc	1/22/85

G.O. or CHARGE NO. -011 PROJECT

SUBJECT

BACKS, THE CANISTERS SHOULD BE UNLOADED AS SOON AS POSSIBLE AND THE ACCESS HATCH BE CLOSED IMMEDIATELY AFTERWORD.

• ASSUMED THE DESIGN WEIGHT VALUES FOR EACH OF THE CANISTERS AS DEFINED IN TABLE 1 OF THIS TRB, (PAGE 7 OF TR Book RH-JWW-01).

SIGNATURE J.W. Willis DATE 7/6/84 TRB NO. RH-JWW-01 PAGE 4

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PAGE NUMBER 78

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Maintenance Hatch Design calculations SHEET NO. 1 OF 6

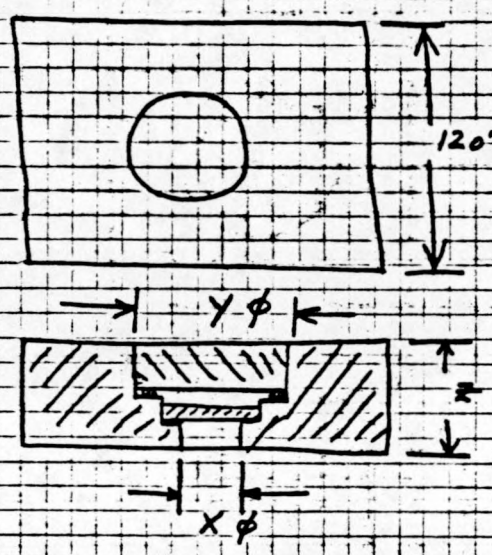
JOB NO. DEPARTMENT AUTHOR Mrinal Bali DATE 22 Jan 85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							JW Willis	1/21/85

EQUIP # SMR 969 H-3-54933

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH ~~PORTS~~ PLUGS



Equipment to pass through part (round)
= 2' φ drums (Low Pollono)

X need not be > 36" φ 48" φ

Z = equivalent of ~~=~~ 60" of Concrete

Y = 60" φ — same as dia at which lifting lugs are placed for the Unloading Parts Design [p. 1 to 7]

SIGNATURE [illegible] DATE 16 Jul 84 TRB NO. MB-01 PAGE 8

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

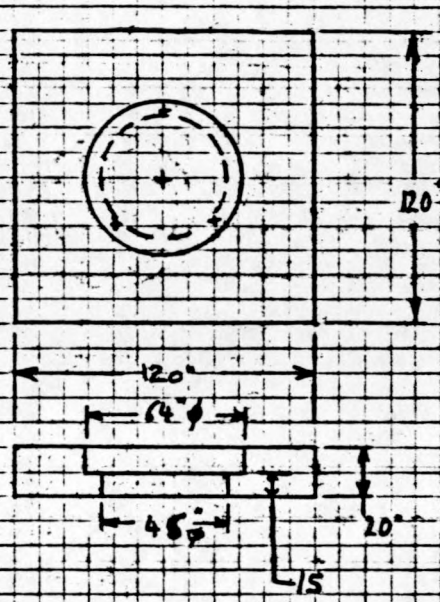
TITLE Maintenance Hatch design calculations SHEET NO. 2 OF 6

JOB NO. DEPARTMENT AUTHOR Mihirnal Wali DATE 22 Jan 85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J.W. Willis	1/21/85

G.O. or CHARGE NO. 5812390 4003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS



Above design no good. What about material for neutron capture?

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

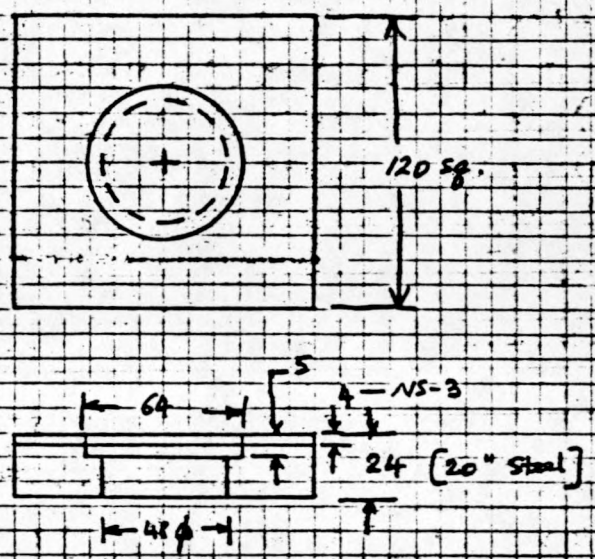
TITLE Maintenance Hatch design calculations SHEET NO. 3 OF 6

JOB NO. DEPARTMENT AUTHOR Nirmal Kali DATE 22 Jan 85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J.W. Willis	1/21/85

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS



~~Weight Analysis~~

~~Weight of steel Slab = 120×120×20 × 0.284 × 0.005~~

~~Minus hole = $\frac{\pi}{4}$ × 48² × 19 × 0.284 × 0.005 =~~

~~Add NS3 wt = 4 × 120 × 120 × 0.044 × 0.005~~

~~$\frac{\pi}{4}$ 64² × 4 ×~~

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RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Maintenance Hatch design calculations SHEET NO. 4 OF 6

JOB NO. DEPARTMENT AUTHOR Mrinal Kali DATE 22 Jan 85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J.W. Willis	1/21/85

G.O. or CHARGE NO. SB123904003 PROJECT TMRS

SUBJECT HATCHES WITH PLUGS

Weight Analysis

Wt. of complete block = 120×120×20×0.284×0.0005 = 41 T

Wt. of NS-3 = 120×120×4×0.064×0.0005 = 2T

Wt. of top NS-3 circle = $\frac{\pi}{4}$ × 64² × 4 × 0.064 × 0.0005 = (0.4 T)

Wt. of top Stl. circle = $\frac{\pi}{4}$ × 64² × 1 × 0.284 × 0.0005 = (0.5 T)

Wt. of bottom circle = $\frac{\pi}{4}$ × 48² × 19 × × 0.284 × 0.0005 = (5 T)

~~44 T~~

37 T

Wt. of plug

NS3 = $\frac{\pi}{4}$ × 64² × 4 × 0.064 × 0.0005 = 0.4 T

Stl. = $\frac{\pi}{4}$ × 64² × 1 × 0.284 × 0.0005 = 0.5 T

plus $\frac{\pi}{4}$ × 48² × 19 × 0.284 × 0.0005 = 5 T

5.9 T

≈ 6 T

So, Crane to Lift (6T)

dedicated mechanism to lift 6+37 = (43T)

SIGNATURE mkali DATE 16 July 84 TRB NO. TMB-01 PAGE 11

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TITLE Maintenance Hatch design calculations SHEET NO. 5 OF 6

JOB NO. DEPARTMENT AUTHOR Mrinal Kali DATE 22 Jan 85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J.W. Willis	1/21/85

S.O. or CHARGE NO. SB123904003 PROJECT TMRS

SUBJECT HATCHES WITH PLUGS

If hatch ~~and plug~~ made of Pb, (and plug of SH.), max. Pb thickness reqd. to replace 60" of concrete = 12.78" ≈ 13"

~~Then, wt~~

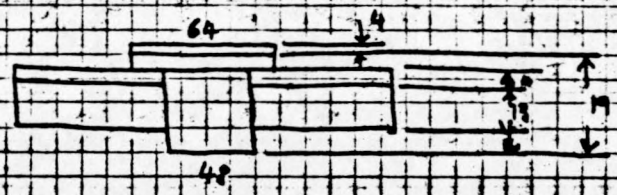
~~Complete block = π 120² × 13 × 0.41 × 0.0005 =~~

~~NS-3 = 120² × 4 × 0.064 × 0.0005 =~~

~~NS-3 missing = $\frac{\pi}{4}$ × 48² × 4 × 0.064 × 0.0005 =~~

~~Pb cap missing = $\frac{\pi}{4}$ 64² × 1 × 0.41 ×~~

~~bottom circle = (same as~~



Total plug weight analysis

Wt. of Pb-block + NS-3 :

$$Pb = \left\{\left[120 \times 120 \times 13\right] - \left(\frac{\pi}{4} \times 48^2 \times 13\right)\right\} \times 0.41 \times 0.0005 = 33.55^T$$

$$NS\text{-}3 = \left[\left(120 \times 120 \times 4\right) - \left(\frac{\pi}{4} \times 48^2 \times 4\right)\right] \times 0.064 \times 0.0005 = 1.61^T$$

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Maintenance Hatch Design calculations SHEET NO. 6 OF 6

JOB NO. DEPARTMENT AUTHOR Mrinal Bali DATE 22 Jan 85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J.W. Willis	4/21/85

G.O. or CHARGE NO. SB123904003 PROJECT MRS

SUBJECT HATCHES WITH PLUGS

Plug + NS-3 :

$$Stl. = \left[\left(\frac{\pi}{4} \times 48^2 \times 17\right) + \left(\frac{\pi}{4} \times 64^2 \times 2\right)\right] \times 0.284 \times 0.0005$$

$$= 5.28T$$

$$NS\text{-}3 = \frac{\pi}{4} \times 64^2 \times 4 \times 0.064 \times 0.0005 = 0.41T$$

total = 40.86

≈ 41T

Note: above does not include a steel casing for the Pb, so this plus Hatch + Plug will be significantly heavier than the pure steel hatch + plug.

DROP PURE Pb idea

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page 301

PAGE NUMBER 92

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Secondary Waste - PWR Volume Reduction SHEET NO. 1 OF 6

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Manual Hogg	1/22/85

G.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS (H-3-54930)

SUBJECT Volume Reduction Efficiency for Shredder System

The volume reduction and packing of secondary waste is a key parameter in the evaluation of the spent fuel consolidation process even though it is not directly linked to the process. Several volume reduction techniques were investigated prior to selecting the low-speed shredder method. See APPENDIX D of MRS Design Report for details of selection process.

Recent proof-in-principle tests conducted in late July 1984 at Shred-Pak Corporation Bensenville, Ill. indicated the shredding method is a viable concept. During the test a portion of the full size skeleton was shredded in a Model-AZ-45. This 38" long portion of the skeleton was placed into a box and occupied a volume of 315 in^3 based on the following dimensions (5.8" height x 7.5" width x 14" length). This skeleton is from a Westinghouse PWR assembly 17x17. Therefore, volume reduction values calculated only apply for this type of skeleton. BWR skeletons without channels will

SIGNATURE J.W. Willis DATE 8/21/84 TRB NO. TWW-01 PAGE 19

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produce higher volume reduction values due to the minimum of support structure. The PWR assembly provides a minimum volume reduction evaluation (conservative for estimating secondary waste costs and storage requirements).

Initial Parameters: Drum Volume

$$55 \text{ gal drum} \times \frac{231 \text{ in}^3}{1 \text{ gallon}} = \underline{12705 \text{ in}^3}$$

Gross Volume of W 17x17 PWR Skeleton:

From 17x17 PWR Drawing:

Skeleton Portion: 156" lg x 7.763 x 7.763 = 9401 in³ including the bottom nozzle

Top Nozzle: 7.730 x 7.730 x 3.163 = 188.99 or 189 in³

Bottom Nozzle: 7.763 x 7.763 x 2.738 = 165.00 in³

Total Gross Volume = 9401 + 189 = <u>9590 in³</u>

The measure weight of this entire skeleton was found to be 61.3 lb.

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Secondary Waste - PWR Volume Reduction SHEET NO. 3 OF 6

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Surinal Yadi	1/22/85

G.O. or CHARGE NO. PROJECT MRS (N-3-54930)

SUBJECT

If 800# weight limit for the 55 gal drum is correct. (per manufacturer of drums USS)

The number of assemblies which would be permitted in drum would be:

$$\text{Assy Limit} = \frac{800\#}{61.3\#/\text{assy}} = \underline{13 \text{ assy}}$$

This represents an upper limit if the skeletons with nozzles could be perfectly volume reduced.

Determine the actual tube and grid length to subdivide the skeleton into Top Nozzle, Skeleton and Bottom Nozzle.

Previous length = 156.98 - 4.5 in - 2.738 = 149.74 in

Use 150.0 inches for conservative length.

Since 38 inch of the center section was tested in the AZ-45 shredder, this length represents 25.3% of entire tube length of 150 inches

% = 38"/150" = 25.3%

The reduced volume from testing of this 38" length was equivalent to 315 in³.

$$\therefore \text{Volume of Tubes \& Grid} = \frac{315 \text{ in}^3}{.253} = \underline{1245 \text{ in}^3}$$

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

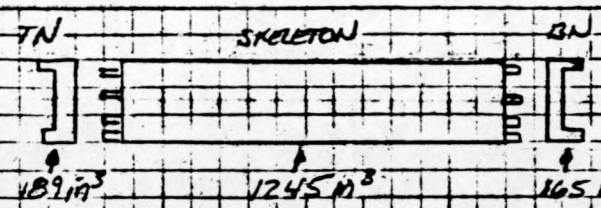
TITLE Secondary Waste - PWR Volume Reduction SHEET NO. 4 OF 6

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/22/85

S.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS (H-3-54930)

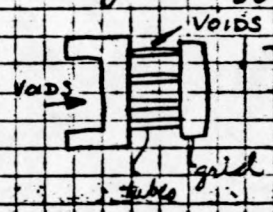
SUBJECT



∴ Total = 1599 in³

This value does not include the voids in the rigid portions of the skeleton which occur at three locations:

- Voids in Top Nozzle
- Voids in Bottom Nozzle
- Voids in between tube in Top Nozzle after being cut off below first grid.



From actual PWR measured dimensions

Voids in Top Nozzle end:

Volume = 6.5 x 6.5 x 2" = 84.5 in³

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Voids in Bottom Nozzle End

Volume = 7.75 x 7.75 x 2.0 = 120.125 in³

Voids in Top Nozzle between nozzle & grid

Volume Gross = 7.730 x 7.730 x 1.5 = 89.63 in³

Assume that 60% of this gross volume is occupied with tube structure and only 30% is available for shredded pieces.

∴ Void Volume = .30 x 89.63 in³ = 26.88 in³

The total of these void volumes must be subtracted from the gross volume of 1599 in³ in order to get a true estimate of the skeleton volume.

∴ Total Skeleton Volume = 1599 - 84.5 - 120.1 - 26.9

TSV = 1367.5 in³

∴ Reduction in Volume = $\frac{V_A}{V_{TSV}} = \frac{12705 \text{ in}^3}{1367.5 \text{ in}^3} = 9.29$

On 9.29 skeletons can be placed in one 55 gallon drum based on volumetric values.

Since the machine (AZ-45) used for this test did not include some specific improvements to

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Secondary Waste - PWR Volume Reduction SHEET NO. 6 OF 6

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 7/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mwinal Bali	1/22/85

G.O. or CHARGE NO. -011 PROJECT MRS (H-3-54930)

SUBJECT: SHREDDER SYSTEM

design to improve the particle size (reduce large pieces), this reduction value is conservative.

Implementation of design improvements to the shredder and the feeding arrangement a 25% improvement in particle size would help the reduction ratio by the following:

25% improvement only in the tube/grid section

∴ the 1245 in³ volume → 933.75 in³

For a new total of 1056.25 in³

Reduction in Volume = $\frac{12705 \text{ in}^3}{1056.25 \text{ in}^3/\text{skeleton}}$ → 12.0 skeletons/drum

Therefore, implementation of these design changes would not only improve the storage of skeletons per drum but also improve decontamination and maintenance of the shredder.

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RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Supply Rack Door Shielding Design (Draft) SHEET NO. 1 OF 2

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Original Draft	1/22/85

G.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS (H-3-9824)

SUBJECT Shielding Requirements For Canister Transfer System

- Determine the approximate combined steel/lead door to be installed between operating gallery & canister transfer station prior to exposure to hot cell. (Initial Design Area-Cell)

Assumptions:

- Door will remain closed during normal operation and opened from outside operating gallery only when empty canisters are to be installed.

- An electrical interlock is necessary to insure that the hot cell/transfer location shield door is closed prior to opening the canister access door. This insures minimum contamination or exposure to personnel.

- Shielding effective capability:

  60" of Concrete ≡ 18.18" of Steel
  ≡ 12.78" of Pb

SIGNATURE JWW DATE 7/9/84 TRB NO. RH-TAN-01 PAGE 14

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULAT SHEET

TITLE Supply Back Door Shielding Design (Early) SHEET NO. 2 OF 2

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mrinal Bali	1/22/85

G.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS

SUBJECT

BISCO NS-3 (PLASTIC) IS USED TO STOP NEUTRON STREAMING.

~~1" of Concrete = [illegible] of Bisco NS3~~

CALCULATIONS: BASED ON THE CONCEPTUAL BASIS FOR DESIGN DOCUMENT - SECONDARY WALLS ARE TO BE AT LEAST 24" THICK.

FOR A COMBINATION OF STEEL/PB DOOR THE EQUIVALENT THICKNESS FOR A 50/50 SPLIT BECOMES:

.303" OF STEEL/IN OF CONCRETE

.213" OF PB/IN OF CONCRETE

12" x .303" OF STEEL = 3.636" OF STEEL

12 x .213" OF PB = 2.556"

6.192" OF DOOR

ASSUME 2" OF BISCO NS-3 is also required

∴ 8.192" OF EQUIVALENT DOOR IS MINIMUM REQUIREMENT

∴ USE AT LEAST 9" THICK DOOR. FOR DESIGN PURPOSES.

SIGNATURE J.W. Willis DATE 7/9/84 TRB NO. RH-JWW-01 PAGE 15

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PAGE NUMBER ~~127~~

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Canister Transfer System Funct. Description SHEET NO. 1 OF 1

JOB NO. DEPARTMENT AUTHOR J. W. Willis DATE 1/16/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mahinal Yahi	1/22/85

Q.O. or CHARGE NO. SR-1239-04-011 PROJECT MRS (4-3-54924)

SUBJECT: Canister Transfer System Functional Req'm'ts

Functional Requirements for Canister Transfer System

- Provide a limited access location in each of the 3 Process Cells for clean canisters for fuel consolidation and drums for overpack and shredded waste storage.
- Provide a means to lift the canisters and drums equal to or slightly below process cell operating floor. This simplifies the access time to pickup canisters in the process cell.
- Incorporate the design to handle transfer of canister end caps into the cell for welding purposes.
- Minimize the number of loading operations to limit the labor involved in this loading operation.

SIGNATURE J. W. Willis DATE 7/5/84 TRB NO. RH-JUN-01 PAGE 8

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE MRS Canister Weights SHEET NO. 1 OF 3

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Minnal Patel	1/22/85

G.O. or CHARGE NO. -OH PROJECT MRS

SUBJECT Canister-Weight-Calculations # H-3-54924

ESTIMATED WEIGHT OF 12" CANISTER - EMPTY

REF: SK-MH-015

CYLINDER LENGTH = 178.50 - .375 - 1.375 = 176.75 IN
or 14.72'

WT = 33.38 #/ft x 14.72' = 491.65 #

FUEL SUPPORT PLATE = 117.9 in²

WT = 117.9 in² x .50 IN THK x .283 #/in³ = 16.68 #

END CAP: Ref. CRANE CATALOG (Welding Fittings Forged Flanges pg. 72)

STANDARD Weight TYPE = 27 #

PINTLE: 7" LONG x 3" DIA AND SOLID (CONSERVATIVE)
WT = 7 IN x 7.068 in² x .283 #/in³ = 14.00 #

W_{TOTAL} = 491.65 # + 16.68 # + 27 # + 14 # = 549.33 #

FOR 14" CANISTER - EMPTY (STANDARD)

CYLINDER LENGTH = 192.0 - 5.0 - 3.0 = 184.0 in LONG
or 15.33'

WT = 15.33' x 36.71 #/ft = 562.88 #

No. Plate WT.
END CAP: Ref CRANE pg. 72) = 33 #/fitting

PINTLE = 14.0 #

W_{TOTAL} = 562.88 # + 33 # + 14 # = 609.88 #

SIGNATURE J.W. Willis DATE 7/5/84 TRB NO. RH-JWW-01 PAGE 5

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PAGE NUMBER ~~129~~

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE MRS Canister Weights SHEET NO. 2 OF 3

JOB NO. DEPARTMENT AUTHOR J.W. Wallis DATE 1/19/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Nirmal Wali	1/22/85

G.O. or CHARGE NO. -011 PROJECT MRS

SUBJECT

14" CANISTER – OVERPACK FOR HLW

SINCE THIS CANISTER IS SAME DIAMETER

BUT 66" SHORTER. (14" DIAMETER)

∴ 5.5' x 36.71 #/ft = 201.9#

Plate wt = 143.1 in² x .5 in x .283 = 20.24#

W_{TOTAL} = 609.88# – 201.9 – 20.24# = 387.7#

26" CANISTER OVERPACK SCH 10 - SK-MH-016 (1 OF 2)

OD = 26.0 in ID = 25.376 wall = .312 pg. 144 OF CRANE CATALOG

Metal Area = 25.18 in² I = 2076 in⁴ Z = 159.7 in³ r = 9.08 in

Cylinder length = 120.0" – 4.75 = 115.25 in

W_T = 115.25 in x 25.18 in² x .283 = 821.26#

Cap W_T = 102# pg. 72 Crane CATALOG (WELDING FITTINGS)

Canister support plate = 505.8 in² x .50 x .283 #/in³ = 71.57#

Pintle = 14.0#

W_{TOTAL} = 821.26# + 102.0 + 71.57 + 14.0 = 1008.83#

FOR 26" CANISTER – 55 GAL DRUM (5 per group)

Assume – 184.00 in long:

SIGNATURE J.W. Wallis DATE 7/5/84 TRB NO. RH-JOW-01 PAGE 6

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE MRS Canister Weights

SHEET NO. 3 OF 3

JOB NO. _____ DEPARTMENT _____ AUTHOR J. W. Willis DATE 11/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Minal Bali	1/22/85

G.O. or CHARGE NO. -011 PROJECT MRS

SUBJECT:

TABLE 1: CANISTER WEIGHT SUMMARY - EMPTY

	ACTUAL #	DESIGN (10% MARGIN) #
12" CANISTER	549	604
14" CANISTER (STANDARD)	670	671
14" CANISTER (HLW)	388	427
26" CANISTER OVERPACK	1009	1110

SIGNATURE J. W. Willis DATE 7/5/84 TRB NO. RH-JWW-01 PAGE 7

RMP-307 (2/78)

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Secondary Waste Corridor Height Calc. SHEET NO. 1 OF 2

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mirinal Wali	1/22/85

G.O. or CHARGE NO. SR-1239-04-011 PROJECT MRS (H-3-54930)

SUBJECT MATERIAL HANDLING - REDUCTION & COMPACTION STRUCTURE

DISCUSSION: LOCATION AND SIZE DEFINITION OF REDUCTION & COMPACTION STRUCTURE TO BE LOCATED ADJACENT TO THE LAG STORAGE AREA AND DRUMS TRANSPORTED UNDER THE LAG STORAGE AREA TO BE REMOVED AT CELL 3 FOR FINAL PACKAGING AND REMOVAL FROM CELL; THIS WILL ELIMINATE HIGH RADIATION CONTAMINATION IN THE EQUIPMENT MAINTENANCE AREA.

CONCEPTUAL REQUIREMENTS:

- TRANSFER CART USED TO MOVE SHREADED MATERIAL COMPACTED INTO 55GAL DRUMS MUST BE PARTIALLY SHIELDED TO REDUCE THE THICKNESS OF CONCRETE BELOW THE LAG STORAGE AREA.
- USE A STEEL ACCESS DOORS TO REACH THE SHREADER EQUIPMENT.
- PER SK-MH-023 SHT 1 AND SK-MA-025 SHT 1 AND ASSUMING THAT THE MANIFOLD COOLANT AIR FLOW DESIGN WILL BE REPLACED WITH INDIVIDUAL

SIGNATURE J.W. Willis DATE 7/23/84 TRB NO. RH-JWW-01 PAGE 16

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Secondary Waste Corridor Height Calc. SHEET NO. 2 OF 2

JOB NO. DEPARTMENT AUTHOR J. W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Surinder Vali	1/22/85

G.O. or CHARGE NO. -011 PROJECT MRS (H-3-54930)

SUBJECT

FLOW DISTRIBUTION THROUGH THE CONCRETE. THIS SITUATION WILL REDUCE THE AVALALABLE SPACE BELOW THE LAG STORAGE.

ASSUMPTIONS: • TOP OF SHIELDING IS 30" ABOVE OPERATING FLOOR PER SK-MH-023 SHEET 1

• CONCRETE EMBEDDED INDIVIDUAL FLOW DISTRIBUTION STRUCTURE ADDS 2" TO THE OVERALL DEPTH OF 270" FROM (30" ABOVE OPERATING FLOOR (OR 24'-6")

(NOTE: SK-MH-023 ONLY INDICATES 4' OF CONCRETE BELOW LAG STORAGE, SHOULD ASSUME 6' DUE TO RECENT DISCUSSIONS. and drawings on 7/23/84. (SK-MH-004 7/13/84)

∴ 26'-6" total from 30" above the operating floor which currently is at 33'6".

So 30" = 2'6" TOTAL = 33'6" + 2'6" = 36'

GAP Between Bottom of Lag Storage and Ground floor @ El = 0'6" becomes.

36' - 26'-6" - 0'6" = 9'0"

17

SIGNATURE J.W. Willis DATE 7/23/84 TRB NO. RH-JWW-01 PAGE 17

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RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Secondary Waste System Functional Requirements SHEET NO. 1 OF 1

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Mihirad Vali	1/22/85

G.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS (H-3-54930)

SUBJECT Shredded Waste Transfer System Functional Requirements

Functional Requirements for Shredded Waste Transfer System.

- Provide Access for Spent Fuel Assembly (SFA) Skeletons to Shredder
- Provide Clean Drums to Transfer System
- Provide Means to Transfer Drum from Storage to the Appropriate Shredder Locations
- Provide Means to Position Drums Beneath Shredder Outlet Chute.
- Provide Means to Transfer Filled Drums to the Lid Closure Station.
- Provide Mechanism to Position Lid on Filled Drum and Secure Prior to Transfer to Cell 3 Operating Floor
- Provide Mechanism to Transfer to Cell 3 Elevator and Lift to Within Pickup Height of Cell 3 Crane.

SIGNATURE J.W. Willis DATE 7/24/84 TRB NO. RH-TWN-01 PAGE 18

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Goal

SHEET NO. 1 OF 25

JOB NO. _____ DEPARTMENT _____ AUTHOR W Blanco DATE 5/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J J Mitchell	1-30-85

Fuel Rod disassembly SME 955 H-3-54911-54914

G.O. or CHARGE NO. _____ PROJECT MRS

SUBJECT Upender, Module F/A clamp

Tooling Rod

1.) Base Platform 6
2.) Power Screw Drive 6
3.) Hydraulic System 6/S
4.) Stone Crusher 6
5.) Gang 5
6.) Manual Spreaders 6
7.) Rotating Screen 6
8.) Fissile Safety Inserts 6B
9.) Modules (BWR, PWR) 5
10.) Clamping 5
11.) Control System 6/S
12.) Storage for Modules 6

Design Parameters

1.) Accepts all fuel types
2.) Absorb removing, handling, cleaning, fuel collection, fissile & control systems
3.) Minimize rad waste
4.) Modular
5.) Consolidate spent fuel rods
6.) Minimize gains into 55 gal. drum for disposal
7.) Mechanized & automated
8.) Round canisters
9.) 3 PWR/9 BWR ... 12" sch 20 CAN. (Ref WTSD Bartlesville)

Considerations

A.) Off-normal
B.) Maintenance
C.) Replacement
D.) Maintenance
E.) Weight
F.) Temperature Effects
G.) Radiation Effects
H.) Lifting Screws ... Self locking

SIGNATURE W Blanco DATE 5/22/84 TRB NO. WMB-001 PAGE 2

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equip

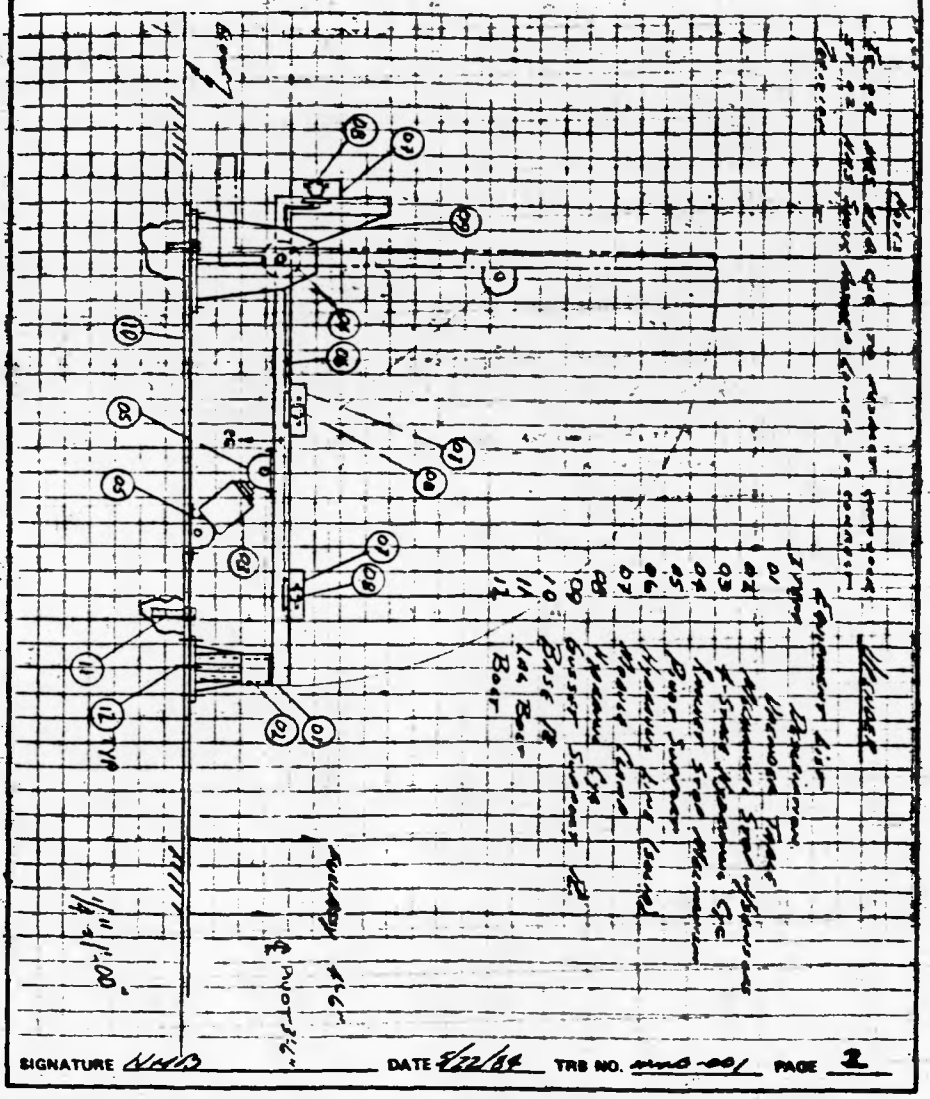
SHEET NO. 2 OF 25

JOB NO. DEPARTMENT AUTHOR W Rhines DATE 1-28-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J Y Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Downender/Upender



SIGNATURE WHR DATE 8/22/84 TRB NO. MMO-001 PAGE 2

RMP-307 (2/78)

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PAGE NUMBER 144

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

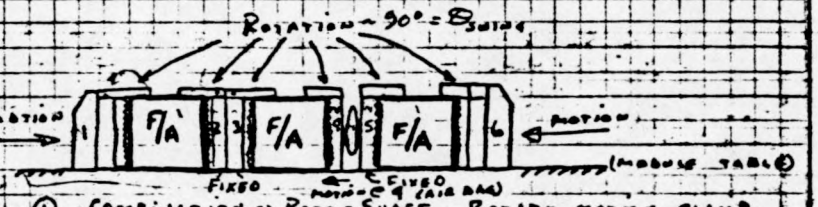
TITLE Fuel Consolidation Equip SHEET NO. 3 OF 25

JOB NO. DEPARTMENT AUTHOR W Blume DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J J Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Pool Clamping (Module 3)



(1) Combination a) Rota-Shaft Rotary motor clamp
b) Linear side clamp @ grid locations

(2) Fixed comb.

(3) " "

(4) Linear actuated via wind hammer actuator

(5) Fixed comb

(6) Same as #(1)

Notes:
1) Application to BIW fuel types must be examined
2) (W) Clamp @ lower end fitting & support @ grids
3) (CE) Clamp @ grids
4) Error Recall (same as above)

SIGNATURE W H Blume DATE 2/2/84 TRB NO. WHB-001 PAGE 3

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equipment SHEET NO. 4 OF 25

JOB NO. DEPARTMENT AUTHOR W H Rhomer DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							L G Mitchell	1-30-85

S.O. or CHARGE NO. PROJECT MRS

SUBJECT Codes & Standards

1.) ANSI/ANS-57.9 Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)

2.) ASME Boiler & Pressure Vessel Code Section VIII Division 1

3.) ASME Boiler and Pressure Vessel Code Section III Subsection NF and Appendix F

4.) AISC-5326 Specifications for Design, Fabrication and Erection of Structural Steel for Buildings

5.) ANSI/ANS-57.1 Design Criteria for LWR Spent Fuel Handling Equipment, 1980

6.) ASTM Carbon Steel Standards

SIGNATURE W H Rhomer DATE 5/8/84 TRB NO. 001 PAGE 4

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equipment

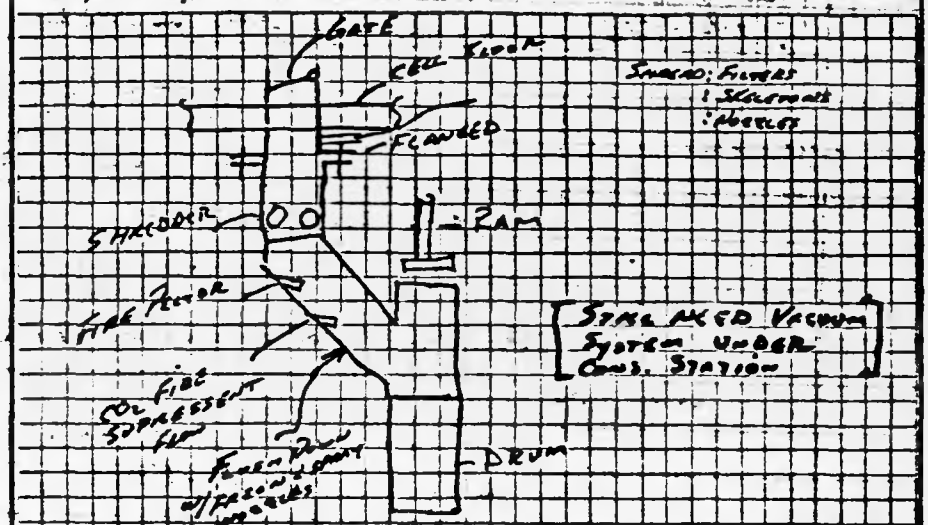
SHEET NO. 5 OF 25

JOB NO. DEPARTMENT AUTHOR W Bloomer DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							D Y Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Shrouds in Maintenance Area



Consideration w/ Ralph Wong
T. Crane
L. Pocono
B. Benson

Recommendation: Use w/ shroud for
in origin. Area.
(Coming or 2nd waste main)

Pyrophorics: Jim Henry PWL Spray on Pyrophoricity
Inert atm
Flash Detection
Flood w/ CO_2

Testing:

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equipment SHEET NO. 6 OF 25

JOB NO. DEPARTMENT AUTHOR W Blanco DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J Z Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Cask Design @ 17x17

Rod Pitch = .496

Rod Dia = .374 o.d.

Guide rods 0.84

" " Dia = .402/.429

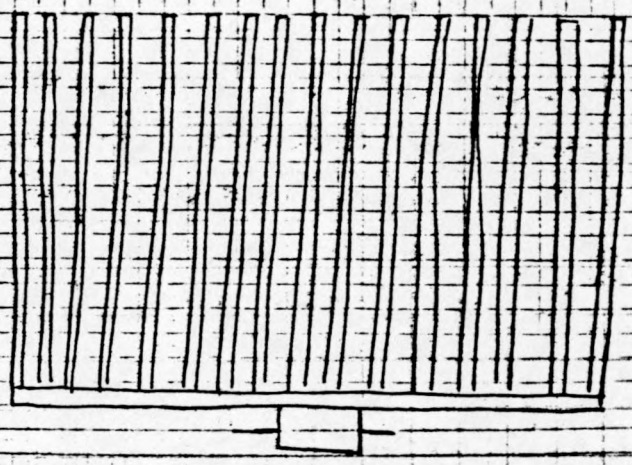
1 Instrument Tube

Rods Total = 17x17 - 29 - 1 = 264 Rods

@ 3 assy = 792 Rods

WEIGHT = 1466.325 lbs each

@ 3 assy = 4398 lbs total



SIGNATURE Walter H Blanco DATE 6/7/84 TRB NO. WMS-09 PAGE 6

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

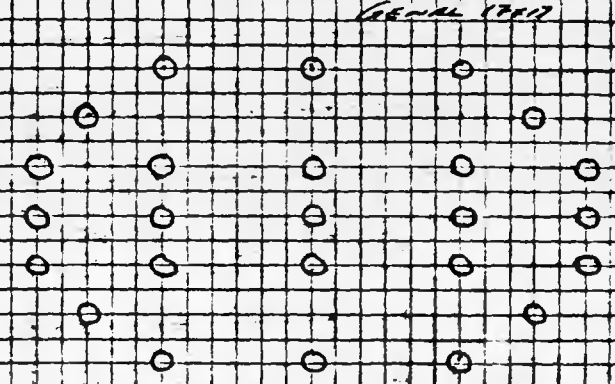
TITLE Fuel Consolidation Equipment SHEET NO. 7 OF 25

JOB NO. DEPARTMENT AUTHOR W Blume DATE 1/31/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							JZ Mitchell	1-30-85

S.O. or CHARGE NO. PROJECT MRS

SUBJECT Comb Arrangement



Area was chosen to represent largest pressure of spent fuel assy's

SIGNATURE W Blume DATE 1/31/85 TYPE NO. [illegible] PAGE 7

RMP-307 (2/78)

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equip SHEET NO. 8 OF 25

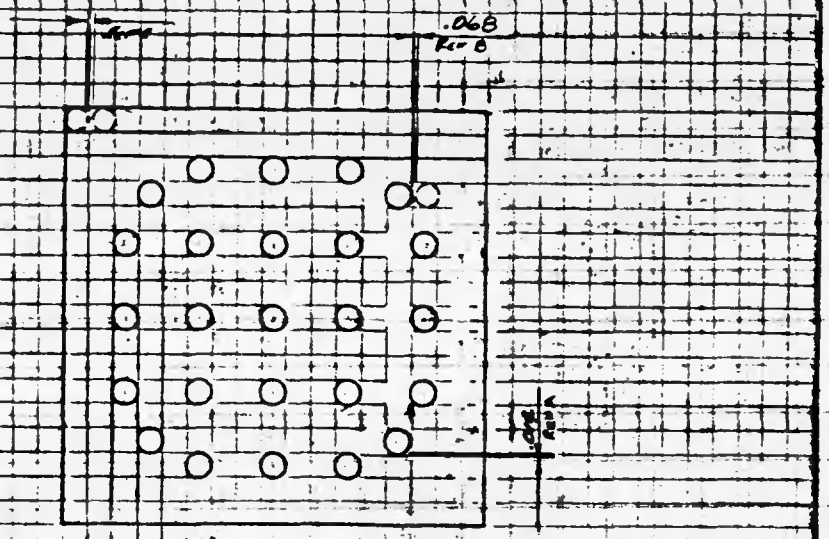
JOB NO. DEPARTMENT AUTHOR W Blanco DATE 1-22-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J Wilde	1-30-85

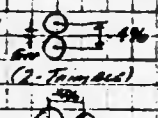
S.O. or CHARGE NO. PROJECT MRS

SUBJECT Comb Arrangement

Rod Dia = 0.374
Thimble Dia = 0.482/.429
Rod Pitch = 0.496

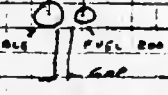


Calc. A



Gap_A = Pitch − Thimble Dia
= .496 − .482
= .014 (Nominal) Worst Case
= .496 − .429
= .067 (Nominal) Best Case

Calc. B



Gap_B = Pitch − ½ Thimble Ø − ½ Rod Ø
= .496 − .482/2 − .374/2
= .068 (Nominal) Worst Case
= .496 − .429/2 − .374/2 = 0.0945 (Nom. Best Case)

Calc. C

Gap_C = Pitch − Rod Ø
= .496 − .374 = 0.122 (Minimum)

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

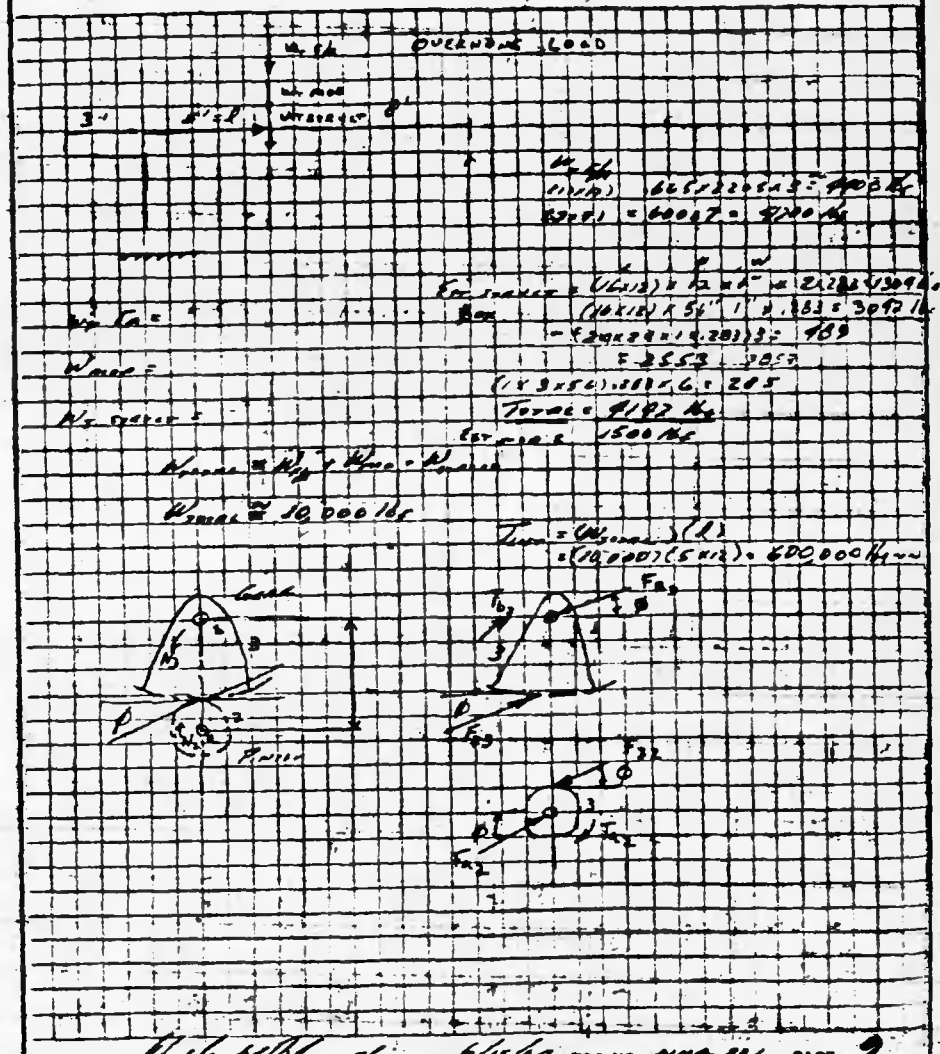
TITLE Fuel Consolidation Equipment SHEET NO. 9 OF 25

JOB NO. DEPARTMENT AUTHOR W Blumer DATE 1/02/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							D Smithell	1-30-85

B.O. or CHARGE NO. PROJECT MRS

SUBJECT Downender



SIGNATURE Walter H Blumer DATE 6/15/84 TRB NO. 0100 001 PAGE 9

RMP-307 (2/78)

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PAGE NUMBER 151

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

RMP

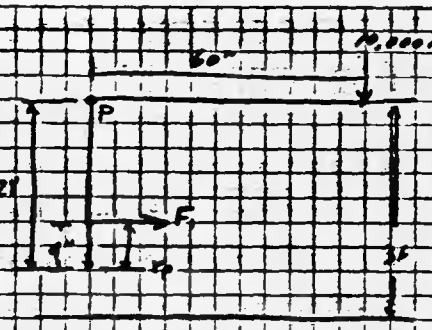
TITLE: FUEL CONSOLIDATION EQUIPMENT SHEET NO. 10 OF 25

JOB NO. DEPARTMENT AUTHOR W.H. Blanco DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J. Y. Griffith	1-30-85

B.O. or CHARGE NO. PROJECT MRS

SUBJECT Rowender



To find F_1

$\Sigma M_p = 0$ ↺

$(10{,}000\,lb)(60\,in) = 25F_1$

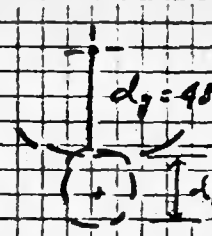
$\therefore F_1 = 25{,}000\,lb$

To Reduce = 25,000 × 4

= 100,000 lb-in

w/ h_g in bearing load = 1.5 × 100,000

= 150,000 lb-in



$d_g = 48$, $N = 120$, $P = 2.5$ } COARSE PITCH

$d_p = 8$, $N = 20$, $P = 2.5$

Assume Face = 5 × p & $p = \frac{\pi}{P} = \frac{\pi}{2.5} = 1.25$

= 5 × 1.25 = 6.5"

Choose Reducer @ 215,000 lb-in out & HT Sy,d = 42 ASSUME SMF

$\therefore W_T = \frac{T_2}{d} = \frac{(215{,}000)(2)}{8} = 53{,}775\,lbf$

$\sigma = \frac{W_T}{F P y} = \frac{53{,}775}{(6.5)(1.25)(.283)} = 23{,}400\,psi$ safe

y = .283 (19½ @ 20 teeth)

SIGNATURE W.H. Blanco DATE 1/18/85 TRB NO. WMS-001 PAGE 10

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THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

RMP

TITLE Fuel Consolidation Equipment SHEET NO. 11 OF 25

JOB NO. DEPARTMENT AUTHOR DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

S.O. or CHARGE NO. PROJECT MRS

SUBJECT Down Ender

Reducer Philadelphia, 1900 Series
Double Worm Reduction
8.22 Input
Torque 215,100 lb-in

Motor Reliance Electric
Three Phase D.C. motor
5 HP
1750 RPM w/ Reversing (Speed control)
RPM Digital Separate Temperature
measurement (Reduced to 100 RPM)

Conveying Speed

$$\left[\frac{\text{Input Rpm}}{\text{Reducer}} \times \frac{N_{\text{Pinion}}}{N_{\text{Gear}}}\right]^{-1} = \quad \frac{\text{min}}{\text{Rev}}$$

We need only 90° = .25 (360°) or 1/4 Rev of Gear

$$\left[\frac{100}{130} \times \frac{20}{130}\right] = .128 \frac{\text{Rev}}{\text{min}} \Rightarrow 7.8 \frac{\text{min}}{\text{Rev}}$$

$$7.8 \frac{\text{min}}{\text{Rev}} \times .25 \text{ Rev} = \boxed{1.95 \text{ min to Travel 90}}$$

SIGNATURE [illegible] DATE 1/22/85 TIME NO. [illegible] PAGE 11

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PAGE NUMBER 455

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equip SHEET NO. 12 OF 25

JOB NO. DEPARTMENT AUTHOR W Blanchard DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1-30-85

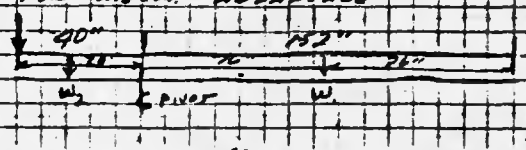
G.O. or CHARGE NO. PROJECT MRS

SUBJECT Reworked Downender

Cradle = 16'

8'-0 CG. 7900 lbs from rear end

Can use up to 40" to load or CG for mech. advantage



$W_2 = 7900\left(\frac{40}{196}\right) = 1612.28\ lbs$

$W_1 = 7900\left(\frac{152}{196}\right) = 6126.5\ lbs$

ΣM_{PIVOT}

$\therefore\ (6127)(76) - (1612)(20) - F_B(40) = 0$

$F_B = 10{,}835$

@ 1/2 of F_B = 5,400 lbs for mechanical advantage (max PB @ 710 lbs/in²)

Assume (20 x 12 x 59") (710) = 5320 lbs @ last 20" length.

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

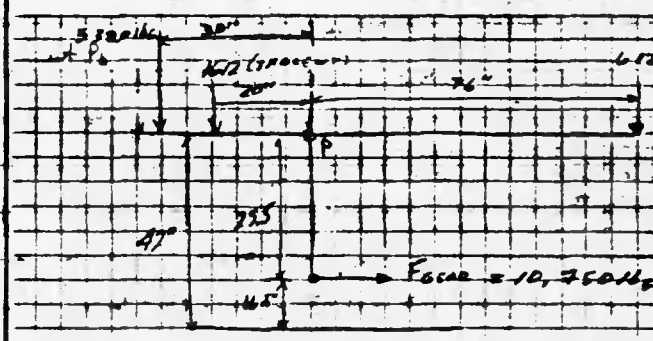
TITLE Fuel Consolidation Equipment SHEET NO. 13 OF 25

JOB NO. DEPARTMENT AUTHOR W Blanco DATE 1-24-85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							R.E. Mitchell	1-30-85

B.O. or CHARGE NO. PROJECT MRS

SUBJECT Reworked Downender



$\Sigma M_P = 0 \quad (6123)(76) - (1612)(20) - (5320)(30) - F_{CLAD}(25.5) = 0$

$\therefore F_{CLAD} = \dfrac{465652 - 32240 - 159600}{25.5} = 10,750 \text{ lb}$

Torque @ Reducer = 10,750 x 4" = 42950 lb-in

Choose 1.05 HP @ 46,900 lb-in

$\dfrac{100 \text{ RPM}}{130 \text{ RPM}} = .769$ RPM output

Unit 275

SIGNATURE Walter H Blanco DATE 1/24/84 TRS NO. [illegible] PAGE 13

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PAGE NUMBER 155

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Fuel Consolidation Equipment SHEET NO. 14 OF 25

JOB NO. DEPARTMENT AUTHOR W Blume DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Estimated Weight Parameters for Downnock

1.) Largest Weight Pwr

15x15, BW @ 1516 lbf/assy

Combined load @ 3 assy

1516 lbf/assy x 3 assy = 4548 lbf ~ 4550 lbf Pwr (Design Basis of Below)

2.) Largest Weight Bwr

BXB-GE-Type 8, 9, 5 x 6

.290 kg/assy x 2205 lbf/kg = 639.5 lbf/assy

Combined load @ 7 assy

639.5 lbf/assy x 7 assy = 4476 lbf Bwr

3.) Δ Pwr-Bwr ≈ 75 lbf

4.) Design wise the variation between Pwr & Bwr fuel is virtually negligible. and design should be based on Pwr fuel, particularly 8 x 8 15x15 type fuel.

6.) Estimated Weight of clamping module

Pwr = 2095
Bwr = 3215 } see T. Kumar and book for breakdown.

7.) Worst Case Analysis
Bwr combined loads = 3215 lbf + 4476 = 7691 lbf

SIGNATURE William H Blume DATE 7/1/84 TRB NO. 0148-001 PAGE 14

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RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Fuel Consolidation Equip SHEET NO. 15 OF 25

JOB NO. DEPARTMENT AUTHOR W Blomer DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	1-30-85

Laser Disassembly Equip. # SME 956 H-3-54915

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Laser Tube (PWR) Parameters

PWR Thimble and Guide Tube I.D. Variations

Manufacturing & Array	O.D. (Inch)	Wall (inch)	I.D. (inch)	No. Tubes	Notes
Babcock & Wilcox					
15x15 (G)	.530	.016	.498	25	See Sample Cal
(I)	.493	.026	.441	1	
17x17 (G)	.465	.0175	.43	24	
(I)	.420	.015	.39	1	
Combustion Engineering					
15x15 (G)	1.115	.040	1.035	4	
(I)	.440	.026	.338	1	
14x14 (G)	1.135	.030	1.075	4	.....Largest
(I)	.440	.026	.338	1	
(G)	1.115	.030	1.055	4	
(I)	.440	.026	.338	1	
16x16 (G)	.97	.035	.80	4	
(I)	.382	.025	.332	1	
(G)	.98	.035	.91	4	
(I)	.382	.025	.332	1	.....Smallest
Westinghouse					
14x14 (G)	.539	.034	.471	16	
(I)	.539	.034	1		
(G)	.4805	.034	.4125	16	
(I)	.539	.034	.471	1	
15x15 (G)	.543	.012	.519	20	
(I)	.543	.012	.519	1	
(G)	.478	.012	.454	20	
(I)	.543	.012	.519	1	
(G)	.545	.015	.515	20	
(I)	.545	.015	.515	1	
(G)	.484	.015	.454	20	
(I)	.545	.015	.515	1	
17x17 (G)	.482	.016	.450	24	14' Core
(I)	.545	.015	.515	1	
(G)	.429	.016	.397	24	14' Core
(I)	.545	.015	.515	1	
17x17(L) (I)	.682	.016	.650	1	
Exxon Refills					
14x14 (G)	1.115	.036	1.043	4	
(I)	1.115	.036	1.043	1	
15x15 (G)	Information N/A				
(I)	.417	.027	.363	1	
15x15 (G)	.544	.017	.510	20	
(I)	.544	.017	.510	1	
17x17 (G)	.480	.016	.448	24	
(I)	.480	.016	.448	1	

SAMPLE CALCULATION: ID = OD-2X Wall Thickness
.530-2X .016 = 0.408

REF. NUCLEAR ASSURANCE CORP. VOL III DOE/ET/47912-3
DOMESTIC LIGHT WATER REACTOR FUEL DESIGN EVOLUTION NAC-C 8129

SIGNATURE W H Blomer DATE 8/21/84 TRB NO. 003 PAGE 1

RMP-307 (2/78)

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Laser Kerf Calc.

Subject: Material Separation of Pole/Bulk Trimmed, Instrument and Tie Rods from Laser Disassembly.

General Information

① Comparison with Dan Ricci:

A.) Laser Kerf = 0.030 in (nominal)

b.) Most material vaporizes when cut.

② Material Properties of Zircaloy-2 & 4

Density = ρ = 6.55 gram/cm³

③ 2.54 cm = 1 in (conversion factor)

Pole Disassembly Worst Case Analysis - Largest Wall Thickness

CE 15x15 ; OD = 1.115 in = 2.8321 cm
ID = 1.035 in = 2.6289 cm
WALL = 0.040 in = 0.1016 cm

Number of rods to be cut = 5

C = CUT = 0.030 in = 0.0762 cm

$$A = \text{Area} = \frac{\pi(OD^2 - ID^2)}{4} = \frac{\pi(2.8321^2 - 2.6289^2)}{4} = 0.8715\,cm^2$$

$$V = \text{Volume} = A \times C = 0.8715\,cm^2 \times 0.0762\,cm = 0.0664\,cm^3$$

SIGNATURE [signature] DATE 7/29/84 TRB NO. 003 PAGE 2

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

RMP

TITLE Fuel Consolidation Equip SHEET NO. 17 OF 25

JOB NO. DEPARTMENT AUTHOR W Bhowal DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Lower Foot Calc.

g/cut = V×ρ = 0.0664 cm³ × 6.55 g/cm³ = 0.4350 g/cut

@ 5 cuts = 5 × 0.4350 g/cut = 2.175 g/5 cut

Fuel Disassembly Worst Case Analysis - Most Fissionable; Lowest Burnup

(a) 17×17 O.D. = 0.482 in = 1.22426 cm
I.D. = 0.450 in = 1.143 cm
Wall = 0.016 in = 0.04064 cm

Number of Tubes to be cut = 25

C = cut = 0.030 in = 0.0762 cm

A: Area = $\frac{\pi(D^2 - ID^2)}{4} = \frac{\pi(1.22426^2 - 1.143^2)}{4} = 0.1511 cm^2$

V = Volume = A×C = 0.1511 cm² × 0.0762 cm = 0.0115 cm³

g/cut = V×ρ = 0.0115 cm³ × 6.55 g/cm³ = 0.0754 g/cut

@ 25 cuts = 25 × 0.0754 g/cut = 1.886 g/25 cut

Fuel Disassembly Worst Case Analysis - Lowest Burnup

GE 7×7 O.D. = 0.570 in = 1.4478 cm

Number to be cut = 8 rod
= 8 Arrow
total = 16

C = cut = 0.030 in = 0.0762 cm

A = Area = $\frac{\pi d^2}{4} = \frac{\pi \times 1.4478^2}{4} = 1.6463 cm^2$

V = Volume = A×C = 1.6463 cm² × 0.0762 cm = 0.1254 cm³

g/cut = V×ρ = 0.1254 cm³ × 6.55 g/cm³ = 0.8217 g/cut

SIGNATURE W Bhowal DATE 7/29/84 TRB NO. 003 PAGE 3

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equip SHEET NO. 18 OF 25

JOB NO. DEPARTMENT AUTHOR [illegible] DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1-30-85

G.O. or CHARGE NO. PROJECT MKS

SUBJECT Lower Knot Calc.

The bushing use per [illegible] purchase
CR 1470 [illegible]
is the lower knot fuel assembly. This
is due to clipping of solid rods vs. hole tubing.

SIGNATURE [illegible] DATE [illegible] TRB NO. 002 PAGE 4

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RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Fuel Consolidation Equip SHEET NO. 19 OF 25

JOB NO. DEPARTMENT AUTHOR W. Blanes DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Whitehall	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Laser Mirror Metals

Metals →	Oxygen Free Copper	Molybdenum	Tungsten
Physical Properties			
Density, lb/cu in.	0.323	0.37	0.70
Melting Temp °F	1981	4730	6120
Specific Heat (68°F) Btu/lb°F	0.092	0.065	0.034
Coef of Thermal Exp (68-572°F) in/in°F	9.8×10^{-6}	2.7×10^{-6}	2.5×10^{-6}
Thermal Conductivity (68°F), Btu/hr/sq ft/°F/ft	226	84.5	96.6
Electrical Resistivity (68°F) Annealed, microhm-cm	1.71	5.2	9.48
Mechanical Properties			
Modulus of Elasticity, psi	17×10^6	47×10^6	59×10^6
Tensile Stress 1000 psi	32-35	95	220
Yield Stress 1000 psi	10-11	82	220
Reduction of Area %	45-55	60	-
Hardness (annealed)	40-45 RF	250 VHN	650 VHN
Optical Properties			
Reflectivity 10.6 μm	99	98	96
Cleanability	Poor	Good	Excellent

SIGNATURE WHB for Ron Pomi DATE 9/22/89 TRB NO. 008 PAGE 5

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation Equip SHEET NO. 20 OF 25

JOB NO. DEPARTMENT AUTHOR W. Rhoads DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MS

SUBJECT Laser Cutting (Pwr)

LASER CUTTING SEQUENCE FOR PWRs

Cutting Sequence	Velocity of Cutting Motion (IPM)	Power (kW) at Cutting Surface	Estimated Material Removal (0.030 width) (cubic inch)	Approximate Time (sec)
1. Slow Position				
2. Position for Upper Handling Attachment Cut (Locate First Tube and Insert Nozzle)	150 X, Z 60 Y	NA NA	NA NA	5 6
3. Rotate Cutter	150 (θ)	0.2	.001	9
4. Retract Cutter	60 (Y)	NA	NA	6
5. Repeat Steps 2, 3, 4 23 times	---	--	.022	414
6. Proceed to Second Assembly and Repeat				5 427
7. Proceed to Third Assembly and Repeat				5 427
Total Time				1296 sec 21.6 min

SIGNATURE [illegible] DATE [illegible] TRB NO. 003 PAGE 6

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation SHEET NO. 4 OF 25

JOB NO. DEPARTMENT AUTHOR M Bhowe DATE 1/22/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT Laser Cutting (Base)

Cutting Sequence	Velocity of Cutting Motion (IPM)	Power (kW) at Cutting Surface	Estimated Material Removal (0.030 width) (cubic inch)	Approximate Time (sec)
10. Cut Eight Tie Rods per Assembly, Total of Seven Assemblies.			0.21	1232
11. Position LDS to Stow Position.				100
TOTAL TIME				2864 sec 47.7 min

SIGNATURE Willis for the Panel DATE 6/22/84 TRB NO. 00 PAGE 7

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REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Jeff Mitchell	4-30-85

B.O. or CHARGE NO. PROJECT MRS

SUBJECT Laser Cutting (BWR)

LASER CUTTING SEQUENCE FOR BWRs

Cutting Sequence	Velocity of Cutting Motion (IPM)	Power (kW) at Cutting Surface	Estimated Material Removal (0.030 width) (cubic inch)	Approximate Time (sec)
1. Stow Position				
2. Position for Upper Lifting Attachment Cut (Locate First Tie Rod).	150 X, Z 60 Y	NA NA	NA NA	5 6
3. Oscillate Cutter	100 X	0.5	0.004	5
4. Retract Cutter	60 Y	NA	NA	6
5. Repeat Steps 2, 3, and 4 Seven Times.	--	--	0.028	154
6. Proceed to Second Assembly and Repeat.			0.030	176
7. Proceed to Third Through Seventh Assembly and Repeat (5 Additional Assemblies).			0.150	880
8. Retract to Stow Position, Horizontally Position BWR Assemblies.				300
9. Reposition LDS to Lower Elevation for Lower Attachment Cuts.				100

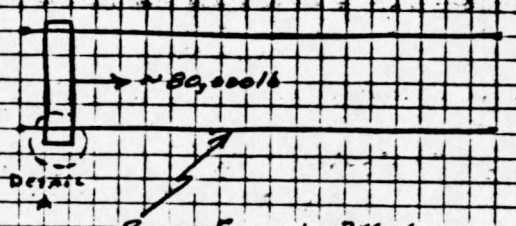
SIGNATURE W H Blanco for Dan Ross DATE 8/22/84 TEB NO. 003 PAGE 8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Rod Consolidation Equipment Zone E 954 N-3-59911-59914
GRIPPER Drive

B.O. or CHARGE NO. PROJECT MRS

SUBJECT Gripper Drive



The amount of effort, measured in pound-inch, required to turn the ball screw and move the load

$$T_d = \frac{P \times L}{2\pi e} = .177\, P \times L \text{ (pound-inches)}$$

T_d = Direct Torque (lb-in)
P = Load (lb) = 40,000
L = Screw lead (inch/turn) = .660
e = Ball screw efficiency ~90% = .9

SIGNATURE [illegible] DATE 5/23/85 TRB NO. 009 PAGE 1

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation SHEET NO. 24 OF 25

JOB NO. DEPARTMENT AUTHOR [illegible] DATE 1/28/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J. Kaitell	1-30-85

S.O. or CHARGE NO. PROJECT

SUBJECT

$$T_d = \frac{(40{,}000\ lb)(.660\ \frac{in}{rev})}{2\pi(.9)} \simeq 4700\ lb\text{-}in$$

Reqd.

$$HP/_{screw} = \frac{RPM \times TORQUE}{63{,}000} = \frac{91 \times 4700}{63{,}000} = 6.75\ HP$$

$$= \underline{7\ HP}$$

REQD

WANT A VELOCITY of ~5 FPM for FUEL ROD EXTRACTION.

$$\therefore\ RPM = \frac{Velocity}{Lead} = \frac{(5\ ft/min \times 12\ in/ft)}{(.660\ in/rev)} \simeq 91\ \frac{Rev}{min}$$

SIGNATURE [illegible] DATE 7/23/84 TRB NO. 004 PAGE 2

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Fuel Consolidation

SHEET NO. 25 OF 25

JOB NO. DEPARTMENT AUTHOR W.H. Bussell DATE 1/21/85

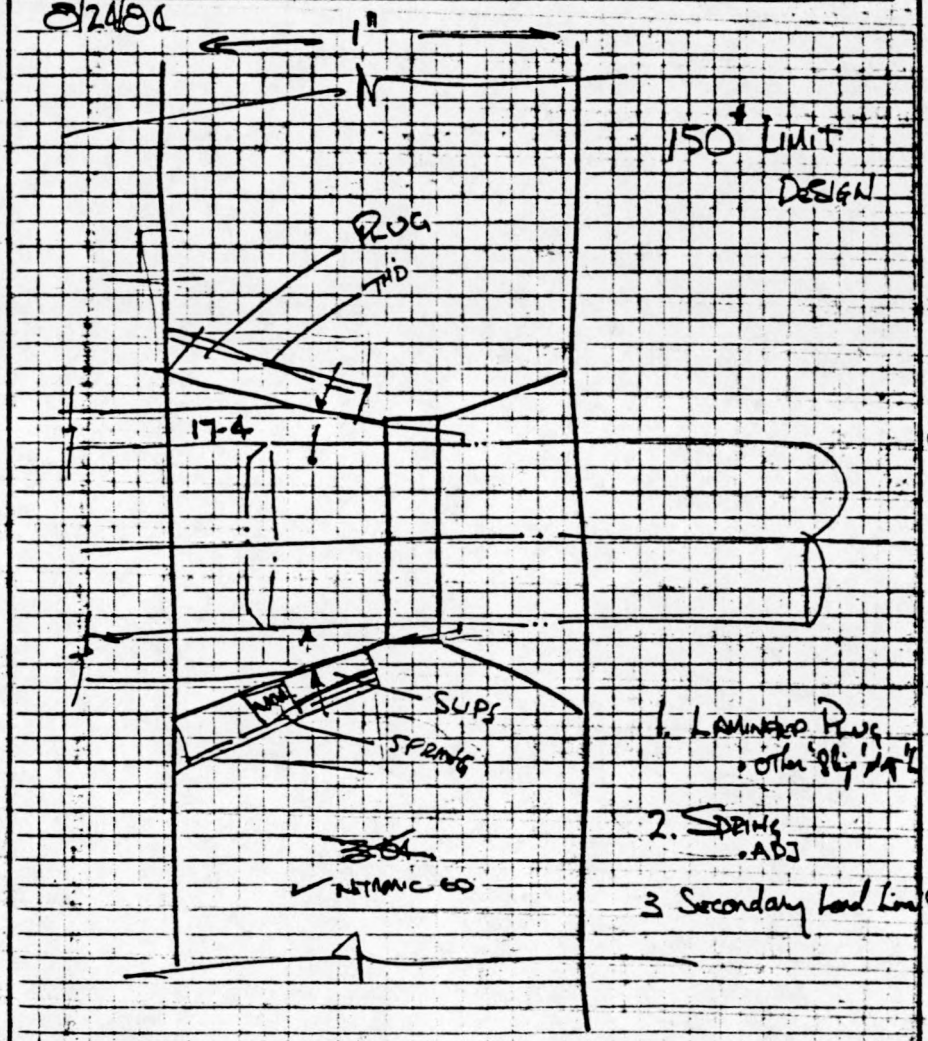
REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							J Mitchell	1-30-85

G.O. or CHARGE NO. PROJECT

T Krause
(BUSSELL) w. Figures & calculations

SUBJECT Gripper

8/24/84



1. Laminated Plug
   • Other 'slip' 17-4
2. Spring
   • ADJ
3. Secondary Load Limit

SIGNATURE WHB for T Krause DATE 8/24/84 TRB NO. 004 PAGE 3

Technologies, Inc.

Other Classifications

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RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Cacouser Supply Rack SHEET NO. 1 OF 4

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Minal Vali	1/22/85

CUR 954

G.O. or CHARGE NO. SB-1239-04-011 PROJECT MRS (H-3-54924)

SUBJECT Canister Storage Rack Concept 2

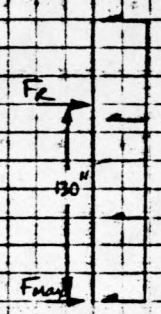
Calculate the Center Tube due to Lateral Loading

Assumptions – 5-12" canisters + 1-14" canister

= 3691# based on Design Wts.

Lateral Support at Bottom – Assume only friction

SS/SS = (Mild Steel / Mild Steel) = .57 Sliding dry from Marks pg. 3-35



$F_{max} = .57 \times DW_{actual}$

$= .57 \times 549\# = 312.93\#$ (Conservative)

$\Sigma M_{F_{max}=0} = 0 = 671\#(94) - 130" \cdot F_R = 0$

$F_R = \underline{485.1\#}$

Assume that in all cases this same load can be transferred into the center tube via radial arms and brackets. ∴ $6 \times 485.1 = 2910.6\#$ @ 130" elevation

$M = 2910.6\# \times 130" = 378378$ in-lbs

$\sigma_{B_{PIPE\,all}} = .57(20000) = 11400$ psi.

$\sigma_B = \frac{MC}{I} = \frac{M}{Z}$

$Z = \frac{M}{\sigma_B} = \frac{378378}{11400} = \underline{33.19}$ in

Use 12" – Sch 40S with $Z = \underline{43.8}$ in

SIGNATURE J.W. Willis DATE 7/6/84 TRB NO. RH-JWW-01 PAGE 10

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE Carousel Supply Rack SHEET NO. 2 OF 4

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							normal Kali	1/22/85

G.O. or CHARGE NO. PROJECT MRS (H-3-5492A)

SUBJECT Frictional Torque For Carousel Design

From Rotek Bearings Co. Pg 22 (1981 Catalog)

$$T = \frac{\mu}{2}(4.4M + AD + 2.2RD)$$

where T = Torque (lb-ft)
M = Moment Load (ft-lb)
A = Thrust Load (lb)
R = Radial Load (lb)
D = Raceway Diam (ft)
μ = .006 for 2100 Series

$$= \frac{.006}{2}[4.4(10{,}000) + 20{,}000(3.794) + 2.2(2000)(3.794)]$$

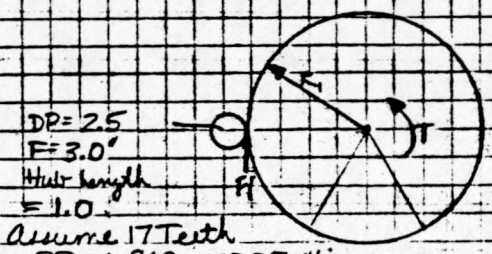
M = 10,000 ft/lb very broad
A = 20,000 lb (rail cone)
R = 2,000 lb (rail screw)
D = 45.53 in or 3.794 ft

$T = \underline{409.72 \text{ ft-lb}} = 4916.64$ in-lb $HP = \frac{T(rpm)}{63025}$

For Bearing 19-46E9Z OD = 51.04 in $= \frac{4916(7)}{63025}$

PD = 50.4 DP 20° STUB 2.5 N = 126 $= \underline{.546 \text{ HP}}$

Max. Tangential Tooth Load = 10600 lbs.



DP = 2.5
F = 3.0"
Hub length = 1.0"
Assume 17 Teeth
PD = 6.800 OD = 7.44 in

$R_1 = 25.2$ in

$F_1 \cdot R_1 = T$

$F_1 = \frac{T}{R_1} = \frac{409.72}{25.2} = 16.25^{\#}$

Rotation Rate of Carousel = 180°/1 min or .5 RPM $\frac{N_1}{N_2} = \frac{17}{126} = .1349$

= .5 RPM × 126/17 = 3.705 RPM @ gear motor output

SIGNATURE JWW DATE 7/6/84 TRB NO. RH-JWW-01 PAGE 11

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Carousel Supply Rack SHEET NO. 3 OF 4

JOB NO. DEPARTMENT AUTHOR J. W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Michael Vali	1/22/85

G.O. or CHARGE NO. PROJECT MRS (H-3-54924)

SUBJECT:

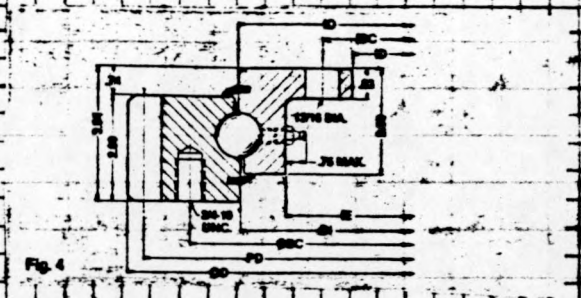


Fig. 4

From Reliance Gearmotor Catalog
Master XL Right Angle Combination Motor

For 1HP Motor with 5RPM output Pg (E-B)

⇒ 5RPM x .1349 = .6745 RPM @ Carousel

Better to use the 1 HP with 7RPM Combination with 1725 RPM Motor

⇒ 7RPM x .1349 = .9443 RPM

Pitch Circle Velocity = V_r = $\frac{rpm(\pi)(50.4)}{12}$ = 12.45 ft/MIN

or 149.5 in/min
or 2.49 in/sec

This appears to be adequate as far as hp and rotational speed @ carousel. Use FD56CG28A with Single phase 115/230 Volts enclosed, fan cooled or Polyphase 230/460 Volts enclosed, fan cooled or explosion proof.

SIGNATURE Jatul DATE 7/6/84 TRB NO. RH-JWW01 PAGE 12

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Crawler Supply Rack

SHEET NO. 4 OF 4

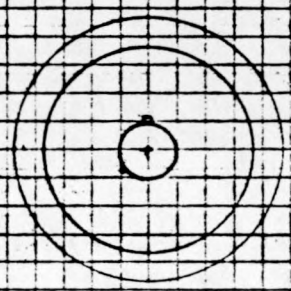
JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/10/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							Nominal Rate	1/22/85

G.O. or CHARGE NO. PROJECT MRS

SUBJECT

For shaft output diameter of 1.500 inches
Check pinion from Rotek
Model No. P.2.5-6.8.D2
PD = 6.8 OD = 7.44 Hub Dia = 5.88 Stock Bore 1.250
Use 1.500" DIA
Bore is OK



SIGNATURE JWW DATE 7/9/84 TRB NO. RH-JNW-01 PAGE 13

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE CSR Lifting Tension SHEET NO. 1 OF 1

JOB NO. DEPARTMENT AUTHOR J.W. Willis DATE 1/18/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/22/85

G.O. or CHARGE NO. -011 PROJECT MRS

SUBJECT Canister Storage Rack (CSR) Concept 1

• Support Calculations

Assume - 5-12" Canisters + 1-14" Canister

= 5 x 604# + 1 @ 671# = 3691#

(Design Loads)

Rack Weight: = 34" x 51 x 1" = 490.7# - Plate

1.5x1.5x.251 = 2.34#/ft

18 @ 20" = 70.2#
20 @ 140" = 546.0#
2 @ 140" = 54.6#
4 @ 132" = 102.96#

773.76#

Total = 3691# + 490.7# + 773.7# = 4955.5#

Assume for design purposes = 5300# Total using 7% conservatism

Area Required to handle 5300# in shear

$\tau_{all} = .40 F_y = .40 \times 30000 psi = 12000 psi$

12000 psi = F/Area

$Area = \frac{5300}{12000} = .4416 in^2 =$

$D = \sqrt{\frac{4A}{\pi}} = .750 in$

Use or assume at least a 1.25 in DIA Rod.

SIGNATURE J.W. Willis DATE 7/5/84 TRB NO. RH-TUW-01 PAGE 9

RMP-307 (2/78)

RMP THE RALPH M. PARSONS COMPANY CALCULATION SHEET

TITLE MRS ENTRY PORT OPERATING TIME SHEET NO. 1 OF 3

JOB NO. DEPARTMENT AUTHOR GEORGE VB HALL DATE 7/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/30/85

G.O. or CHARGE NO. SB1239. PROJECT MRS

SUBJECT ENTRY PORT OPERATING TIME

1. ASSUMPTIONS
   - A. ONE PORT PER HOT CELL
   - B. 1800 MTU SPENT FUEL
   - C. 60/40 SPLIT PWR/BWR
   - D. ONE FUEL CASK CART/CELL

2. CRITICAL PATH OPERATIONS

		TIME HRS
A REMOVE CASK VALVE COVERS/CHECK CONTAM		1.5
B THRU AIRLOCK		1.0
C INSTALL CONTAMINATION BARRIERS		1.0
D. REMOVE FUEL ASSEM		SEE BELOW
E REPLACE INNER SEAL		1.0
F THRU AIRLOCK		1.0
G INSTALL INNER HOLD NUTS & DRAIN		2.25
H MOVE TO REC. BAY		2.00
		9.75
RAIL CASKS		
FOR PWR (TN-12) 12 ASSEM	6 HR	15.75
FOR BWR (TN-12) 32 ASSEM	16 HR	25.75

RATE: PWR 12/15.75 = 0.76 ASSEM/HR (1.312 HR/ASSEM)

BWR 32/25.75 = 1.25 ASSEM/HR (.805 HR/ASSEM)

TRUCK CASKS		
PWR (NLI - 1/2)	5	10.25
BWR	1.0	10.75

RATE: PWR - .098 ASSEM/HR
BWR .093 ASSEM/HR

REQUIRED RATE - PWR - 0.535 ASSEM/HR
BWR 0.886 ASSEM/HR

RATE IS MET WITH RAIL CASK BUT WITH TWO TRUCK PORTS, THE UNLOADING RATE IS 2x .098/.093 = .196/.186 ASSEM/HR
FOR 3 CELL 3x.098/.093 = .294/.279 ASSEM/HR

STILL TOO SLOW

SIGNATURE GVB Hall DATE 20 Mar 84 TRB NO. 01 PAGE 12

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE MRS ENTRY PORT OPERATING TIME SHEET NO. 2 OF 3

JOB NO. DEPARTMENT AUTHOR GEORGE VB HALL DATE 7/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

G.O. or CHARGE NO. 581239 PROJECT MRS

SUBJECT ENTRY PORT OPERATING TIME

1. ASSUMPTIONS - SAME AS PV2, EXCEPT TWO ENTRY PORTS PER CELL

2. CRITICAL PATH OPERATIONS

A. THRU AIRLOCK 1.0
B. INSTALL CONTAM. BARRIERS 1.0
C. REMOVE FUEL SEE P.12
D. REPLACE INNER SEAL/HD 1.0
3.0

RATE SR PWR 8 9.0
LS2 BWR 16 19.0
TRUCK 1 PWR 0.5 3.5
2 BWR 1.0 4.0

TRUCK CASK RATE (2 PORTS)

PWR 2 × 1/3.5 = 0.571 ASSEM/HR

BWR 2 × 2/4.0 = 1.000 ASSEM/HR

BOTH EXCEED REQUIRED UNLOADING RATE OF
PWR 0.535 ASSEM/HR
BWR 0.886 ASSEM/HR

SPLIT NEEDED FOR FULL UNLOADING CELL UTILIZATION (3 CELLS)

$(.535 \times 3.5 + .886 \times 2)x + (.535 \times .75 + .886 \times .59375)(1-x) = 3$

$2.917x = 3 - .977 = 2.023$

$x = 0.7628$ .67 .708

$1-x = 0.2372$ .33 .292

76% by truck USES 2.770 CELLS
24% by rail USES 0.230 CELLS

SIGNATURE GVBHall DATE 20 Mar 84 TRB NO. CH01 PAGE 13

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE MRS ENTRY PORT OPERATING TIME SHEET NO. 3 OF 3

JOB NO. DEPARTMENT AUTHOR GEORGE VB HALL DATE 1/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	4/30/85

G.O. or CHARGE NO. 50/239 PROJECT MRS

SUBJECT ENTRY PORT OPERATING TIME

50/50 TRUCK/RAIL SHIPPING SPLIT
60/40 PWR/BWR SPLIT
50% EFFICIENCY

	PWR	BWR
TRUCK SHIPMENTS	180 x .6	180 x .4
OR RAIL SHIPMENTS	108 x .6 x 2 x 45	126 x 2 x .5 x 2 x 45
	.2676 ASSEM/HR	.443 ASSEM/HR
	or 3.73 HR/ASSEM	2.25 HR/ASSEM

UNLOADING PORTS	HRS/ASSEM PWR	BWR
TRUCK	3.50	2.0
RAIL	0.75	.69375
CONSOLIDATION	1.6	1.1
WELD, TEST & DECON	2.25	0.9

SIGNATURE GVB Hall DATE 20 Nov 84 TRB NO. [illegible] PAGE 19

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE Cask Unloading Requirements for MRS R&H SHEET NO. 1 OF 2

JOB NO. DEPARTMENT AUTHOR George VB Hall DATE 1/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/30/85

G.O. or CHARGE NO. 581239-02-003 PROJECT MRS

SUBJECT Cask Unloading Cell Requirements (SF)

DRAFT FDC-Ltd F&C 84 states (for spent fuel)

INITIAL REQMTS 2000 MTU/y (P.5)
WORKING TIME 3 shifts/day, 7 days/wk, year round (P.3.1)
EXPANSION 4000 MTU/y (P.3.1)
SHIPPING CASKS: TRUCK NLI-1/2 1/2
RAIL TN-12 12/32

ASSUMPTIONS
PWR/BWR SPLIT IS 60/40
UNLOADING TIME IS PER WI:JBW:81-176
@ 2 hrs + 1 hr/ASSEMBLY
(see OPS 1.11, 1.12, F1.13)
0.46 MTU/ASSEM PWR / 0.18 MTU/ASSEM BWR

TOTAL ASSEMBLIES/HR @ 50% EFFICIENCY

		2000	4000
PWR:	$\frac{2000 \times 0.60}{.5 \times .46 \times 7 \times 52 \times 24}$ =	0.597	1.194
BWR	$\frac{2000 \times .40}{.5 \times .18 \times 7 \times 52 \times 24}$ =	1.048	2.035

UNLOADING RATES:

TRUCK
PWR: $\frac{1 \text{ ASSEM}}{3 \text{ HRS}}$ = 0.333 ASSEM/HR
BWR: $\frac{2 \text{ ASSEM}}{4 \text{ HRS}}$ = 0.50 ASSEM/HR

RAIL
PWR: $\frac{12 \text{ ASSEM}}{14 \text{ HR}}$ = 0.857 ASSEM/HR
BWR: $\frac{32 \text{ ASSEM}}{34 \text{ HRS}}$ = 0.941 ASSEM/HR

NOTE: THE 1 ASSEMBLY/HR UNLOADING RATE IS CONSIDERED VERY CONSERVATIVE
TRUCK + RAIL MUST = ASSEM PROCESSING RATE
ON THIS BASIS THE FOLLOWING NUMBER OF UNLOADING PORTS IS RECOMMENDED:

PORT DESCRIPTION	NUMBER OF PORTS FOR 2000 MTU/YR	NUMBER OF PORTS FOR 4000 MTU/YR
TRUCK	1	1
RAIL	1	2
COMBINATION (CONTINGENCY)	1	1

SIGNATURE George VB Hall DATE 6 March 84 TRB NO. GH01 PAGE 10

RMP-307 (2/78)

RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE: CASK UNLOADING REQUIREMENTS FOR MRS R&H SHEET NO. 2 OF 2

JOB NO. DEPARTMENT AUTHOR: GEORGE VB HALL DATE: 1/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
								1/30/85

G.O. or CHARGE NO. SB1239-02-003 PROJECT MRS

SUBJECT: CASK UNLOADING REQUIREMENTS (SF) - SIGNED [illegible]

(PROJECT D-360) FEB 84, REV-1)

(REV 1, FEB '84) STATES 1800 MTU/yr will be 60% PWR/BWR SPLIT BY WEIGHT AND 0.462 MTU/PWR, 0.1986 MTU/BWR

RESULTING ASSEMBLY/HR THROUGHPUT REQUIRED AT 50% EFFICIENCY

PWR: $\frac{1800 \times .6}{.5 \times 462 \times 7 \times 52 \times 24 \times 360}$ = 0.535 ASSEM/HR 1.070

BWR: $\frac{1800 \times .4}{.5 \times .186 \times 7 \times 52 \times 24}$ = 0.886 ASSEM/HR 1.772

UNLOADING RATES (FROM P46)

	PWR	BWR
TRUCK	0.333	0.500
RAIL	0.857	0.941
TOTAL	1.290	1.441

IF UNLOADED @ ½ HI/ASSEM, the unloading rates are:

	PWR	BWR
TRUCK	0.400	0.667
RAIL	1.500	1.778
Σ	1.900	2.445

ALLOWABLE ASSEMBLY UNLOADING TIME TO ACHIEVE 3600 MTU RATE WITH BWR ASSEMS.

$$1.772 = \frac{2}{2+2x} + \frac{32}{2+32x}$$

$$1.772 = \frac{1}{1+x} + \frac{16}{1+16x}$$

$$1.772(1+17x+16x^2) = 1+16x+16+16x = 17+32x$$

$$1.772+30.12+28.352x^2 = 17+32x$$

$$28.352x^2 - 1.876x - 15.228 = 0$$

$$x^2 - 0.066x + .0011 = .537 + .0011$$

$$(x - .033)^2 = .532$$

$$x = 0.7669 \text{ HRS}$$

OR 46 MIN

SIGNATURE [signature] DATE 9/12/84 TRB NO. GHC1 PAGE 11

RMP-307 (2/78)

TITLE MRS Discharge Port Shadow Shield SHEET NO. 1 OF 3

JOB NO. DEPARTMENT AUTHOR George V B Hall DATE 1/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/30/85

G.O. or CHARGE NO. SB123904004 PROJECT MRS

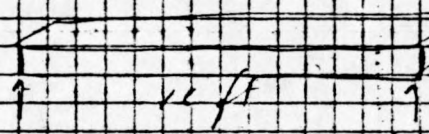
SUBJECT: R&H Bldg - Discharge Port Shadow Shield

Assume shield is 16 ft x 3 ft x 15" thick

check a gross weight when 3 ft dimension is vertical

$wt = (16 \times 3)12 \times 15 \times .26$

$wt = 26956^{\#}$ say $27000^{\#}$



$S = \frac{36 \times 15^2}{6} = 1350 \text{ in}^3$ (S1), $I = \frac{36 \times 15^3}{12} = 10125 \text{ in}^4$

$E = 13E6$ (page C2)

$\omega = 36 \times 15 \times .26 = 140.4 \#/\text{in}$

simple supports, uniform load:

see Roark, case 2e, p 100:

$a = 0$, $w_1 = w$

$M = \frac{wl^2}{8} = \frac{140.4 \times (16 \times 12)^2}{8} = 646943.2$

$\sigma = \frac{M}{S} = \frac{646943.2}{1350} = 479.2 \text{ psi}$

$y = \frac{5wl^4}{384EI} = \frac{5 \times 140.4 \times (16 \times 12)^4}{384 \times 13 \times 10^6 \times 10125} = 0.0189$

$\theta = \frac{wl^3}{24EI} = \frac{140.4 \times (16 \times 12)^3}{24 \times 13E6 \times 10125} = .00031 \text{ rad}$

cont →

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TITLE MRS Discharge Port Shadow Shield SHEET NO. 2 OF 3

JOB NO. DEPARTMENT AUTHOR George VB Hall DATE 1/23/85

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	4/30/85

G.O. or CHARGE NO. SB1239-04-004 PROJECT MRS / R&H Bldg

SUBJECT Discharge Port Shadow Shield

from p 29

FORCES ON PIVOTS

wt of shield: 27000# (see p29)

force from hydraulic actuator assume min req'd ✓

$\frac{27000}{4.6046} = 5865.7$ req 9550

for 2000 psi @ 2" ϕ F = 6283

2½ ϕ F = 9817

2 3/8 ϕ F = 8860

use 2½ ϕ & assume F = 9800

Arrange geometry as hydraulic cylinder shown in sketch, then $F_H = F_V = 9550$ and $F_S = 6750$

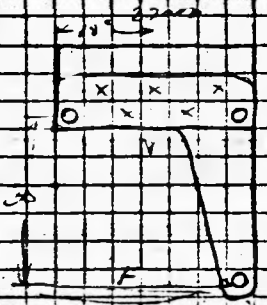
Reaction of forces (all) is 9550#

sign of pivot pin for $\tau = .5 \times 20000 = 10000$

and F.S. = 3

so $A = \frac{5 \times 9550}{10000} = 4.775$

$D = 2.465$ use 2.5 ϕ



$F = \frac{27000 \times 13}{22.75} = 8100$

effective: $P = \left[\left(\frac{27000}{2}\right)^2 + 8100^2\right]^{1/2}$

$P = 15743$ req 15750

for pivot design for τ 10000 F.S. = 5

$A = \frac{5 \times 15750}{10000} = 7.875$

so $D = 3.16$, use 3.25 ϕ

then $\tau_s = 9493$ psi, cont →

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RMP

THE RALPH M. PARSONS COMPANY

CALCULATION SHEET

TITLE MRS Discharge Port Shadow Shield SHEET NO. 3 OF 3

JOB NO. DEPARTMENT AUTHOR George VB Hall DATE 1/23/85

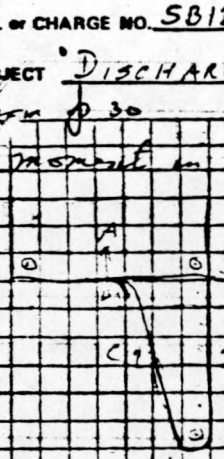
REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE
							[illegible]	1/30/85

G.O. or CHARGE NO. SB123704.004 PROJECT MRS / RH Bldg

SUBJECT Discharge Port Shadow Shield

from p 30

moment in link



at A-A : M = 8100 x 27.5 = 222750

for E = 5.5 ; S_b = 30000

$S = \frac{5 \times 222750}{30000} = 37.125$

for b = 2 h = 18.55 — 10.5

3 8.61

5 6.67

for h = 15 b = 0.99

at B-B :

M = 8100 x 22.5 = 182250

S = 30.375

for b = 1, h = 12.5 9.75

at C-C

M = 12.5 x 8100 = 101250

for b = 1, h = 10.65 7.92

at 7.5 h = 7.79 5.51

5.0 6.3

at 2.5 h = 4.79 2.18

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