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ENGINEERING DATA TRANSMITTAL

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1	SNF-5290	N/A	0	SNF Bounding Drop Support Calculations	Sn	1	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Rea-son	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Rea-son	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1		Design Authority Doug Chenault	[signature]	11-8-99	R3-86	3		J. Bazinet			S8-06
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18.	19.	20.	21. DOE APPROVAL (if required)
[signature] 11-8-99 Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	[signature] 11-8-99 Design Authority/ Cognizant Manager / Date	Ctrl No. ○ Approved ○ Approved w/comments ○ Disapproved w/comments

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SNF-5290, Rev. 0

SNF BOUNDING DROP SUPPORT CALCULATIONS

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Key Words: Drops, Impact Factor, Bounding, MCO, Cask, SNF

Abstract:
This report evaluates different drop heights, concrete and other impact media to which the transport package and/or the MCO is dropped. A prediction method is derived for estimating the resultant impact factor for determining the bounding drop case for the SNF Project.

Release Approval 11/16/99
Date

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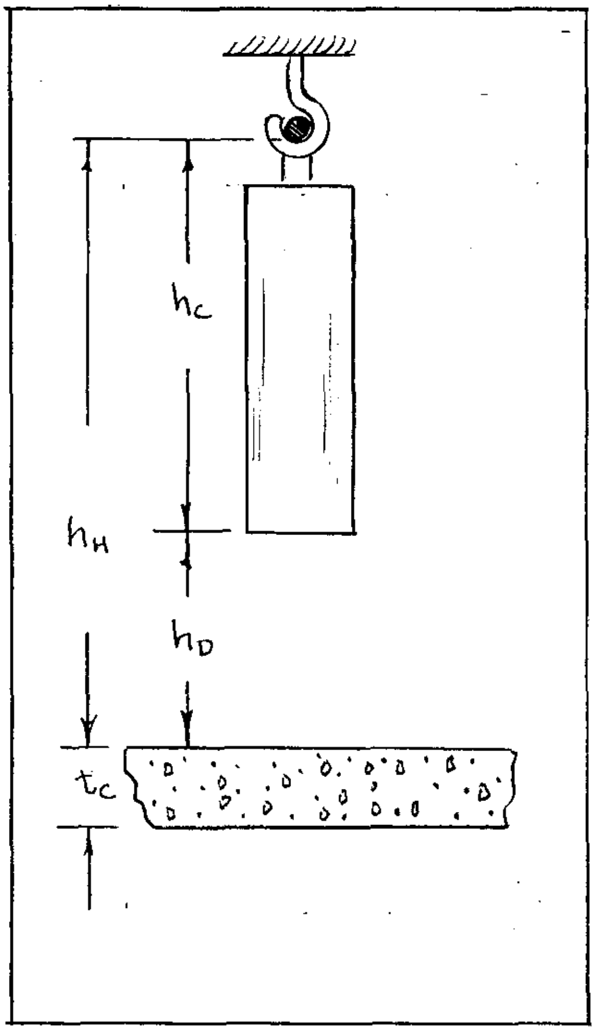
Approved For Public Release

Subject: Bounding Drop Determination
Originator Doug Chenault
Reviewer S.K. Farnworth

Date 11/08/99
Date 11/8/99



OBJECTIVE: Determine the bounding drop for the SNF Fuel Package utilizing the dynamic/non-linear drop analyses conducted to-date together with the height and impact media gathered by FDNW in Reference 4 below.

The desired solution is to conduct a drop comparison by static analytical means. References for the analytical comparisons are:

1. "Mechanics of Materials", E.P. Popov, Prentice Hall, 1952, page 400.
2. "Shock and Vibration Handbook", Cyril M. Harris, 3rd Ed., McGraw-Hill, 1988, page 41-3.
3. "Report of the ASCE Committee on Impactive and Impulsive Loads", Conference Paper, ASCE-Civil Engineering and Nuclear Power, Vol. V, 9/15/80, page 2-61
4. "Engineering Study for SNF Bounding Drop Assessment for Cask/MCO Transport Path Impact Media and Hook Height", Greg Lisle, FDNW, September, 1999.
5. "Formulas for Stress and Strain", R. J. Roark, 4th Ed., McGraw-Hill, 1965.

FIND: Determine the calculation ratios necessary to adjust the impact factors resulting from the drop of an object onto an impact media such as concrete from varying heights, varying impact media thicknesses , and varying impact media strengths. Note: In the following calculations, the soil stiffness under the concrete is assumed to be constant. The symbols as used herein are defined as:

$\approx$ is approximately equal to., $\doteq$ is proportional to, f is a function of.

Variables are: h_D = Drop Height (see Figure)
t_c = Impact Media Thickness
C_s = Impact Media Thickness
f'_c = Concrete Strength
IF = Unitless Factor for impact magnification on static forces or acceleration (g) when applied dynamically.

Per reference 1 and 2, (for drop heights large compared to the static deflection (Δ) resulting from the "dropped" body resting on the impact media, IF $\approx (2h/\Delta)^{1/2}$, IF = $f\ (h_D)^{1/2}$ as $IF_1 = IF_2\ (h_{D1}/h_{D2})^{1/2}$ {variation due to drop height}.

Per reference 3, $K = 180/(f'_c)^{1/2}$ and K is proportional to the penetration which is taken as equivalent to deflection or concrete displacement x or Δ as, where x is very small compared to the diameter of the dropped object.

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$x \doteq (K)^{1/2}$, therefore it can be shown that $x^2 \doteq (f'_c)^{-1/2}$ or $x \doteq (f'_c)^{-1/4}$. Since $IF \doteq (1/x)^{1/2}$ (Reference 1) then $IF \doteq (f'_c)^{1/4}$ and for comparison to two impact media, $IF_1 \doteq IF_2\,(f'_{c1}{}^{1/4}/f'_{c2}{}^{1/4})^{1/2}$ or $IF_1 \doteq IF_2\,(f'_{c1}/f'_{c2})^{1/8}$ {variation due to concrete strength when concrete is the impact media}.

Note: The symbols as used herein are defined as:

$\approx$ is approximately equal to., $\doteq$ is proportional to, f is a function of.

Concrete stiffness (C_s) and concrete thickness are proportional and can be treated as one variable. Since a concrete slab acts in general as a circular plate supported by soil (i.e. uniform pressure over lower surface), then the displacement (x) from a load acting on the slab varies as $1/t_c^3$. (Reference 5).
This is treating the impact factor, IF, as a function of displacement which is a function of the thickness cubed in a slab bending situation. Thus since $IF \doteq (1/x)^{1/2}$, it can be shown that $IF \doteq t^{3/2}$, therefore $IF_1 \doteq IF_2\,(t_1/t_2)^{3/2}$.

As derived above, the following conclusions can be made for simplicity.
..thicker media = larger impact g's.
..stronger media = larger g's.
..higher drop = larger g's.
And in summary, combining all factors assuming equal contribution:

$IF_1 = IF_2\,(h_{D1}/h_{D2})^{1/2}\,(f'_{c1}/f'_{c2})^{1/8}\,(t_1/t_2)^{3/2}$ --------------------BOUNDING EQUATION-----------------------------

As an example, the analyses reported in the Safety Analysis for Packaging, HNF-SD-TP-SARP-017, Rev. 0 for a 30 foot drop onto 8 inches of 4000 psi. concrete yielded a drop acceleration impact of 27 g's. Use this as a base to compare to the maximum drops in the K-Basin from reference 4.

Drop height at Rail Car Foundation....19 ft. 6 in. less height of cask (181.75 inches per TN Dwg. 3035-3, Rev. 7) = 52.25 inches = 4.35 ft.
Thickness of 3750 psi concrete is 15 inches.

$IF_1 = 27(4.35/30)^{1/2} = 0.381\,(27)$ or height change only yields 10.3 g's
$IF_1 = 27(15/8)^{3/2} = 2.57(27)$ or concrete thickness change only yields 69 g's
$IF_1 = 27(3750/4000)^{1/8} = 0.992\,(27)$ or concrete strength change only yields 26.8 g's

Total effect to give the equivalent impact factor or equivalent g's at the K-Basins is: 27 x0.381 x 0.992 x 2.57 = 26.2 g's, this g level is acceptable per the MCO Performance Specification (HNF-SD-0426).

The other K-Basin drops that have a potential for higher g levels are shown in Table 1.

The above base drop case will be compared to the drop case analysed for the CSB and then utilized for the other potential drop cases at the CSB. From this a bounding drop case will result.

The following check of the above 30 foot drop base case as compared to the calculated forty inch vertical drop at the CSB follows. The CSB forty inch drop case was analysed through the use of Abaqus by Carleton Moore of FDNW and filed as HNF-3243 and titled, "Detailed Simulation of Cask and Multi-Canister Overpack Vertical Drop onto the Canister Storage Building Receiving Area Floor". The drop and its parameters are: drop height is forty (40) inches, concrete thickness is 60 inches, concrete strength is 9000 psi. Per Abaqus, the resulting g value or equivlent impact factor was 210 g's.

$\underline{IF_{40"} = IF_{30'}\,(40/30x12)^{1/2}\,(9000/4000)^{1/8}\,(60/8)^{3/2} = 205}$, thus 205 compares very closely to 210 predicted by Abaqus. Note: The resulting 210 g's occured at the MCO center.

This baseline CSB package drop case which gave an impact of 210 g's deceleration will be used for comparison to the other possible drop conditions. From this, a bounding drop should evolve.

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All possible package drop scenarios are listed in Table 1 and were taken from Reference 4. The package is the cask and MCO together as a unit.

TABLE 1

CASK/MCO (PACKAGE)BOUNDING MEDIA LOCATIONS AND PARAMETERS

Location	Thickness t_c	f'_c	Drop Height h_D	$(h_{D1}/h_{D2})^{1/2}$ or (A)	$(f_{c1}/f_{c2})^{1/8}$ or (B)	$(t_1/t_2)^{3/2}$ or (C)	IF = 210(A)(B)(C)
CSB Baseline	60"	9000 psi	40"	1	1	1	210
K-Basin Loadout Pit	21"	3750 psi	361.25"	3.0	0.896	0.207	117
K-Basin Slab-on-Grade	12"	3750 psi	52.25"	1.14	0.896	0.089	19
K-Basin L.O. Pit Wall	17.75"	3750 psi	16.25"	0.637	0.896	0.161	19
*K-Basin Rail Car Fndation	15"	3750 psi	52.25"	1.14	0.896	0.125	26.8
CSB Slab to Receiving Pit	60"	8712 psi. maximum	142.25"	1.88	0.996	1.0	393 <u>Bounding Case</u>
CSB Receiving Pit	18"	4800 psi.	365.25"				Case not applicable as an Impact Limiter is in place
CSB Slab to Receiving Pit limiting case @ 60" Drop	60"	8712 psi maximum	60"	1.22	0.996	1.0	256 Note: This case was added to give crane operation margin over the 40 inch lift (not per Ref. 4)

*The rail car foundation drop case in the table is similar to the example shown earlier in the text except the Table 1 case compares to the CSB baseline 40 inch drop case whereas the previous example compared to the transportation case of a thirty (30) foot drop. Both comparisons yielded the same answer which shows the bounding equation has merit.
Note: The drop height is the hook height less the cask length of 181.75 inches.

The following is an assessment for drop of the MCO alone without the transportation cask. The baseline comparative case is the analysis titled "MCO Vertical 2 ft. Drop with Five Light Baskets" which is Section 16 of analysis report by FDNW filed under Kaiser Memo ECS-W-96-1620 for W.O. E50470/P6X900. The analysis report by Carleton Moore On 2/14/96 is titled "Transportation Cask Operational and Accident Drop Analyses". Of note, is that this analyses was conducted when the FDNW analysts were using a large soil stiffness which was later lowered after consultation with the WMNW analysts. The higher soil stiffness in the above analysis gives an impact factor IF of 54. Calculations by the packaging organization in the referenced SARP show that these IF levels go to 27 to 33.5 with a lesser stiffness. What this means is that the IF resulting from the soil stiffness effect is conservative by a factor of approximately two.
The baseline MCO drop case gave 54 g's for a drop height of 24 inches onto 8 inches of 4000 psi concrete.
All possible MCO drop scenarios are listed in Table 2 and were taken from reference 4.

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TABLE 2

MCO BOUNDING MEDIA LOCATIONS, PARAMETERS AND IMPACT FACTOR

Location	Thickness t_c	f'_c	Drop Height h_D	$(h_{D1}/h_{D2})^{1/2}$ or (A)	$(f_{c1}/f_{c2})^{1/8}$ or (B)	$(t_1/t_2)^{3/2}$ or (C)	IF = 54(A)(B)(C)
MCO Baseline, 2' Drop	8"	4000 psi	24"	1	1	1	54
Receiving Pit @ CSB	18"	4800 psi maximum	293.125"				Covered by Concentric Drop Analysis (SNF-5276)
Slab around Pit	60"	8712 psi maximum	70.125"	1.709	1.102	20.5	2085
CSB Operating Area	60"	8965 psi maximum	70.125"	1.709	1.106	20.5	2092
Slab @ Vault Floor	68"	7000 psi maximum	574.125"				Impact limiter in Storage Tube PacTec TR-003 Report
Slab @ Weld Station	60"	9064 psi maximum	70.125"	1.709	1.108	20.5	2096 Bounds
Weld Station Pit @ Recessed Area	24"	4800 psi maximum	121.125"				Drop similar to eccentric drop on storage tube,glancing blow low strain, and impact limiter
Weld Station Pit	24"	4800 psi maximum	306.125"				Impact Limiter used PacTec Report TR-003
Drop onto Turret not per ref.4, see attach-ment	11"	steel	18.5"				320 Refer to attached Turret analysis

The maximum concrete compressive strength was used to be conservative.
Note: The drop height is the hook height less the MCO length from the bottom of the lift ring or $h_H - 158.875" = h_D$. Reference Dwg. H-2-82804 and 042.

CONCLUSION:

The bounding drop for the SNF Fuel Package utilizing the dynamic/non-linear drop analyses conducted to date together with the height and impact media gathered by FDNW in the preceding report is the 142.25 inch drop onto 60 inches of concrete in the CSB. However, a drop of this height will not be permitted (i.e., will be prevented) and therefore, the 40 inch drop onto the 60 inch concrete becomes the bounding drop for the work presented.

ATTACHMENT 1

MCO Drop onto MHM Turret

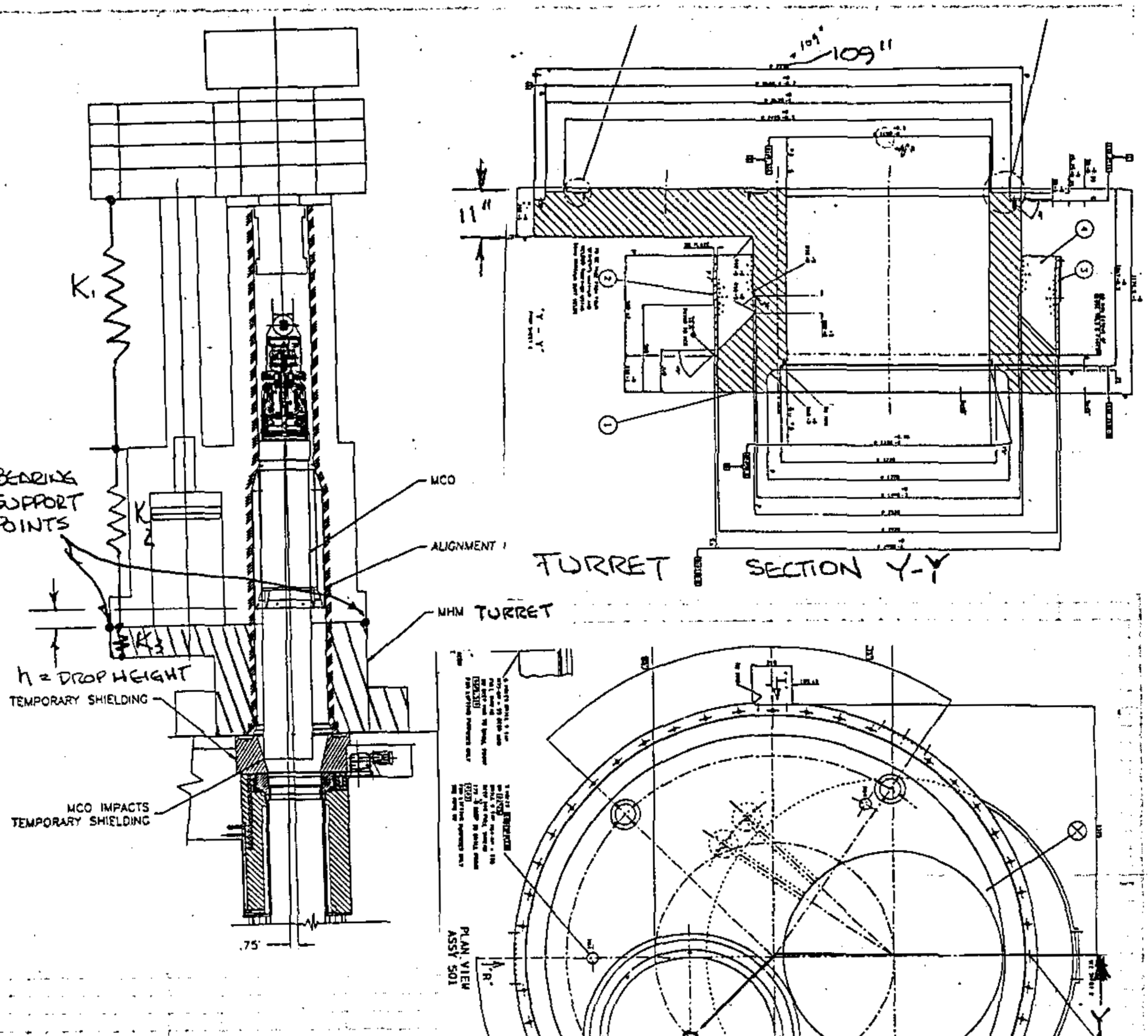
ANALYTICAL CALCULATIONS

Page 1 of ____

Subject: MCO Drop onto MHM Turret

Originator: Doug Chenault   Date: 10/27/99

Checker: ____   Date: ____



OBJECTIVE: FIND THE IMPACT FACTOR FOR THE MCO DROPPING A HEIGHT "h" ONTO THE ROTATING MHM TURRET.

ANALYTICAL CALCULATIONS

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Subject MCO Drop onto MHM Turret

Originator Doug Chenault Date 10/27/99

Checker Date

FIND: THE SPRINGRATE OF THE MHM WHICH AFFECTS THE IMPACT LOADS ON THE MCO IF DROPPED ONTO THE TURRET PLATE.

CRAIG SWENSON AND I ARE PURSUING A TURRET AXIAL STIFFNESS FROM THE VENDOR, BUT THIS ANALYSIS WILL GO FORTH WITH CONSERVATIVE ASSUMPTIONS.

THE STIFFNESS OF THE MHM CAN BE REPRESENTED BY A SET OF SERIES SPRINGS K_1, K_2 & K_3 AS DENOTED ON PAGE 1.

$$\frac{1}{K_{TOT}} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} \quad \text{OR} \quad \frac{1}{K_{TOT}} = \sum \frac{1}{K_N}$$

THUS THE STIFFEST SPRING IN A STACK GOVERNS AND ANY LESS STIFF SPRINGS WILL ONLY LOWER THE EFFECTIVE TOTAL SPRINGRATE. ALSO IF THE CHOSEN SPRING IS THE WEAKEST IN THE STACK, THE EFFECTIVE TOTAL SPRINGRATE WILL NEVER EXCEED ITS VALUE.

EXAMPLES: LET $K_1 = 50{,}000$
$K_2 = 30{,}000$ $K_{TOT} = 15{,}800$ ∴ $K_3 = 100{,}000$ IS CONSERVATIVE TO USE
$K_3 = 100{,}000$

OR $K_1 = 50{,}000$
$K_2 = 100{,}000$ $K_{TOT} = 15{,}800 < K_3$ (THE WEAKEST)
$K_3 = 30{,}000$ ∴ 30,000 IS CONSERVATIVE TO USE.

THIS FACT ALLOWS ONE TO WORK WITH ONLY THE TURRET STIFFNESS SINCE THE OVERALL ASSEMBLY STIFFNESS IS UNKNOWN AT THIS TIME DUE TO THE PROPRIETARY NATURE AND EFFECT OF THE TURRET SLEW BEARING.

ANALYSING THE TURRET AS A FLAT PLATE FIXED AT THE BEARING WITH A CENTRAL APPLIED LOAD OF 20,000 lbs (MCO WEIGHT) GIVES A DEFLECTION OF 0.00033 IN.

ANALYSIS OF THE TURRET ON A FINITE ELEMENT PROGRAM WITH THE LOAD APPLIED AT POINT GIVES:
$\Delta = 0.00033$ inches (CORRELATES TO ABOVE)
$\Delta = 0.00036$ inches, WITH HOLE FOR MCO RELEASE ACCOUNTED FOR.

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ANALYTICAL CALCULATIONS

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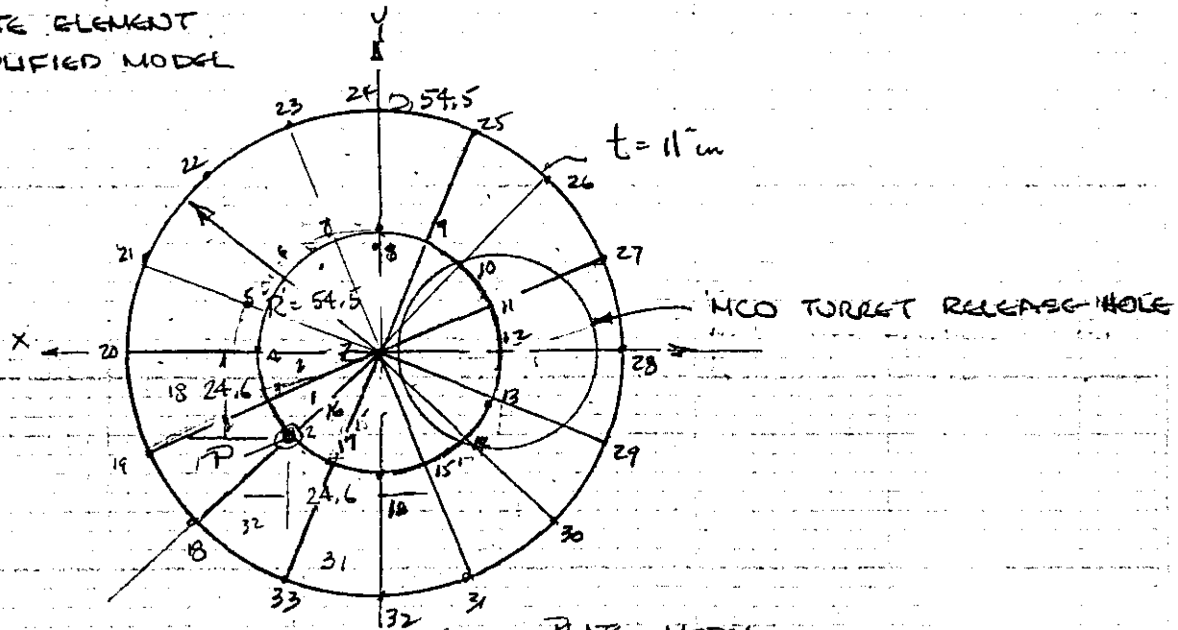
Subject: MCO Drop onto MHM Turret
Originator: Doug Chenault Date: 10/26/99
Checker: Date:

FINITE ELEMENT SIMPLIFIED MODEL



BY MAKING ELEMENTS 1, 2, 15, 16, 17, 18, 31, 32 WITH LOW MODULUS, ONE CAN SIMULATE THE TURRET HOLE.

WITHOUT THE HOLE, THE STATIC DEFLECTION IS 0.00033 in/20,000 lbs

1	2 3 1	1 11
2	3 4 1	1 11
15	16 17 1	1 11
16	17 2 1	
17	18 19	3 2
18	19 20	4 3
31	32 33	17 16
32	33 18	2 17

Put load at node 10 for case simulating hole (mirror image)

THE ANALYSIS SHOWS THAT THE HOLE EFFECT IS SMALL — $\Delta_{ST} = .00036$

ASSUMING THAT THE TURRET PLATE CONTROLS THE STIFFNESS, IE SERIES SPRINGS INCLUDING THE CYLINDER ETC. CAN ONLY LOWER THE STIFFNESS AND SOFTEN THE IMPACT.

PER FDNW REPORT ON BOUNDING HTS, THE MCO HOOK (TWO-BLOCK HEIGHT) IS 19'1 in. WHICH CORRESPONDS TO A 70.2 in drop to the floor, OR A DROP OF 70.2 - 55.16 = 15.04 in.

$$I.F \sim \sqrt{\frac{2h}{\Delta_{ST}}} = \sqrt{\frac{2(15)}{.00036}} = 289$$

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IF USING THE CSB PRINT (H-2-828859), the DROP HT = 18.5" OR IF = 320
(BASED ON STOP SLEEVE CONTACT)

19' 1" = 229
MCO = 160 } 69 in.

ANALYTICAL CALCULATIONS

Subject: MCO Drop onto MHM Turret

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Checker: ____   Date: ____

THUS THE RESULTING IMPACT FACTOR IS 290 to 320 OR IN TERMS OF ACCELERATION, ABOUT THAT MANY G'S. (THIS WOULD BE LOWER IF THE TOTAL MHM SPRINGRATE WERE KNOWN) FROM THE PREVIOUS WORK ON BOUNDING DROPS,

A DROP OF THE CASK ONTO THE CSB RECEIVING AREA CONCRETE FROM 40 inches YIELDED 210 g's.

A FULL DROP HEIGHT OF 142 1/4 inches w/o Height LIMITERS GAVE 393 g's, & THUS WOULD STILL BE THE BOUNDING DROP.

IF LIMITED TO 60 IN, THE IMPACT FACTOR FOR THE CASK DROP IS:

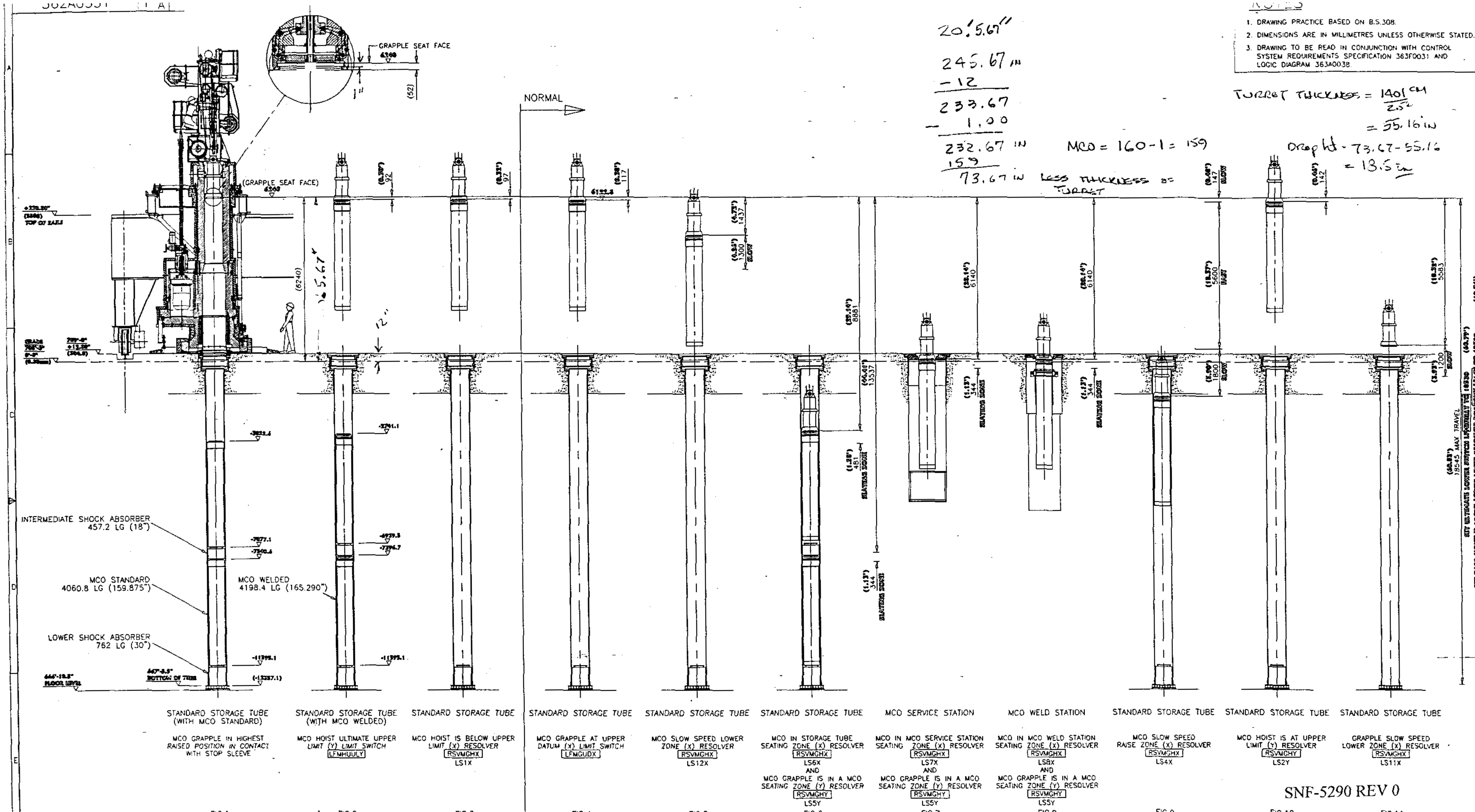
$$I_{F_2} = I_{F_1}\sqrt{\frac{h_2}{h_1}} = 210\sqrt{\frac{60}{40}} \cong 260$$

THUS THE MCO DROP ONTO THE TURRET AND THE CASK DROP ONTO THE CSB RECEIVING AREA FLOOR ARE ESSENTIALLY EQUIVALENT.

THE STUDY BY WMNW USING COMPARISONS TO EPRI DATA SHOW THAT THE 60 INCH CASK DROPS ARE YIELDING IMPACT FACTORS OF:

VERTICAL DROP = 280
HORIZONTAL DROP = 290

AGAIN SHOWING EQUIVALENCY TO THE MCO TO TURRET DROP DONE CONSERVATIVELY.



NOTES

1. DRAWING PRACTICE BASED ON B.S.308.
2. DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE STATED.
3. DRAWING TO BE READ IN CONJUNCTION WITH CONTROL SYSTEM REQUIREMENTS SPECIFICATION 363F0031 AND LOGIC DIAGRAM 363A0038.

20'5.67"
245.67 in
−12
233.67
− 1.00
232.67 in
159
73.67 in less thickness of turret

MCO = 160 − 1 = 159

Turret thickness = 1401 cm / 2.54 = 55.16 in
Drop ht − 73.67 − 55.16 = 13.5 in

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FDNW values for drop height
Two block height per report = 19'1" = 229"
Less MCO height to bottom of lift ring = 158.9 } 70.1
Less turret thickness of 55.16 in = ~15 in

U.S. DEPARTMENT OF ENERGY
WESTINGHOUSE HANFORD COMPANY
MDK-SDX-452456
WHC-S-0468

H-2-828859

ALSTOM Automation Ltd.
Whetstone, Leicester, LE8 6LH, England

THIRD ANGLE PROJECTION
DO NOT SCALE. IF IN DOUBT − ASK
DOCUMENT CHANGE CONTROL
CODES APPLY AS COMBINATION OF FOLLOWING :-
REVIEW R NONE REQUIRED N
VERIFICATION V CURRENT DOCUMENT
SUBMISSION S CONTROL RS

F&WM | 4683 HANFORD MHM
1:50 | MCO HANDLING M/C | MCO HOIST
DW 21/09/98 | HOIST LEVELS
AM ML
22/09/98 | 362A0531 | 1 | A

PAST RELEASES | ISSUE

MODIFICATIONS TO THIS DRAWING MUST BE MADE USING THE AUTOCAD CAD SYSTEM
SIZE 'A0' 841 x 1189mm
WHEN QUOTING THE DRAWING NUMBER PLEASE STATE LATEST LETTER OF ISSUE
DRAWING TYPE COMPUTER CODE : 8

10

ATTACHMENT 2

ENGINEERING STUDY FOR SNF BOUNDING DROP ASSESSMENT FOR CASK/MCO TRANSPORT PATH IMPACT MEDIA AND HOOK HEIGHT

ENGINEERING STUDY FOR SNF BOUNDING DROP ASSESSMENT FOR CASK/MCO TRANSPORT PATH IMPACT MEDIA AND HOOK HEIGHT

Prepared By [signature] 11/3/99 Date

Checked By [signature] 11/03/99 Date

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PURPOSE

The purpose of this bounding drop study is to gather information for Spent Nuclear Fuel (SNF) on packaged fuels associated with a loaded Cask/MCO or loaded MCO only (See attached Statement of Work). The study gathers information about impact media, maximum design hook height, and two-block hook height for the lifting cranes along the travel paths of the cask and MCO. The travel paths covered in this study include the travel path from the load-out pit to the transport system trailer at K-Basin, from the transport system trailer to the receiving pit at the Canister Storage Building (CSB), and from the receiving pit to the storage tubes and welding stations at the CSB. The study will assist the design organization in preparing the worst case (bounding) drop at all locations or at each facility. This information was requested by the DOE safety report reviewers.

SUMMARY AND CONCLUSIONS

The following tables are the results from the information gathering. References for the results are indicated within the Input Data section of this report. The maximum hook height is measured from the bowl of the hook, which is the point on the hook that is in contact with the lifting bail of the item being lifted.

Impact Media/Hook Heights
K-Basin (KW)

Area	Impact Media	Thickness	Compressive Strength	Rebars	Maximum Design Hook Height Above Impact Media	Two-Block Hook Height Above Impact Media
Load-Out Pit	Concrete	1'-9"	3750* psi	#7's @12" O.C. E.W.E.F.	45'-9"	51'-6"
Slab-On-Grade Column Line 13-15 & D-F	Concrete	1'0"	3750* psi	#3's @12" Centered	20'-0"	25'-9"
Load-Out Pit Wall	Concrete	1'-5 ¾"	3750* psi	#5 Vert. @12" O.C. #5 Hor. @ 12"O.C.I.F. #6 Hor. @ 12"O.C.O.F.	18'-0"	23'-9"
Top of Rail Rail Car Foundation (See Note 1)	Concrete	1'-3"	3750* psi	#5's @12" Parallel to Rails E.F. #4's @12" Perp. To Rails E.F.	20'-0"	25'-9"

Note 1: Rail car foundation has two 90 ARAA rails.

* indicates a concrete compressive strength based on the minimum 28 day design compressive strength with the 25% increase

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Impact Media/Hook Heights
Shipping and Receiving Area
CSB

Area	Impact Media	Thick	Min Comp. Strength	Max Comp. Strength	Avg Comp. Strength	Rebars	Maximum Design Hook Height Above Impact Media	Two-Block Hook Height Above Impact Media
Slab-On-Grade	Conc.	5'-0"	See Note 1	8712** psi	See Note 1	#11's @ 6" O.C. E.W.E.F.	27'-0"	28'-0"
Receiving Pit	Conc.	1'-6"	N/A	N/A	4800* psi	#7's @ 8" O.C. E.W.E.F.	45'-7"	46'-7"

Note 1: Test data available for only one test cylinder. Results are listed as Max Comp. Strength

* indicates a concrete compressive strength based on the minimum 28 day design compressive strength with the 20% increase

** indicates a concrete compressive strength based on actual 90 compressive test results with the 10% increase

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Impact Media/Hook Heights
MCO Handling Machine (MHM)
CSB

Area	Impact Media	Thick	Min Comp. Strength	Max Comp. Strength	Avg Comp. Strength	Rebars	Max Design Grapple Height Above Impact Media	Two-Block Grapple Height Above Impact Media
Receiving Pit	Conc.	1'-6"	N/A	4800* psi	N/A	#7's @ 8" O.C. E.W.E.F.	37'-8"	37'-8
Slab-On-Grade Around Receiving Pit Column Lines 1-2 & A.1-E.9	Conc.	5'-0"	See Note 1	8712** psi	See Note 1	#11's @ 6" O.C. E.W.E.F.	19'-1"	19'-1"
Canister Storage Operating Area Column Lines 2-5.5 & A.1-E.9	Conc.	5'-0"	5830** psi	8965** psi	7755** psi	#11's & #14's	19'-1"	19'-1"
Slab-On-Grade Vault Floors	Conc.	5'-8"	5200*** psi	7000*** psi	6317*** psi	#11's @ 9" O.C. E.W. Top Mat #11's @ 6" O.C. E.W. Bot Mat	61'-1"	61'-1"
Slab-On-Grade Around Welding Station Column Lines 6-7 & A.1-E.9	Conc.	5'-0"	7392** psi	9064** psi	8228** psi	#11's @ 6" O.C. E.W.E.F.	19'-1"	19'-1"
Slab-On-Grade Recessed Area Welding Station Column Lines 6-7 & A.5-D	Conc.	2'-0"	N/A	4800* psi	N/A	#11's @ 6" O.C. E.W. Top Mat #11's @ 6" O.C. O.W. Bot Mat	23'-4"	23'-4"
Slab-On-Grade Recessed Area Welding Station Column Lines 6-7 & A.5-D	Conc.	2'-0"	N/A	4800* psi	N/A	#7's @ 8" O.C. E.W.E.F.	38'-9"	38'-9"

Note 1: Test data available for only one test cylinder. Results are listed as Max Comp. Strength

* indicates a concrete compressive strength based on the minimum 28 day design compressive strength with the 20% increase

** indicates a concrete compressive strength based on actual 90 compressive test results with the 10% increase

*** Indicates a concrete compressive strength determined by a Windsor probe

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ASSUMPTIONS

The following assumptions have been made regarding the concrete strengths:

1) Due to the age of the concrete at the CSB, approximately 2-3 years old (this does not apply to the vault floors which are approximately 7 years old), concrete strengths are assumed to be as follows:

   - 10% greater than the minimum 90 day design compressive strength or actual 90 day compressive strength as determined from test cylinders when test data was available.

   - 20% greater than the minimum 28 day design compressive strength or actual 28 day compressive strength as determined from test cylinders when test data was available.

2) Where concrete strengths are not based on actual compressive testing or Windsor probe evaluation, the minimum design strength obtained from the design drawings and specifications was used.

3) Due to the age of the concrete at K-Basin, approximately 45 years old, concrete strengths are assumed to be 25% greater than the minimum 28 day design compressive strength.

The following assumptions have been made regarding the hook heights:

1) The maximum design height for the hooks is the hook height at the first limit switch.

2) The two-block height for the hook is the hook height at which the hoist hook becomes physically blocked from going any higher.

INPUT DATA

K-Basin (KW)

The Cask/MCO will be located in the load-out pit (Pit No. 2) prior to being moved to the transport system trailer. The load-out pit is located in the northwest corner of 105K Facility, between Column Lines 13 and 14 and Column Lines D and E (Ref. 1). The crane that will lift the Cask/MCO from the load-out pit to the transport system trailer is an overhead bridge crane. The trolley assembly on the bridge structure is a 32/3 ton trolley hoist from Ederer Cranes (Ref. 20, 21). The Cask/MCO will be lifted with the 32 ton capacity hoist. The bridge structure spans between Column Lines 13 and 15 and allows the crane to transport the Cask/MCO to the travel system trailer. The travel system trailer will be located between Column Lines E and F and nearly in line with Column Line 14.

All the concrete at the 105K Facility along the travel path between Column Lines 13 and 15 and Column Lines D and F has a minimum 28 day design compressive strength of 3000 psi (Ref. 16). The reinforcing bars are ASTM A-15-50T, Intermediate Grade, which corresponds to Grade 40 (Ref. 15). The concrete was poured over 40 years ago. Although the actual strength of the concrete is unknown, the age of the concrete would give it a strength 20-25% greater than the actual 28 day compressive strength.

The impact media in the floor of the load-out pit is a reinforced concrete foundation pad cast against the soil. The foundation pad is 1'-9" thick with #7 reinforcing bars at 12" on center each way each face. The top of the foundation pad has a reference elevation of (-) 25'-9" (Ref. 1).

The impact media along the travel path between Column Lines 13 and 15 and from Column Lines D to F is a reinforced concrete slab on grade. The slab between Column Line D and E is 1'-0" thick with #3 reinforcing bars at 12" on center each way centered in the slab. The top of the slab has a reference elevation of 0'-0". The load-out pit walls extend 2'-0" above the slab. The maximum thickness of the load-out pit walls above the slab is 1'-5 ¾". The reinforcing steel varies with #5 vertical reinforcing bars at 12" on center each face and #5 horizontal reinforcing bars at 12" on center inside face and #6 horizontal reinforcing bars at 12" on center outside face (Ref. 1).

A portion of the area between Column Lines E and F, where the transport system trailer will be setting, was designed as a reinforced concrete rail car foundation. The rail car foundation is isolated from the surrounding slab by expansion joints. The rail car foundation is 1'-3" thick with #5 reinforcing bars at 12" on center running parallel to the rails and #4 reinforcing bars at 12" on center running perpendicular to the rails. The rails were specified as 90 ARAA. The top of the rail on the rail car foundation has a reference elevation of 0'-0" (Ref. 2).

The top of the trolley rail on the bridge crane has a reference elevation of 29'-11". The hook on the 32 ton capacity hoist has a height to within 10'-5" below the top of the trolley rail according to Reference 20. After installation, the hook height was raised 6 inches (Leonard Rodgers, K-Basin Area Engineer). The maximum design height of the hook on the 32 ton capacity hoist above the top of the foundation pad at the bottom of the load-out pit is 45'-9". The maximum height of the hook on the 32 ton capacity hoist above the top of the slab on grade and the rail car foundation is 20'-0".

The most conservative two-block condition for the 32 ton capacity hoist will occur when the main block has been lifted to the point where the load cell starts to become wedged in the main block sheave. Wedging of the load cell will cause the hook to rotate almost horizontally. This two-block condition will give the lifting point on the hook a reference elevation of 25'-8 ¼". The two-block hook height for the 32 ton capacity hoist is 5'-8 ¼" higher than the design height for the hook. Information about the two-block condition for the hoist was obtained from Leonard Rodgers, K-Basin Area Engineer.

Canister Storage Building (CSB)

The transport system trailer enters the CSB through a roll up door at the northwest corner of the building between Column Lines 1.2 and 1.8 (Ref. 8). The transport system trailer will back into the CSB and position the Cask/MCO between Column Lines AA.3 and A.1. The crane that will lift the Cask/MCO from the transport system trailer is an American Crane and Equipment Corporation (ACECO) 60/10 ton double girder crane (Ref 17). The Cask/MCO will be lifted with the 60 ton capacity hoist. The crane runs on an on-grade rail system that runs parallel with Column Line 1.2 and allows the crane to transport the Cask/MCO to the receiving pit in the floor of the CSB. The receiving pit is located between Column Lines 1.2 and 1.8 and nearly in line with Column Line B (Ref. 8).

The impact media along the travel path between Column Lines 1.2 and 1.8 and from Column Lines AA.3 to B is a reinforced concrete slab on grade. The slab is 5'-0" thick with #11 reinforcing bars at 6" on center each way each face. . The following 90 day compressive strength is based on 1 concrete test cylinder. The 90 day compressive strength was 7920 psi. There was only one test result available for the 90 day compressive strength test. The reinforcing bars are ASTM A615 Grade 60. The top of the slab on grade has a reference elevation of 709'-0" (Ref. 3, 9, 10).

The impact media at the bottom of the receiving pit is a reinforced concrete foundation pad cast against the soil. The foundation pad is 1'-6" thick with #7 reinforcing bars at 8" on center each way each face. The concrete has a minimum 28 day design strength of 4000 psi. The reinforcing bars are ASTM A615 Grade 60. The top of the foundation pad has a reference elevation of 690'-5" (Ref. 3, 11, 12).

The top of the trolley rail of the ACECO 60/10 ton double girder crane has a reference elevation of 740'-9" (Ref. 17). The hook on the 60 ton capacity hoist has a maximum design height to within 4'-9" below the top of the trolley rail for a reference elevation of 736'-0". The maximum design height of the hook on the 60 ton capacity hoist is 27'-0" above the top of the floor slab between Column Lines 1.2 and 1.8 and from Column Lines AA.3 to B. The maximum design height of the hook on the 60 ton capacity hoist is 45'-7" above the top of the foundation pad at the bottom of the receiving pit.

The two-block condition for the 60 ton capacity hoist will occur when the main block has been lifted to the point where the main block is in contact with a structural I-beam located beneath the main hoist. Dimensional location for this I-beam is not available from the ACECO drawings. ACECO was contacted to obtain the reference elevation of the bottom of the I-beam. The reference elevation of the bottom of the said I-beam is 741'-10 ½".

The lifting point on the hook of the main block is located 4'-10 ½" below the top of the block. The reference elevation for the hook on the 60 ton capacity hoist in the two-block condition is 737'-0". The two-block hook height for the 60 ton capacity hoist is 1 foot higher than the design height for the hook (Ref. 18, 19).

MCO Handling Machine (MHM)

The MHM is a large specialized bridge type crane located within the CSB. The MHM runs on a set of on-grade rails and spans nearly 127 feet. The MHM was designed by GEC Alsthom Engineering Systems LTD out of England (Ref. 21). The turret assembly on the MHM picks the Cask/MCO with a set of grapple hooks. The turret assembly traverses the bridge of the crane on a trolley system. With the large span of the bridge and the rail system, the MHM has the ability to transport the CASK/MCO over a large area between Column Lines 1 and 7 and Column Lines A.1 and E.9 (Ref. 4, 8, 13).

The impact media beneath the Cask/MCO while being transported by the MHM is reinforced concrete. Since the MHM has such a wide range of coverage, there are several different thickness and strength designs as well as maximum MHM grapple hook heights above the media. The Cask/MCO will be setting in the receiving pit when the MHM grabs the Cask/MCO and transports it over the canister storage operating area or to the welding stations.

The receiving pit is located between Column Lines 1.2 and 1.8 and nearly in line with Column Line B. The impact media at the bottom of the receiving pit is a concrete foundation pad cast against the soil. The foundation pad is 1'-6" thick with #7 reinforcing bars at 8" on center each way each face. The concrete has a minimum 28 day design strength of 4000 psi. The reinforcing bars are ASTM A615 Grade 60. The top of the foundation pad has a reference elevation of 690'-5" (Ref. 3, 12).

The canister storage operating area encompasses the area over the vaults between Column Lines 2 and 5.5 and Column Lines A.1 and E.9. The impact media of the canister storage operating area is reinforced concrete. The floor of the canister storage area is basically the roof to the vaults below. Concrete beams are 5'-0" thick with varying widths and span the short distance between the individual vault walls. Concrete was placed around all the access hatches to the vaults at the same time the beams were poured to give the appearance of a slab. The following 90 day compressive strengths are based on 76 concrete test cylinders. The concrete has a minimum 90 day compressive strength of 5300 psi and a maximum 90 day compressive strength of 8150 psi. The average 90 day compressive strength is 7050 psi. The reinforcing bars vary from #11's and #14's depending on the beam section. All the reinforcing bars are ASTM A615 Grade 60. The surface of the canister storage operating area is cambered upward 1 inch over each vault. The low point on the top of the canister storage operating area has a reference elevation of 709'-0" (Ref. 3, 4, 6).

The floor of the vaults is located beneath the canister storage operating area between Column Lines 2 and 5.5 and Column Lines A.1 and E.9. The impact media of the vault floors is a reinforced concrete slab on grade. The slab is 5'-8" thick with #11 reinforcing bars at 9" on center each way in the top mat and #11 reinforcing bars at 6" on center each way in the bottom mat. The following compressive strengths were determined by 12 Windsor probe evaluations. The minimum compressive strength is 5200 psi and the maximum compressive strength is 7000 psi. The average compressive strength is 6317 psi The reinforcing bars are ASTM A615 Grade 60. The top of the vault floors have a reference elevation of 667'-0" (Ref. 3, 5, 7).

The welding stations are located between Column Lines 6 and 7 and between Column Lines A.5 and D. The impact media around the top of the welding stations is a reinforced concrete slab on grade. The slab is 5'-0" thick with #11 reinforcing bars at 6" on center each way each face. The following 90 day compressive strengths are based on 2 concrete test cylinders. The concrete has a minimum 90 day compressive strength of 6720 psi and a maximum 90 day compressive strength of 8240 psi. The average 90 day compressive strength is 7480 psi. The reinforcing bars are ASTM A615 Grade 60. The top of the slab on grade has a reference elevation of 709'-0" (Ref. 3, 13, 14).

A welding station has several recessed areas from the top of the slab. The impact media for one of the recessed areas is a reinforced concrete slab on grade that is a monolithic extension of the slab surrounding the welding station. The recessed slab is 2'-0" thick with #11 reinforcing bars at 6" on center each way in the top mat and #11 reinforcing bars at 6" on center in one direction in the bottom mat. The concrete has a minimum 28 day design strength of 4000 psi. The reinforcing bars are ASTM A615 Grade 60. The top of this recessed area has a reference elevation of 704'-9" (Ref. 3, 13, 14).

The impact media for the other recessed area of the welding station is a reinforced concrete foundation pad cast against the soil. The foundation pad is 2'-0" thick with #7 reinforcing bars at 8" on center each way each face. The concrete has a minimum 28 day design strength of 4000 psi. The reinforcing bars are ASTM A615 Grade 60. The top of the foundation pad has a reference elevation of 689'-4" (Ref. 3, 13, 14).

The maximum design height of the grabbing point for the grapple hooks on the MHM has a reference elevation of 728'-1. The design of the MHM incorporates a plug above the grapple hook assembly that will not allow the grapple hooks to lift the Cask/MCO higher than the maximum design height. Therefore, the maximum design height and the two-block height for the MHM are the same (Ref. 22). The maximum height of the grabbing point for the grapple hooks on the MHM over the various impact media is as follows:

- 19'-1" above the top of the floor slab between Column Lines 1 and 7 and from Column Lines A.1 to E.9.
- 37'-8" above the top of the foundation pad at the bottom of the receiving pit.
- 61'-1" above the top of the vault floors.
- 23'-4" above the top of the first recessed area as has been discussed above about the welding stations.

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- 38'-9" above the top of the other recessed area as has been discussed above about the welding stations.

References

1. Drawing H-1-21072 Sht. 1 Rev. 5, Structural Concrete Sections & Details At Elev. 0'-0" Storage & Transfer Area

2. Drawing H-1-21073 Sht. 1 Rev. 4, Structural Concrete Sections & Details At Elev. 0'-0" Storage & Transfer Area

3. Drawing H-2-119275 Sht. 2 Rev. 3, Structural Canister Storage Bldg General Notes & Typ Dets

4. Drawing H-2-119276 Sht. 1 Rev. 4, Structural Canister Storage Bldg Vault Oper Floor Plan

5. Drawing H-2-119278 Sht. 1 Rev. 5, Structural Canister Storage Bldg Vault Cross Sections

6. Drawing H-2-119280 Sht. 1 Rev. 3, Structural Canister Storage Bldg Vault Oper Flr Reinf Dets

7. Drawing H-2-119286 Sht. 1 Rev. 5, Structural Canister Storage Bldg Vault Reinf Cross Sect K

8. Drawing H-2-119305 Sht. 1 Rev. 1, Structural Load-In/Load-Out Floor Plan

9. Drawing H-2-119306 Sht. 1 Rev. 1, Structural Load-In/Load-Out Reinforcing Plan

10. Drawing H-2-119307 Sht. 1 Rev. 1, Structural Load-In/Load-Out Sections & Details

11. Drawing H-2-119310 Sht. 1 Rev. 1, Structural MCO Service Station Sections & Details

12. Drawing H-2-119310 Sht. 2 Rev. 1, Structural MCO Service Station Sections & Details

13. Drawing H-2-119336 Sht. 1 Rev. 0, Structural Hot Conditioning Annex Floor Plan

14. Drawing H-2-119337 Sht. 1 Rev. 0, Structural Hot Conditioning Annex Sections And Details

15. Construction Specification Project CA-512-R, Specification HW-4739, Reinforcing Steel for Concrete Rev. 0 (Dated 11/11/52)

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16. Construction Specification Project CA-512-R, Specification HW-4740, Forming, Placing, Finishing and Curing of Plain and Reinforced Concrete Rev. 1 (Dated 11/10/52)

17. ACECO Drawing D-14899-001 Sht. 1 Rev. 0, 60/10 Ton Double Girder Crane General Arrangement, Elevation

18. ACECO Drawing D-14899-300 Sht. 1 Rev. 0, 60/10 Ton Receiving Crane Trolley Arrangement

19. ACECO Drawing D-14899-370 Sht. 1 Rev. 1, 60/10 Ton Receiving Crane Main Hoist Lower Block Assembly

20. EDERER Incorporated, Drawing PA-2109 Rev. B, Proposal/Clearance Drawing 32/3 Ton Trolley & Hoist

21. EDERER Incorporated, Drawing D-35221 Dated 4/14/97, Trolley Assembly

22. GEC Alsthom Engineering Systems LTD Drawing 362A0551 Sht. 2 Rev. D, MCO Handling M/C Turret Assembly