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Refer to: NIS:REK-71-298

June 11, 1971

Director, Division of Materials Licensing
U.S. Atomic Energy Commission
Washington, D. C. 20545

Attention: Mr. Donald A. Nussbaumer, Chief
Fuel Fabrication & Transportation Branch

Subject: Additional Information - Processing
Yankee Reload Fuel SNM-777, Docket 70-820

Reference: NIS:REK-71-278 dated March 31, 1971

Dear Mr. Nussbaumer: Regulatory File Cy.

As recently discussed, United Nuclear Corporation wishes to clarify, modify and add to its recent application to process Yankee Reload Fuel. This recent application was submitted by the Reference. The modifications and additions are for the structural evaluation only. They include corrections to the calculations, sketches for both Yankee and Dresden fixtures and drop test results for fuel rods. This rev ised structural analysis, ENH-71-263 dated 6/2/71 replaces the previous analysis, ENH-69-672 in its entirety. Also attached are a revised page for the nuclear safety evaluation which also reflects the change in the structural analysis report number and an updated list of effective pages.

Included with this additional information is revised drawing E-302863-4 which shows an added inner portion of the safety ring. This ring is also shown on the sketch of the fixture as used with Yankee Reload fuel. The modified safety ring precludes the bending of rods into the center void portion of the fixture.

Current commitments require processing of this material in early August 1971. Your early consideration is requested.

Sincerely,

Peter Loysen

Peter Loysen, Manager
Nuclear & Industrial Safety

PL:g
Attach.

2743

D-51

EFFECTIVE PAGES

DOCKET 70-820, SECTION 800, SUBSECTION 820

SUBPART	SUBJECT	PAGE	ISSUE DATE
823.1	General Considerations	1 of 2	3/31/71
		2 of 2	10/31/68
823.2	Process Description	1 of 3	10/31/68
		2 of 3	3/31/71
		3 of 3	10/31/68
823	Flow Diagram 823-I	1 of 1	10/31/68
823	Flow Diagram 823-IA	1 of 1	2/6/70
823	Nuclear Safety Evaluation - Dresden 1 Fuel Elements (BWR)	1 of 6	10/31/68
		2 of 6	2/6/70
		3 of 6	10/31/68
		4 of 6	10/31/68
		5 of 6	2/6/70
		6 of 6	10/31/68
823	Supplement to Nuclear Safety Evaluation - Dresden Fuel Elements (BWR)	1 of 2	2/6/70
		2 of 2	2/6/70
823	Nuclear Safety Evaluation - Yankee Fuel Elements (PWR)	1 of 4	2/6/70
		2 of 4	10/31/68
		3 of 4	10/31/68
		4 of 4	10/31/68
823	Nuclear Safety Evaluation - Yankee Reload Fuel (PWR)	1 of 5	3/31/68
		2 of 5	3/31/68
		3 of 5	3/31/68
		4 of 5	3/31/68
		5 of 5	3/31/68
823	Nuclear Safety Evaluation Pickle-Corrosion Fixture	1 of 2	6/14/71
		2 of 2	3/19/71

I. DESCRIPTION

A stainless steel fixture with different circular plate holders for various core types held in place by a standard hollow center rod is used to pickle and corrosion test rods filled with low enrichment UO_2 pellets. The fuel rods are arranged in concentric rings formed by holes in the top and bottom plates. Details of construction are shown on the Referenced drawings listed on Table I.

II. NUCLEAR SAFETY OF INDIVIDUAL FIXTURES

The criticality of the fixtures has been analyzed using UNC reactor design codes. These analyses are referenced and K_{eff} values listed on Table I. It should be noted that the fixture for Yankee Reload Fuel was modified by removing the inner ring so that there are only six rings as was recommended in NED-1083. The reactivity increase due to loss of cladding was considered in all cases and this contribution is also listed on Table I.

Although the K_{eff} value for Yankee Reload Fuel slightly exceeds the limit stated in Subpart 823.2.10 (K_{eff} reflected ≤ 0.9), the fixture is considered to be subcritical by a sufficient amount.

III. INTERACTION

Based on the analysis set forth on page 4, NED-21, the interaction effects for fixtures in pickle tanks, rinse tanks and corrosion test vessels is considered negligible.

IV. STRUCTURAL INTEGRITY

A structural evaluation was performed to determine that the fixture would contain the rods in the proper arrangement under accident conditions of a dropped full fixture. The results of this structural evaluation are shown on ENH-71-263 and its Addendum. The fixture for 252 Dresden Rods has not been evaluated and will not be used at this time. The inspection criteria of Subsection 304 will be applied during use for processing.

V. CONCLUSION

Fixtures D-302863-2 and D-302863-4 are nuclearly safe.

LICENSE: SNM-777, DOCKET: 70-820	
SECTION: 800, SUBPART: 823	
Nuclear Safety Evaluation -	
Pickle - Corrosion Fixtures	
PAGE 1 OF 2	
APPROVED:	
ISSUED:	6/14/71
SUPERSEDES:	3/19/71

ENH-71-263
6/2/71

STRUCTURAL ANALYSIS OF DRESDEN CORROSION RACK E-302863

Requirements

Corrosion rack must retain fuel rods within original safe geometry in the event the rack is dropped from any crane in building 24-D. The maximum height of drop would be 20 feet and could only occur within an autoclave, which would guide the rack so that it could only land on its bottom supporting legs. The autoclave would also prevent the possibility of the rack falling on its side after impact.

Assumptions

Fuel rods would remain within safe geometry providing holddown plate would remain in position after drop. Holddown plate is secured in main structure by means of a 3/8 inch diameter stainless steel pin. Criteria of failure is based on shearing of pin (maximum allowable shear stress = .75 S_t maximum = 67,500 psi) as a result of force developed in drop. Calculations are based on rack and legs stopping simultaneously while upper portion of rack continues downward with fuel rods, absorbing energy through elasticity of fuel rods and center pipe only. The cushioning effect of the fluid in the autoclave is neglected.

Comments

The shearing load applied to the pin was chosen as the criterion for failure for the following reasons.

1. A deflection of the legs and/or bottom plate would tend to cushion the impact.

2. The shear area of the pin permits higher stresses to be applied at the pin than would occur elsewhere in the fixture. A failure of this pin might conceivably allow the fuel rods to rebound out of the fixture following impact.

References

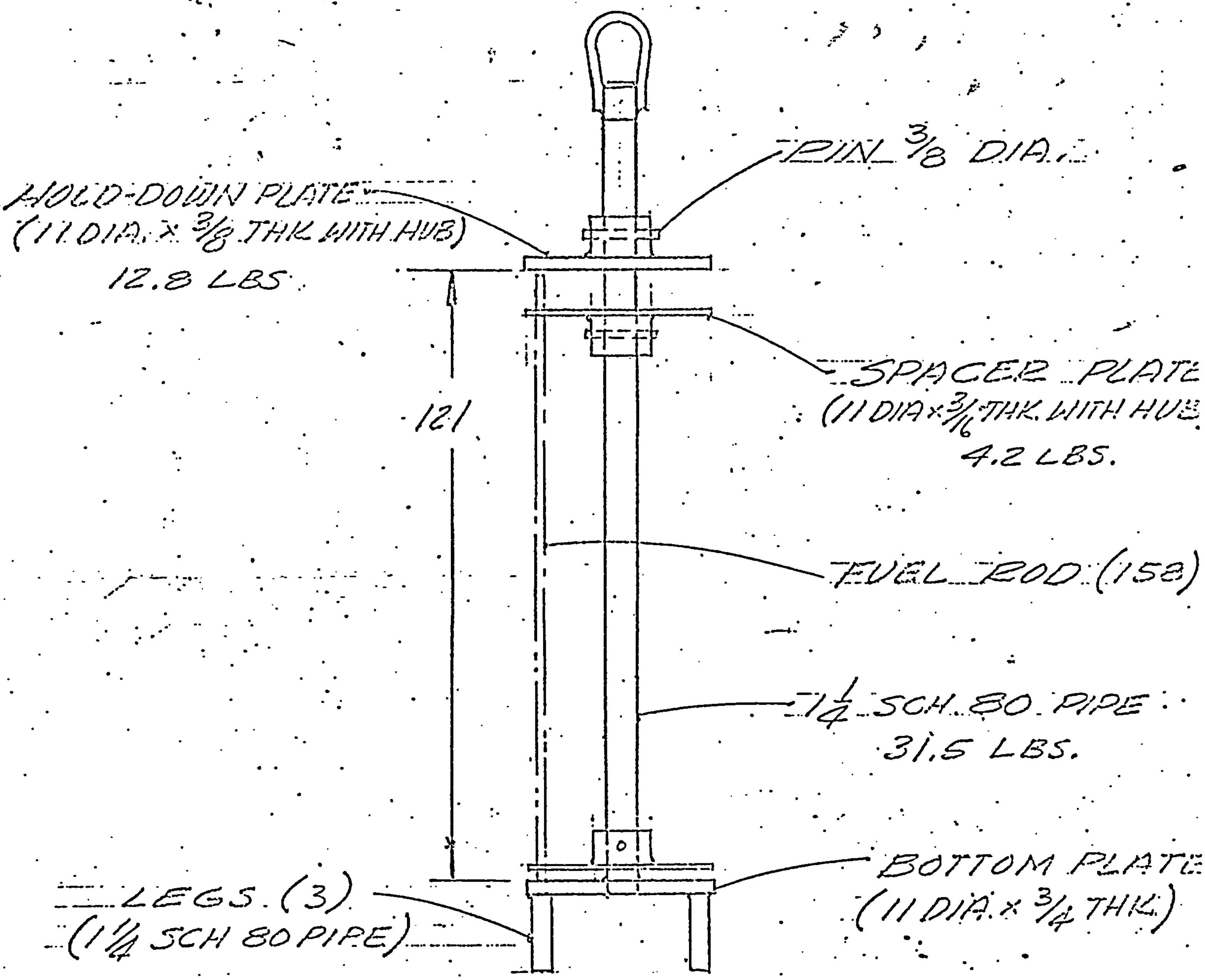
Mark's Handbook for Mechanical Engineers, 7th edition, Pg. 5-62, 5-27 (Figure 22)
Ryerson Catalog #118
ASM Metal Progress Databook

Data

Capacity of fixture - 158 Dresden rods
Net weight of rack - 91 lbs.
Gross weight (158 fuel rods) - 1,434 lbs.
Weight of holddown plate - 12.8 lbs.
Weight of spacer plate - 4.2 lbs.
Weight of center pipe - 31.5 lbs.
Pin 3/8 diameter - tensile strength: 90,000 to 95,000 psi

Conclusion

We find the corrosion rack to be structurally safe based on the following calculations:



DRESDEN CORROSION
RACK - E-302863

ALL STAINLESS STEEL CONST.

CALCULATIONS

POSSIBLE FAILURE DUE TO WEIGHT OF FIXTURE

MAX. S_t OF PIN = 90,000 P.S.I.
E PIPE = 28,000,000 P.S.I.

$$Sd_F = S_S \left(1 + \sqrt{1 + \frac{2h}{e}} \right)$$ WHERE

Sd_F = DYNAMIC STRESS AT PIN (SHEAR) DUE TO FIXTURE WEIGHT
S_S = STATIC STRESS AT PIN = $\left(\frac{P}{A}\right)$ PIN
h = HEIGHT OF DROP IN INCHES $(12 \times 20) = 240$
e = ELONGATION OF PIPE WITH STATIC LOAD = $\left(\frac{SL}{E}\right)$ PIPE
S PIPE = $\frac{P'}{A'} = \frac{52.7}{.600} = 88$ P.S.I.
P' = WEIGHT OF HOLD DOWN PLATE, SPACER AND PIPE (48.5 LBS)
A' = AREA OF PIPE (.600) SQ IN.
P = WEIGHT OF HOLD DOWN PLATE (12.8 LBS)
A = SHEAR AREA OF PIN (.221) SQ IN.
L PIPE = 121 INCHES
E PIPE = 28×10^6 PSI

$$Sd_F = \frac{12.8}{.221} \left[1 + \sqrt{1 + \frac{(2)(.240)}{\frac{(88)(121)}{(28)(10^6)}}} \right]$$

$$Sd_F = 57.8 \left[1 + \sqrt{1 + \frac{(480)(28)(10^6)}{(81)(121)}} \right]$$

$$Sd_F = 57.8 \left(1 + \sqrt{1 + 1.372 (10^6)} \right)$$

$$Sd_F = 57.8 \left(1 + 1000 \sqrt{1.372} \right)$$

$$Sd_F = (57.8)(1{,}172)$$

$$Sd_F = \underline{67{,}700 \text{ P.S.I.}}$$

POSSIBLE FAILURE CAUSED BY FUEL RODS REBOUNDING AFTER IMPACT, ASSUMING n RODS STRIKE TOP PLATE AT SAME INSTANT.

A DROP TEST WAS PERFORMED TO DETERMINE THE MAX. REBOUND HEIGHT, h'. THE VALUE WAS FOUND TO BE 11/16 INCHES REBOUND FROM A 20 FT. DROP. ADDING 1/32 INCHES TO COMPENSATE FOR A POSSIBLE MEASUREMENT ERROR, THE VALUE OF h' BECOMES .72 INCHES.

$$Sd \text{ DUE TO ONE ROD} = Sd_r = S_{SR}\left(1 + \sqrt{1 + \frac{2h'}{e}}\right)$$

$$Sd_r = S_{SR}\left(1 + \sqrt{1 + \frac{1.44}{e}}\right)$$

$$S_{SR} = \frac{\text{ROD WT.}}{\text{AREA PIN}} = \frac{8.5}{.221} = 38.46 \text{ P.S.I.}$$

$$e = \left(\frac{PL}{AE}\right)_{ROD}$$

A ROD = .052 IN.^{2}

L ROD = 116 INCHES

E. ROD = $(11)(10)^6$ PSI

$$e = \frac{(8.5)}{(.0521)} \cdot \frac{(.116)}{(11)(10)^6} = (1721)(10)^{-6} \text{ INCHES}$$

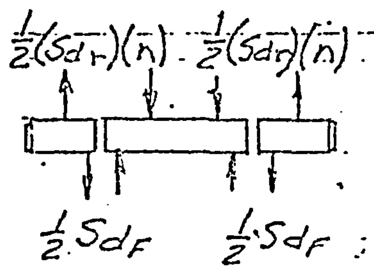
$$Sd_r = 38.46\left(1 + \sqrt{1 + \frac{1.44}{(1721)(10)^{-6}}}\right)$$

$$Sd_r = 38.46\left(1 + \sqrt{1 + (.0008365)(10)^6}\right)$$

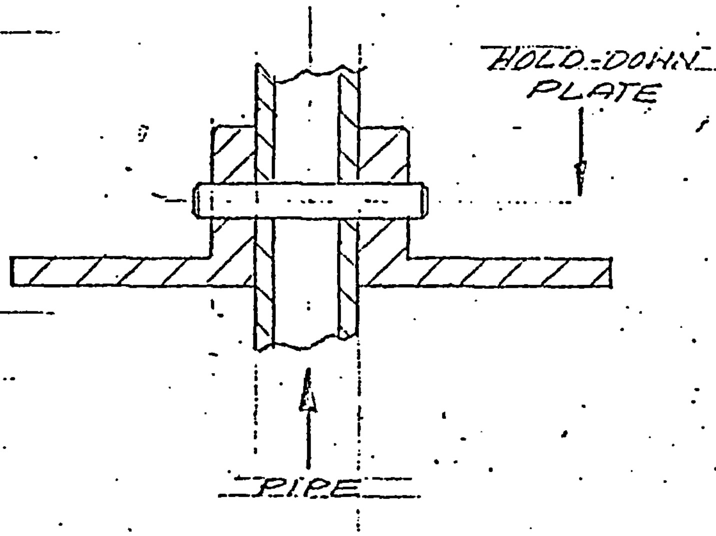
$$Sd_r = 38.46\left(1 + \sqrt{.837}\right)$$

$$Sd_r = 38.46\,(29.9) = 1150 \text{ P.S.I.}$$

COMBINED DYNAMIC MAX. LOAD, S_{dc}



SHEAR STRESSES ON PIN



TOTAL FORCES ON HOLD DOWN PLATE

$S_{df} = 67,700$ ↑↓ ; $S_{dr} = 1150$ ↓↑

TOTAL DYNAMIC STRESS, $S_{dc} = S_{df} + S_{dr}(n)$ (WHERE n = No. OF RODS REBOUNDING SIMULTAN.

MAX. ALLOWED $S_{dc} = 67,500$ P.S.I. = .75(90,000)

$$67,500 = -67,700 + (1150)(n)$$

$$135,200 = 1150\,n$$

$$117 = n$$

THE PROBABILITY OF 117 RODS REBOUNDING TO STRIKE THE HOLD DOWN PLATE SIMULTANEOUSLY IS EXTREMELY SMALL.

Addendum I to ENH-71-263

Subject: Structural Analysis of Dresden Corrosion Rack E-302863

E-302863-4 Modification for Yankee Fuel Rods

The rack, as modified, will hold 285 Yankee rods at 3.16 lbs. each. The weight of the rods will be 901 lbs. compared with 1,434 lbs. for 158 Dresden rods.

Since the rack has been shown to be structurally safe for the 158 Dresden rods, it will be structurally safe when loaded with 285 Yankee rods.

CPD recommends structural approval for 285 Yankee rod loading for corrosion rack E-302863-4.

Prepared G. Halla
G. Halla, Process Eng.

Reviewed L. Studwell
L. Studwell, Eng.-In-Charge/Mech. Section

ADDENDUM II

STRUCTURAL ANALYSIS OF DRESDEN CORROSION RACK

DROP TESTING OF YANKEE RELOAD FUEL RODS

I. Description of Test

The bending and bowing effects caused by dropping Yankee-Reload fuel rods were checked by actual drop test. Three different tests were performed on individual dummy rods. The dummy rods were constructed to rod design dimensions but were loaded with stainless steel pellets.

Rods were dropped by hand such that they fell 22 to 25 feet striking a concrete driveway. During each test, the rod was dropped in such a manner to cause impact to occur at an increasing angle.

II. Test Results

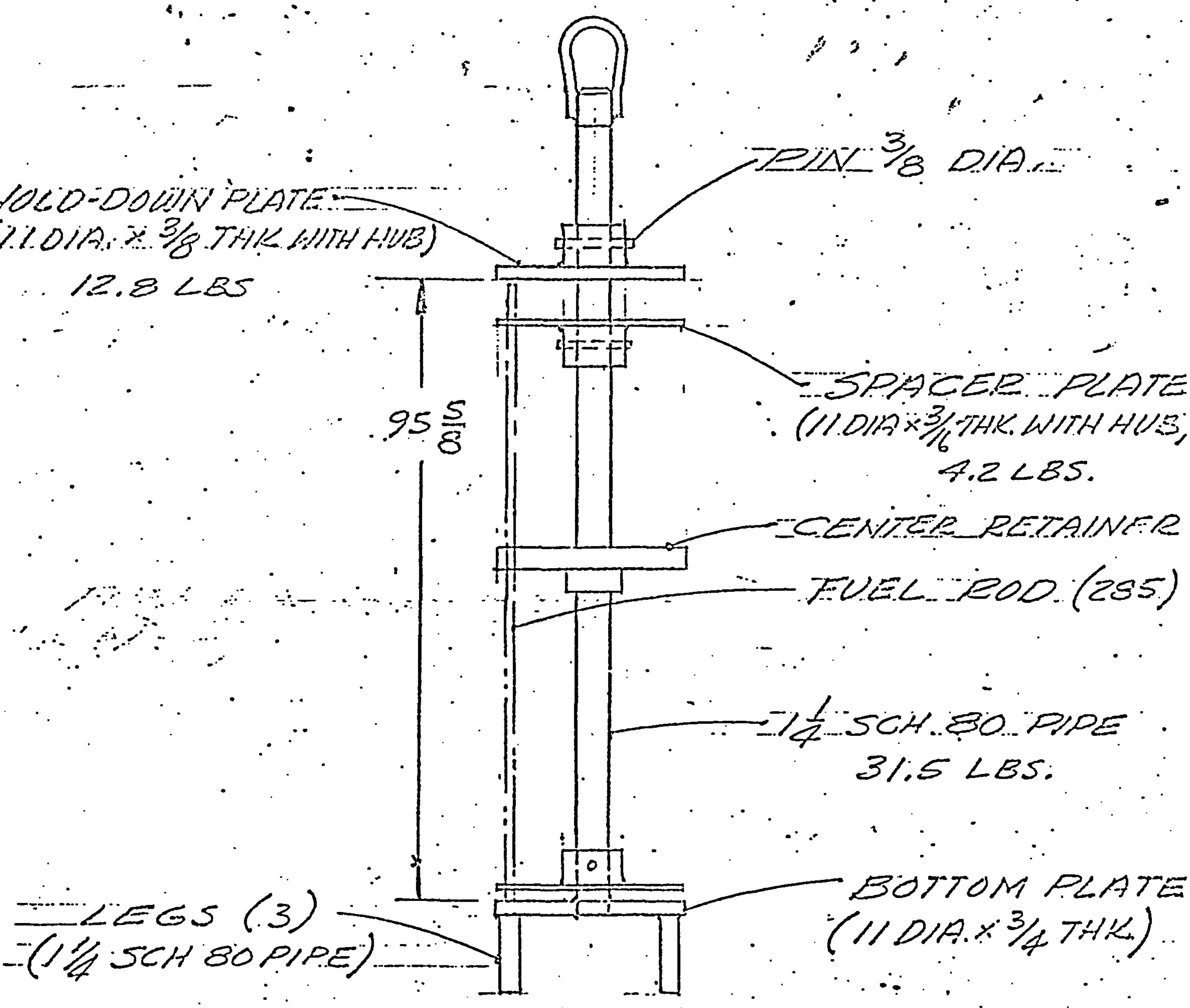
Test No. 1 was a straight drop. The rod struck the impact surface essentially vertically and rebounded directly upward approximately 6 inches. During the rebound, the rod was noted to oscillate with maximum deflection of approximately 1/2 inch. Rod damage was confined to some crushing of the bottom end plug.

Test No. 2 was performed with the rod at an approximate 5^{o} angle. After striking the impact surface, the rod rebound upward and at an angle in the direction of its axis. Rebound distance was approximately 2 to 3 inches vertically. During rebound the rod oscillated approximately 1 to 1 1/2 inches. Rod damage noted was again some crushing of the bottom end plug plus a permanent bend of approximately 1/4 inch starting about 5 inches from the point of impact.

Test No. 3 was performed with the rod at an approximately 30^{o} angle. After striking the impact surface, the impact end deflected upward violently and the upper end struck the impact surface rather heavily. After both impacts, the rod oscillated violently approximately 4 to 6 inches. Rod damage was extensive with top and bottom bows of approximately 9 inches. These bends were located approximately 1/3 of the distance from the top and the bottom.

III. Conclusions

The most likely accidental drop of these rods held in the Pickle-Corrosion Test Fixture would be vertical. This is assumed, since the fixture weight results in nearly vertical orientation during movement plus the openings of corrosion vessels, pickle tanks and rinse tanks are sufficiently small to preclude angular dropping of a loaded fixture. Therefore, a drop of the fixture would result in the vertical displacement of the rods upon impact. This is further assured since the rods are not attached but rest on the fixture bottom plate and the rods are constrained by individual openings in the top and bottom spacer plates of the fixture plus a central retainer which restricts both outward and inward deflection. Thus, the results of Test No. 1 best describes the expected effects of an accidental fixture drop on the individual rods contained therein.



DRESDEN CORROSION RACK - AS REVISED FOR USE WITH YANKEE RODS E-302863-4

ALL STAINLESS STEEL CONST.