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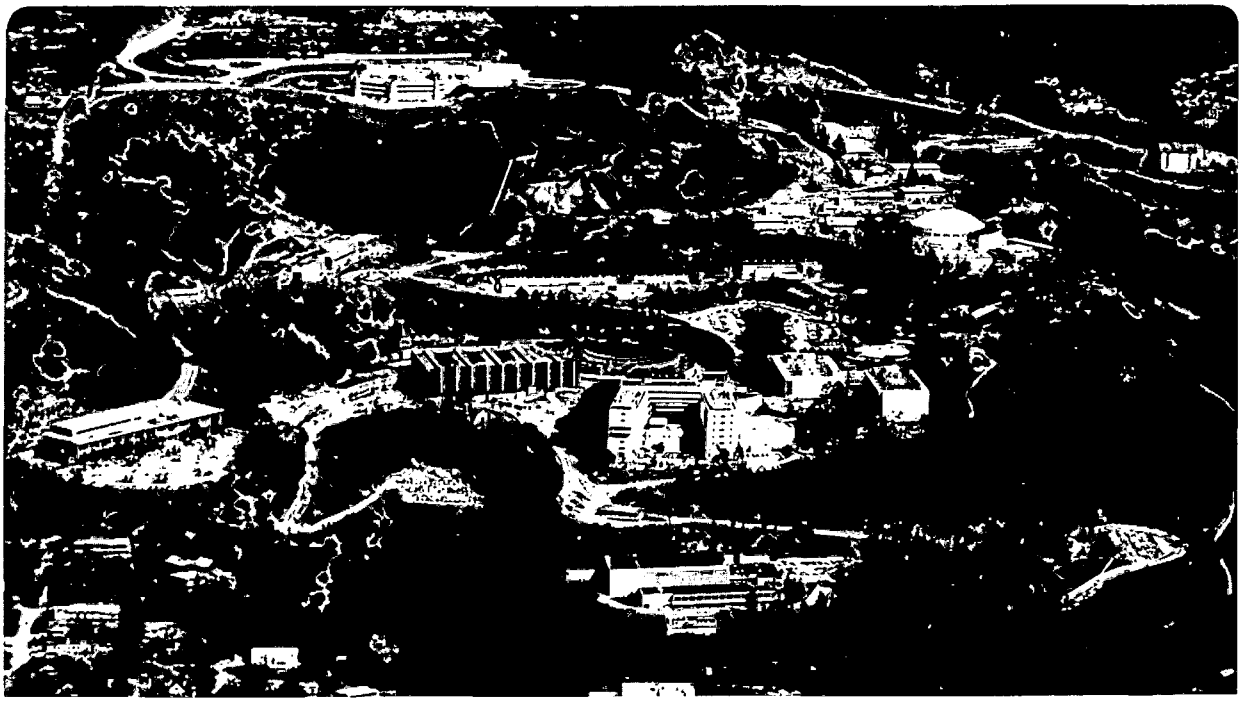

DISCLAIMER

LAWRENCE BERKELEY LABORATORY – UNIVERSITY OF CALIFORNIA **ENGINEERING NOTE**	CODE NB0301	SERIAL M5709	PAGE 1 of 7
AUTHOR MARTIN FONG	DEPARTMENT MECHANICAL	LOCATION B16T	DATE 3-16-81

PROGRAM – PROJECT – JOB
NBETF

PANEL TEST COOLING SYSTEM

TITLE
PRESSURE VESSEL CALCULATIONS

SAFETY CASE #81-011

THIS IS AN ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII, DIVISION 1 CALCULATION FOR THREE VERTICAL HIGH PRESSURE VESSELS. THE VESSELS HAVE THE SAME CONSTRUCTION EXCEPT FOR THE PENETRATIONS AT THE END CLOSURES. THE HIGH PRESSURE WATER TANK, 20G0024, HAS FIVE PENETRATIONS THROUGH EACH END CLOSURE. THE TWO GAS ACCUMULATORS, 20G003A, EACH HAS FOUR PENETRATIONS AT THE TOP END AND TWO PENETRATIONS AT THE BOTTOM END. THE VESSELS ARE CONSTRUCTED BY WELDING AN ASME CODED, 2:1 ELLIPTICAL HEAD TO EACH END OF A 24 in O.D. BY 52.12 in LONG SEAMLESS STEEL PIPE. THE VESSELS WILL BE LOCATED AT BUILDING 16.

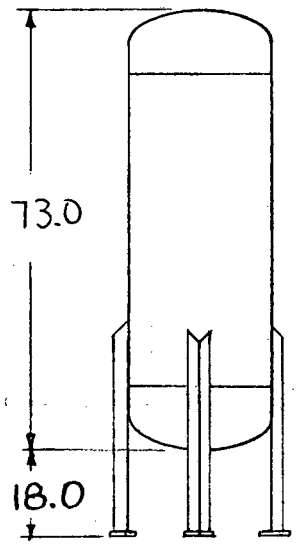

FIG. 1 TYPICAL VESSEL WITHOUT PENETRATIONS

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DESIGN PARAMETERS:

DESIGN WORKING PRESSURE, P = 1450 psig, INTERNAL

DESIGN TEMPERATURE < 200°F

INTERNAL VOLUME = 13 ft^3 OR 97.2 gal.

CORROSION ALLOWANCE = .06 in

FLUID IS WATER PRESSURIZED BY NITROGEN OR ARGON GAS. NO SEPARATION BETWEEN WATER AND GAS.

CYLINDRICAL SHELL:

MATERIAL = SA106 GRADE B SEAMLESS PIPE

DIMENSIONS, SCHEDULE 100 PIPE

O.D. = 24 in NOMINAL

I.D. = 20.938 in NOMINAL

WALL THICKNESS = 1.531 in NOMINAL
= 1.340 in MINIMUM

ALLOWABLE STRESS, S = 15,000 psi, TABLE UCS-23, p. 250

REQUIRED SHELL THICKNESS, t

$$t = \frac{PR}{SE - .6P}$$ UG-27(c)(1), p. 20

R = INSIDE RADIUS; CORRODED CONDITION

$$= [24 - 2(1.340 - .06)]/2 = 10.72 \text{ in}$$

E = 1 FOR SEAMLESS PIPE

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$$t_{REQ} = \frac{(1450)(10.72)}{(15000)(1)-(.6)(1450)} = \boxed{1.100 \text{ in}}$$

MAXIMUM ALLOWABLE WORKING PRESSURE, MAWP

$$P = \frac{SEt}{R+.6t}$$ UG-27(c)(1), p. 20

$t = 1.340 - .06 = 1.280$ in, CORRODED CONDITION

$$P_{MAWP} = \frac{(15000)(1)(1.280)}{10.72+(.6)(1.280)} = \boxed{1671 \text{ psig}}$$

2:1 ELLIPTICAL HEAD:

MATERIAL = SA 515 GRADE 70

DIMENSIONS

O.D. = 24.0 in

WALL THICKNESS = 1.75 in NOMINAL
= 1.531 in MINIMUM

ALLOWABLE STRESS = 17500 psi, TABLE UCS-23, p.250

REQUIRED HEAD THICKNESS, t

$$t = \frac{PD}{2SE-.2P}$$ UG-32(d), p. 28

$D = 24.0 - 2(1.531-.06) = 21.058$ in, CORRODED CONDITION

E = 1 FOR SEAMLESS HEAD

$$t_{REQ} = \frac{(1450)(21.058)}{2(17500)(1)-(.2)(1450)} = \boxed{.880 \text{ in}}$$

MAXIMUM ALLOWABLE WORKING PRESSURE, MAWP

$$P = \frac{2SEt}{D + .2t} \qquad \text{UG-32(d), p. 28}$$

$t = 1.531 - .06 = 1.471$ in, CORRODED CONDITION

$$P = \frac{(2)(17500)(1)(1.471)}{21.058 + (.2)(1.471)} = \boxed{2411 \text{ psig}}$$

MAXIMUM ALLOWABLE WORKING PRESSURE FOR THE VESSEL IS GOVERNED BY THE SHELL. RELIEF VALVES WILL BE SET AT 1670 psig.

PENETRATIONS THROUGH THE HEADS

ALL PENETRATIONS ARE SPACED GREATER THAN TWICE THE AVERAGE DIAMETER OF ADJACENT HOLES. UG-42(a) ALLOWS EACH PENETRATION TO BE CONSIDERED BY ITSELF. 2 in PIPE SIZE OR SMALLER DOES NOT REQUIRE REINFORCEMENT IN ACCORDANCE WITH UG-36(c)(3). THE HEAD THICKNESS IS SELECTED TO PROVIDE INTEGRAL REINFORCEMENT FOR THE 3 in WELD NECK FLANGES.

REQUIRED REINFORCEMENT CROSS-SECTIONAL AREA

$$A = d\,t_r F \qquad \text{UG-37(b), p. 40}$$

$F = 1$ UG-37(b), p. 40

$d = 2.900 + 2(.06) = 3.02$ in, CORRODED CONDITION

t_r = THICKNESS REQUIRED FOR SEAMLESS SPHERE OF RADIUS = .9D UG-37(b)(3), AND TABLE UG-37

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$$t_r = \frac{PK_1D}{2SE - .2P}$$ UG-32(f) p. 29 AND EXAMPLE 6 p. 540

$$t_r = \frac{(1450)(.9)(21.058)}{2(17500)(1) - (.2)(1450)} = .792 \text{ in}$$

$$A_{REQ} = (3.02)(.792)(1) = \boxed{2.392 \text{ in}^2}$$

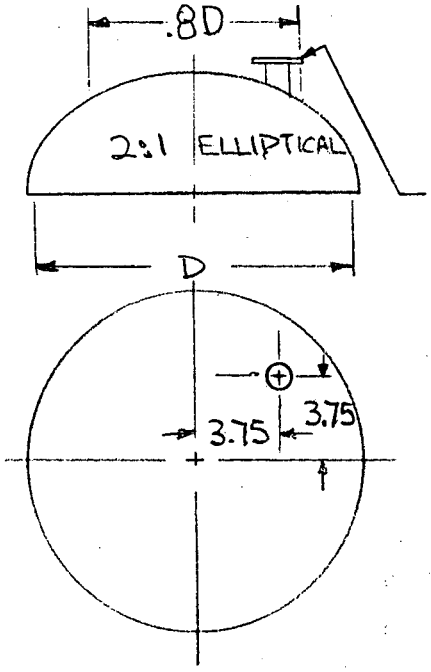

FIG. 2 REINFORCEMENT MUST BE WITHIN .8D. UG-37(b)(3)

3" 900# ASA FLANGE
I.D. = 2.900 in
O.D. = 3.500 in
t = .300
.8D = .8(21.058) = 16.846 in

HOLE CENTER RELATIVE TO HEAD CENTER = $\sqrt{(3.75)^2 + (3.75)^2}$
= 5.303 in

AVAILABLE CROSS-SECTIONAL AREA, CONSIDERING ONLY THE HEAD AREA

$$A_1 = (E_1 t - F t_r)(R_n + t_n + t - R_n)2$$ FIG. L-7, p. 530 & UG 40 (d)(1), p. 42

SINCE .8D LIMITS THE AVAILABLE CROSS-SECTIONAL AREA, $(R_n + t_n + t - R_n)2$ IS NOT TOTALLY APPLICABLE.

$$R_n = \frac{2.900}{2} + .06 = 1.51 \text{ in}$$

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$t_n = .300 - .06 = .24$ in

ON ONE SIDE,

$$t_n + t = .24 + 1.471 = 1.711 \text{ in}$$

ON THE OTHER SIDE,

$$\frac{16.846}{2} - (5.303 + 1.51) = 1.61 \text{ in}$$

$$A_1 = [(1)(1.471 - (1)(.792)](1.61 + 1.711) = 2.255 \text{ in}^2$$

AVAILABLE AREA FROM FLANGE CROSS-SECTION IS SMALLER OF

$A_2 = (t_n - t_{rn}) 5 t f_r$ (a)

OR $A_2 = (t_n - t_{rn})(5t_n + 2t_e) f_r$ (b)

} UG 42(d)(2), p. 42 & p. 530

$$f_r = \frac{S_n}{S_v}$$

$$t_{rn} = \frac{PR_n}{SE - .6P}$$ FOR FLANGE AS CYLINDER

$S = 17500$ psi FOR SA-105 FORGINGS, TABLE UCS-23, p. 252

$$t_{rn} = \frac{(1450)(1.51)}{(17500)(1) - (.6)(1450)} = .132 \text{ in}$$

$S_n = S_{FLANGE} = 17500$ psi

$S_v = S_{HEAD} = 17500$ psi

} L-7, p. 529

$$f_r = \frac{17500}{17500} = 1.0$$

$t_e = 0$, NO ADDITION OF REINFORCEMENT

(a) $A_2 = (.24 - .132)(5)(1.471)(1) = .794 \text{ in}^2$

(b) $A_2 = (.24 - .132)[(5)(.24) + (2)(0)](1) = .13 \text{ in}^2$

$A_2 = .13 \text{ in}^2$

$A_3 = 0$

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AVAILABLE AREA FROM EXTERNAL WELDMENT,

$A_{41} = (\text{LEG DIMENSION})^2 \times f_r$ p. 530

$A_{41} = (.375)^2(1) = .141 \text{ in}^2$

$A_1 + A_2 + A_3 + A_{41} = 2.255 + .13 + 0 + .141 = 2.526 \text{ in}^2$

$2.526 \text{ in}^2 > 2.392 \text{ in}^2$, SO NO ADDITIONAL REINFORCEMENT IS REQUIRED FOR THE FLANGES.

REFERENCE: ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII, DIVISION 1, 1980 EDITION

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