

# Lawrence Berkeley National Laboratory

## Recent Work

**Title**

PRESSURE VESSEL CALCULATIONS

**Permalink**

<https://escholarship.org/uc/item/8016s0mg>

**Author**

Fong, Martin.

**Publication Date**

1981-03-01



# Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

## Engineering & Technical Services Division

RECEIVED  
LAWRENCE  
BERKELEY LABORATORY

AUG 19 1951

LIBRARY  
DOCUMENTS

**For Reference**

Not to be taken from this room



LBID-381  
c.1

## **DISCLAIMER**

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the 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 I 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, 20G0034, 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.

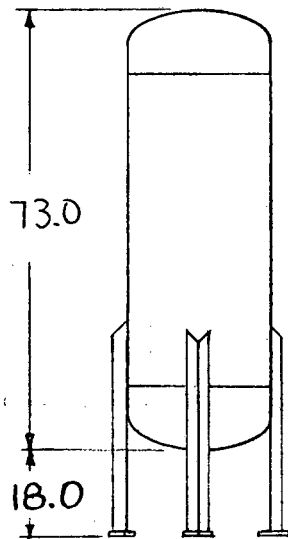


FIG. 1 TYPICAL VESSEL WITHOUT PENETRATIONS

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA		CODE	SERIAL	PAGE
<b>ENGINEERING NOTE</b>		NB0301	M5709	2 of 7
AUTHOR	DEPARTMENT	LOCATION	DATE	
M FONG	MECHANICAL	B16 T	3-16-81	

## DESIGN PARAMETERS:

DESIGN WORKING PRESSURE,  $P = 1450$  psig, INTERNAL

DESIGN TEMPERATURE  $< 200^\circ\text{F}$

INTERNAL VOLUME =  $13 \text{ ft}^3$  OR  $97.2 \text{ gal.}$

CORROSION ALLOWANCE =  $.06 \text{ in}$

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. =  $24 \text{ in}$  NOMINAL

I.D. =  $20.938 \text{ in}$  NOMINAL

WALL THICKNESS =  $1.531 \text{ in}$  NOMINAL  
 $= 1.340 \text{ in}$  MINIMUM

ALLOWABLE STRESS,  $S = 15,000 \text{ psi}$ , TABLE UCS-23,  
 p. 250

REQUIRED SHELL THICKNESS,  $t$

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

$R =$  INSIDE RADIUS, CORRODED CONDITION

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

$E = 1$  FOR SEAMLESS PIPE

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA		CODE	SERIAL	PAGE
<b>ENGINEERING NOTE</b>		NB0301	M5709	3 of 7
AUTHOR	DEPARTMENT	LOCATION	DATE	
M FONG	MECHANICAL	B16T	3-16-81	

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

MAXIMUM ALLOWABLE WORKING PRESSURE, MAWP

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

$$t = 1.340 - .06 = 1.280 \text{ in, CORRODED CONDITION}$$

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

2:1 ELLIPTICAL HEAD:

MATERIAL = SA 515 GRADE 70

DIMENSIONS

$$O.D. = 24.0 \text{ in}$$

$$\begin{aligned} \text{WALL THICKNESS} &= 1.75 \text{ in NOMINAL} \\ &= 1.531 \text{ in MINIMUM} \end{aligned}$$

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

REQUIRED HEAD THICKNESS,  $t$

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

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

$E = 1$  FOR SEAMLESS HEAD

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

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA		LBID 381	SERIAL	PAGE
<b>ENGINEERING NOTE</b>		CODE NB0301	M5709	4 OF 7
AUTHOR	DEPARTMENT	LOCATION	DATE	
M FONG	MECHANICAL	B16T	3-16-81	

MAXIMUM ALLOWABLE WORKING PRESSURE, MAWP

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

$$t = 1.531 - .06 = 1.471 \text{ in, CORRODED CONDITION}$$

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

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

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

$$F = 1 \quad \text{UG-37(b), p.40}$$

$$d = 2.900 + 2(.06) = 3.02 \text{ in, CORRODED CONDITION}$$

$$t_r = \text{THICKNESS REQUIRED FOR SEAMLESS SPHERE OF RADIUS} = .9D \quad \text{UG-37(b)(3), AND TABLE UG-37}$$

## ENGINEERING NOTE

CODE

NB0301

SERIAL

M5709

PAGE

5 OF 7

AUTHOR

M FONG

DEPARTMENT

MECHANICAL

LOCATION

B16T

DATE

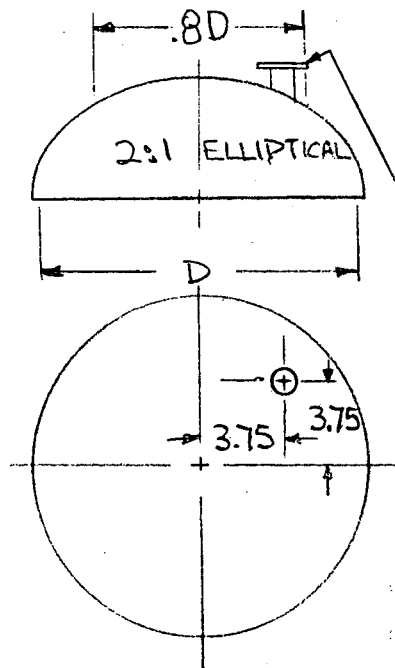
3-16-81

$$t_r = \frac{PK_1 D}{2SE - .2P}$$

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

 $t = .300$  $.8D = .8(21.058) = 16.846 \text{ in}$ 

HOLE CENTER RELATIVE TO

$$\text{HEAD CENTER} = \sqrt{(3.75)^2 + (3.75)^2}$$

$$= 5.303 \text{ in}$$

AVAILABLE CROSS-SECTIONAL AREA, CONSIDERING ONLY  
THE HEAD AREA

$$A_i = (E_1 t - F t_r) (R_n + t_n + t - R_n) 2 \text{ Fig. L-7,}$$

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.

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



**ENGINEERING NOTE**

CODE

NB0301

SERIAL

M5709

PAGE

6 of 7

AUTHOR

M FONG

DEPARTMENT

MECHANICAL

LOCATION

B16T

DATE

3-16-81

$$t_n = .300 - .06 = .24 \text{ in}$$

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

$$A_2 = (t_n - t_{rn}) 5 t_f r \quad (a) \quad \left. \begin{array}{l} \text{UG 42(d)(2), p. 42} \\ \text{\& p. 530} \end{array} \right\}$$

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

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

$$t_{rn} = \frac{P R_n}{S E - .6 P} \quad \text{FOR FLANGE AS CYLINDER}$$

$$S = 17500 \text{ psi} \quad \text{FOR SA-105 FORGINGS, TABLE UCS-23, p. 252}$$

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

$$S_n = S_{\text{FLANGE}} = 17500 \text{ psi}$$

$$S_v = S_{\text{HEAD}} = 17500 \text{ psi}$$

L-7, p. 529

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

$t_e = 0$ , NO ADDITION OF REINFORCEMENT

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

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

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

$$A_3 = 0$$

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA		CODE	SERIAL	PAGE
<b>ENGINEERING NOTE</b>		NB0301	M5709	7 of 7
AUTHOR	DEPARTMENT	LOCATION	DATE	
M FONG	MECHANICAL	B16T	3-16-81	

AVAILABLE AREA FROM EXTERNAL WELDMENT,

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

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

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

$2.526 \text{ in}^2 > 2.392 \text{ in}^2$ , SO NO ADDITIONAL

REINFORCEMENT IS REQUIRED FOR THE FLANGES.

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

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

TECHNICAL INFORMATION DEPARTMENT  
LAWRENCE BERKELEY LABORATORY  
UNIVERSITY OF CALIFORNIA  
BERKELEY, CALIFORNIA 94720