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END CAP CALORIMETER/VESSEL CALCULATIONS
-----SUBJECT: DETERMINATION OF THE DIMENSIONS FOR THE CENTRAL
CALORIMETER'S CRYOSTATSTANDARD USED: ASME BOILER AND PRESSURE VESSEL CODE
SECTION VIII-DIVISION 1

THE END CAP CALORIMETER'S CRYOSTAT IS COMPOSED OF TWO VESSELS; ONE NESTED INSIDE THE OTHER. FIGURE 1 SHOWS A SIMPLIFIED SKETCH OF THE NESTED VESSELS. DRAWINGS 3740.220-MD-222076 REV. A SHOWS THE DETAILS OF THE INNER VESSEL. DRAWING 3740.220-MD-222075 REV. A SHOWS THE DETAILS OF THE OUTER VESSEL.

AS SHOWN IN FIGURE 1 THE CRYOSTAT CONSISTS OF TEN DIFFERENT GEOMETRIC PARTS. THE PARTS LABELED 1-4 ARE CYLINDRICAL SHELLS, THE PARTS LABELED 5 AND 6 ARE COMMON TORISPHERICAL HEADS AND THE PARTS LABELED 7-10 ARE UNIQUE HEADS.

PART 1

GIVEN: $P=15$ PSI EXTERNAL AND 15 PSI INTERNAL $D=204$ IN $R=101.375$ IN $L=64$ IN

MATERIAL SS 304

 $S=18750$ PSI $E=.65$ WELD EFFICIENCY SINGLE WELDED BUTT JOINT WITH
BACKING STRIP NOT SPOT EXAMINED.ASSUME $T=.625$ IN

USING UG-28:

 $D/T=204/.625=326.4$ $L/D=64/204=.313$ FROM FIGURE 5-UGO-28.0 FACTOR $A=.0008$ FROM FIGURE 5-UHA-28.1 FACTOR $B=8000$ $PA=4*B/(3*(D/T))=4*8000/(3*326.4)=32.68$ PSI

USING UG-27

FOR CIRCUMFERENTIAL STRESS:

 $P=S*E*T/(R+.6*T)=18750*.65*.625/(101.375+.6*.625)=74.86$ PSI

FOR LONGITUDINAL STRESS

 $P=2*E*S*T/(R-.4*T)=2*.65*18750*.625/(101.375-.4*.625)=150.6$ PSI $PA>P$ $32.68>15$ AND $74.86>15$ THEREFORE THE WALL THICKNESS IS ADEQUATE

PART 2

GIVEN: P=40 PSI INTERNAL AND 15 PSI EXTERNAL
D=193.5 IN
R=96.125 IN
L=61 IN
MATERIAL SS 304
S=18750 PSI
E=.65
ASSUME T=.625 IN

USING UG-28

$$D/T = 193.5 / .625 = 309.6$$

$$L/D = 61 / 193.5 = .315$$

FROM FIGURE 5-UGO-28.0 FACTOR A=.00085

FROM FIGURE 5-UHA-28.1 FACTOR B=8400

$$PA = 4 * B / (3 * D/T) = 4 * 8400 / (3 * 309.6) = 36.17 \text{ PSI}$$

USING UG-27

FOR CIRCUMFERENTIAL STRESS:

$$P = S * E * T / (R + .6 * T) = 18750 * .65 * .625 / (96.125 + .6 * .625) = 78.93 \text{ PSI}$$

FOR LONGITUDINAL STRESS:

$$P = 2 * E * S * T / (R - .4 * T) = 2 * .65 * 18750 * .625 / (96.125 - .4 * .625) = 158.90 \text{ PSI}$$

PA > P 36.17 > 15 AND 78.93 > 40 THEREFORE THE WALL THICKNESS IS ADEQUATE

PART 3

GIVEN: P=40 PSI EXTERNAL AND 15 PSI INTERNAL
D=5 IN
R=2.5 IN
L=87 IN
MATERIAL SS304
S=18750 PSI
E=.65
ASSUME T=.125 IN (MINIMUM WALL THICKNESS ALLOWED BY DIV. 2)

USING UG-28

$$D/T = 5 / .125 = 40$$

$$L/D = 87 / 5 = 17.4$$

FROM FIGURE 5-UGO-28.0 FACTOR A=.00070

FROM FIGURE 5-UHA-28.1 FACTOR B=7700

$$PA = 4 * B / (3 * (D/T)) = 4 * 7700 / (3 * 40) = 256.66 \text{ PSI}$$

USING UG-27

FOR CIRCUMFERENTIAL STRESS:

$$P = S * E * T / (R + .6 * T) = 18750 * .65 * .125 / (2.25 + .6 * .125) = 663.81 \text{ PSI}$$

FOR LONGITUDINAL STRESS:

$$P = 2 * E * S * T / (R - .4 * T) = 2 * .65 * 18750 * .125 / (2.25 - .4 * .125) = 1384.9 \text{ PSI}$$

PA > P 256.6 > 40 AND 663.81 > 15 THEREFORE THE WALL THICKNESS IS ADEQUATE

PART 4

GIVEN: $P=15$ PSI INTERNAL AND 15 PSI EXTERNAL

$D=2.5$ IN

$R=1.25$ IN

$L=93$ IN

MATERIAL SS304

$S=18750$ PSI

$E=.65$

ASSUME $T=.125$ IN (MINIMUM WALL THICKNESS ALLOWED BY DIV. 2)

USING UG-28

$D/T=2.5/.125=20$

$L/D=93/2.5=37.2$

FROM FIGURE 5-UGC-28.0 FACTOR $A=.0029$

FROM FIGURE 5-UHA-28.1 FACTOR $B=12100$

$PA=4*B/(3*(D/T))=4*12100/(3*20)=806.66$ PSI

USING UG-27

FOR CIRCUMFERENTIAL STRESS:

$P=S*E*T/(R+.6*T)=18750*.65*.125/(1.25+.6*.125)=1149.76$ PSI

FOR LONGITUDINAL STRESS:

$P=2*E*S*T/(R-.4*T)=2*.65*18750*.125/(1.25-.4*.125)=4062.5$ PSI

$PA>P$ $806.6>15$ AND $1149.7>15$ THEREFORE THE WALL THICKNESS IS ADEQUATE

PART 5

GIVEN: $P=40$ PSI INTERNAL AND 15 PSI EXTERNAL

$R=L=193.5$ IN

MATERIAL SS304

$S=18750$ PSI

$E=.65$

ASSUME $T=.625$ IN

USING UG-33

$A=.125/(R/T)=.125/(193.5/.625)=.000403$

FROM FIGURE 5-UHA-28.1 FACTOR $B=5500$

$PA=B/(R/T)=5500/(193.5/.625)=17.76$ PSI

USING UG-32

$P=S*E*T/((.885*L+.1*T))=18750*.65*.625/((.885*193.5+.1*.625))=44.46$ PSI

$PA>P$ $17.76>15$ AND $44.46>40$ THEREFORE THE WALL THICKNESS IS ADEQUATE

PART 6 AND PART 8

GIVEN: P=15 PSI INTERNAL AND 15 PSI EXTERNAL

R=L=204 IN

MATERIAL SS304

S=18750 PSI

E=.65

ASSUME T=.625 IN

USING UG-33

$A = .125 / (R/T) = .125 / (204 / .625) = .00038$

FROM FIGURE 5-UHA-28.1 FACTOR B=5200

$PA = B / (R/T) = 5200 / (204 / .625) = 15.93 \text{ PSI}$

USING UG-32

$P = S * E * T / (.885 * L + .1 * T) = 18750 * .65 * .625 / (.885 * 204 + .1 * .625) = 42.18 \text{ PSI}$

$PA > P$ 15.93 > 15 AND 42.18 > 15 THEREFORE THE WALL THICKNESS IS
ADEQUATE

PART 7

GIVEN: P=40 PSI EXTERNAL AND 15 PSI INTERNAL

R=L=193.5

MATERIAL SS304

S=18750 PSI

E=.65

ASSUME T=1.75 IN

USING UG-33

$A = .125 / (R/T) = .125 / (193.5 / 1.75) = .00113$

FROM FIGURE 5-UHA-28.1 FACTOR B=9000

$PA = B / (R/T) = 9000 / (193.5 / 1.75) = 77.20 \text{ PSI}$

USING UG-32

$P = S * E * T / (.885 * L + .1 * T) = 18750 * .65 * 1.75 / (.885 * 193.5 + .1 * 1.75) = 118.02 \text{ PSI}$

$PA > P$ 77.20 > 40 AND 118.02 > 15 THEREFORE THE WALL THICKNESS IS
ADEQUATE

PART 9

GIVEN: P=40 PSI INTERNAL AND 15 PSI EXTERNAL
R=L=100 IN
MATERIAL SS304
S=18750 PSI
E=.65
ASSUME T=.42 IN

USING UG-33

$A = .125 / (R/T) = .125 / (100 / .42) = .000525$
FROM FIGURE 5-UHA-28.1 FACTOR A=6600
 $PA = B / (R/T) = 6600 / (100 / .42) = 27.72 \text{ PSI}$

USING UG-32

$P = S * E * T / (.885 * L + .1 * T) = 18750 * .65 * .42 / (.885 * 100 + .1 * .42) = 57.81 \text{ PSI}$
 $PA > P \quad 27.72 > 15 \text{ AND } 57.81 > 40$ THEREFORE THE WALL THICKNESS IS
ADEQUATE

PART 10

GIVEN: 15 PSI INTERNAL AND 15 PSI EXTERNAL
R=L=100 IN
MATERIAL SS304
S=18750 PSI
E=.65
ASSUME T=.42 IN

USING UG-33

$A = .125 / (R/T) = .125 / (100 / .42) = .000525$
FROM FIGURE 5-UHA-28.1 FACTOR A=6600
 $PA = B / (R/T) = 6600 / (100 / .42) = 27.72 \text{ PSI}$

USING UG-32

$P = S * E * T / (.885 * L + .1 * T) = 18750 * .65 * .42 / (.885 * 100 + .1 * .42) = 57.81 \text{ PSI}$
 $PA > P \quad 27.72 > 15 \text{ AND } 57.81 > 15$ THEREFORE THE WALL THICKNESS IS
ADEQUATE

IT SHOULD BE NOTED THAT PARTS 7 AND 9 FORM ONE HEAD AND PARTS
8 AND 10 FORM ANOTHER HEAD. ASME CODE DIVISION 1 DOES NOT
ADDRESS THESE GEOMETRIES THEREFORE AN ANALYSIS USING FINITE
ELEMENT TECHNIQUE WAS USED TO DETERMINE THE WALL THICKNESSES
AND REINFORCEMENT RINGS. AS A ROUGH CHECK THE WALL THICKNESSES
FROM THE FINITE ELEMENT WORK WAS USED AS GIVEN FOR UG-32 AND
UG-33 AND ASSUME THE HEADS APPROXIMATES TORISPHEREICAL HEADS.