QA RECORD



# CALCULATION OF ASME CODE COVERAGE FOR SECTION XI NDE EXAMINATIONS

"QUALITY RELATED"



Prepared By: Thomas L. Stocklem Date: 8-11-97

Technical Review: Joel W. Whitaker NDE Level III, Date: 8-11-97

ISO Approval: Leon L. Lemm Date: 8-15-97

| Rev. No. | Date | Description |
|---|---|---|
| 0 | 4/3/96 | Initial issue. |
| 1 | 8/15/97 | Incorporate TC 97-09. |

1.0 Scope

The scope of this procedure is to provide generic guidelines for calculating the ASME Section XI code coverage obtained during volumetric and surface examinations. This procedure incorporates the requirements of Code Case N-460.

2.0 Purpose

This procedure applies to the calculation of ASME Section XI Code coverage for vessel welds, piping welds, and integral attachments. This procedure applies to personnel performing surface or volumetric examinations and may be used as a guide when calculating the examination coverage for preservice and inservice examinations when the coverage is less than that required by ASME Section XI. Coverage limitations may be due to an obstruction, interference, geometric configuration or other applicable reason.

3.0 References

3.1 ASME Section XI 1989 Edition

3.2 ASME Code Case N-460

4.0 Definitions

4.1 Examination Coverage- The percentage of the examination surface or volume obtained during the performance of the examination.

4.2 Examination Surface- The surface of the weld and base material required to examined by ASME Section XI using a surface examination method.

4.3 Examination Volume- The volume of weld and base material required to be examined by ASME Section XI using a volumetric examination method.

4.4 Scan Limitation- A limit on the ability to scan the surface(s) as required by procedure.

4.5 Surface Limitation- A limit on the ability to perform a surface examination of the required surface(s) because of an interference.

4.6 Volumetric Limitation- A limit on the ability to scan the required examination volume because of the geometric configuration, a physical interference, or a metallurgical condition of the material being examined.

5.0 General

5.1 During the performance of inservice inspections, ASME Section XI requires examination coverage to be essentially 100% of the weld area or volume. For examination coverage less than 100%, TVA has implemented ASME Code Case N-460 which states that when the entire examination volume or area cannot be examined due to interference by another component or part geometry, a reduction in examination coverage for Class 1 or Class 2 welds may be accepted provided the reduction in coverage for that weld is less than 10%.

5.2 Surface examinations are typically conducted on the weld area plus a defined amount of base material on each side of the weld. Volumetric examinations specify a particular volume to be examined. The Section XI required examination volume or surface examination area for each type of weld is depicted in figures of IWB-2500 or IWC-2500 as applicable. As depicted for piping welds, volume width generally constitutes the weld plus 1/4t on each side while volume thickness generally constitutes the lower 1/3 of the piping thickness for the length of the weld. The exception normally includes code category B-O which includes the weld plus 1/2 inch and full volume for the length of the weld. As depicted, for vessel welds, the volume width generally constitutes the weld plus 1/2t on each side of the weld while volume thickness generally constitutes the entire component thickness (i.e. full volume). The volume changes with variations in weld configuration (e.g. transition between different pipe thickness or vessel weld configurations).

5.3 The Section XI required examination volume or area shall be verified prior to calculation of the limitation.

6.0 Documenting and Calculating Examination Coverage

6.1 While performing a surface or ultrasonic examination, the NDE Examiner shall make every attempt to examine 100 percent of the examination area or volume.

6.2 When practical, the two beam path directions for ultrasonic examinations should be performed from two sides of the weld or additional angles employed in order to maximize coverage.

6.3 If 100% percent of the examination surface or volume cannot be examined, the NDE Examiner should perform the following under the direction of the inspection coordinator or the NDE Level III:

6.3.1 Perform additional examinations with higher angles in order to maximize cover for ultrasonic exams.

6.3.2 Perform another surface method (i.e., PT in lieu of MT) in order to maximize coverage.

6.3.3 Perform alternative NDE methods if applicable.

6.4 The examiner shall accurately document all limitations, obstructions, interferences, geometric configurations or other applicable reasons for not obtaining the required code coverage.

6.5 The examiner shall document the limitation on a sketch. Examination coverage estimates may be performed by the examiner or the reviewer.

7.0 Calculation Basis

7.1 Volumetric Examinations- Piping Welds and Vessels less than 2 inches in thickness

a) For welds with access from both sides, each of the four required scans are equal to 25%.

b) For welds with access from one side only due to interference/configuration (e.g. pipe to valve), the axial scan (scan 3 or 4) equals 50% and the circumferential scans (scan 5 and 6) each equal 25% for total of 100%.

c) Examination volume coverage may be increased as previously discussed or by use of refracted longitudinal wave techniques on stainless steel or dissimilar metal welds. Use of refracted longitudinal waves to penetrate stainless steel weld material will increase the examination volume coverage by the amount depicted on the examination coverage drawing.

d) The effects of adjacent component interferences (e.g. welded lug attachments) along the weld length are also taken into account with the reduction in coverage identified as a percentage of reduced volume.

7.2 A typical method for calculating coverage due to ultrasonic piping limitations is contained in Attachments 2 and 2A.

8.0 Surface Examinations - Piping Welds And Integral Attachments

8.1 Examination area coverage calculations are based upon one of the following suppositions:

a) The total examination area is calculated, typically length x width, then the total area of limitation or interference is subtracted from the total examination area.

b) The area of achieved coverage achieved is divided by the total examination area for percentage of examination achieved.

8.2 A typical method for calculating surface examinations is contained in Attachment 4.

9.0 Ultrasonic Examinations - Vessel Welds

9.1 Examination volume coverage calculations are based upon the following suppositions:

a) To achieve full examination coverage nine different scans are required for a typical nozzle examination. The following may be used for other vessel configurations:

1) 0 degree (weld metal scan)
2) 45 degree Transverse-scan from vessel side of the weld
3) 45 degree Transverse-scan from nozzle side of the weld
4) 60 degree Transverse-scan from vessel side of the weld
5) 60 degree Transverse-scan from nozzle side of the weld
6) 45 degree Parallel-scan CW direction
7) 45 degree Parallel-scan CCW direction
8) 60 degree Parallel-scan CW direction
9) 60 degree Parallel-scan CCW direction

9.2 Attachment 3 describes ASME code compliance for full volume examination coverage for transverse scans in vessel applications.

9.3 Typical methods for calculating coverage due to ultrasonic vessel limitations is contained in Attachments 3A, 3B, 3C, and 3D.

10.0 Responsibilities

10.1 The examiner or designee shall document the amount of code coverage obtained on Attachment 1 after all necessary steps to perform additional examinations has been completed in order to maximize coverage.

10.2 Attachment 1 shall be reviewed by another individual with the same or higher NDE certification.

10.3 The NDE Level III or data reviewer shall review Attachment 1 in order to verify that the information is accurate and correct.

10.4 The NDE Level III may recalculate the examination coverage to obtain a more accurate value of the examination surface or volume examined. The calculation shall be documented on the exam report.

10.5 The NDE Level III may require an alternate examination technique or method, or request that the interference be removed. For nozzle examinations, supplemental scans from the nozzle bore or flange face may provide complete coverage of the weld.

10.6 If the examination coverage indicates less than 90 percent of the required examination volume or surface, the site ISI supervisor shall be notified.

10.7 The site ISI supervisor shall ensure that examination results are accurately documented and incorporate results into a Request for Relief if necessary.

ATTACHMENT 1

| TENNESSEE VALLEY AUTHORITY | EXAMINATION SUMMARY AND RESOLUTION SHEET | REPORT NO. R- |
|---|---|---|

PROJECT: _____ UNIT: _____
SYSTEM: _____
WELD I.D.: _____
CONFIG: _____ TO: _____
FLOW
PROCEDURE: N- _____ REV.: _____ TC: _____
NDE METHOD: ☐ UT ☐ PT ☐ MT ☐ VT

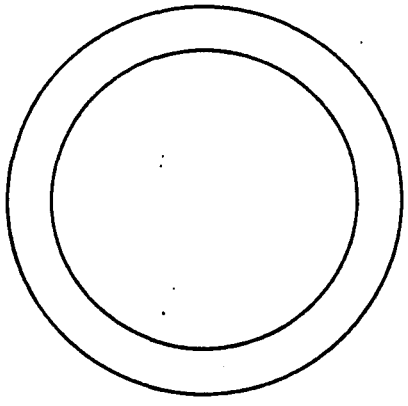
EXAMINER: _____ LV: _____
EXAMINER: _____ LV: _____
EXAMINER: _____ LV: _____
EXAMINER: _____ LV: _____
CAL. BHT NO'S: _____

EVALUATOR: _____ LEVEL: _____ DATE: _____
CONCURRENCE: _____ LEVEL: _____ DATE: _____

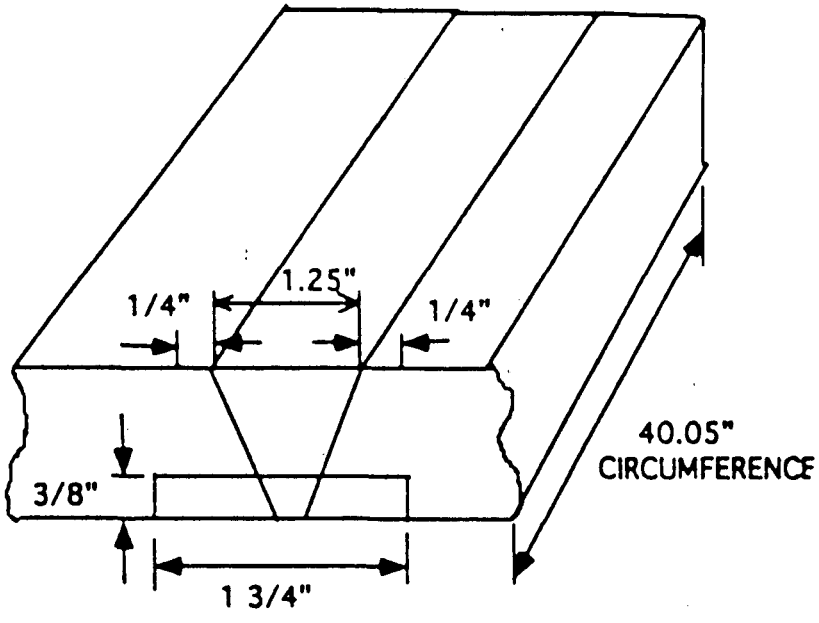
ANI
DATE:
PAGE ___ OF ___

TVA 19870C (NP 7/92)

ATTACHMENT 2



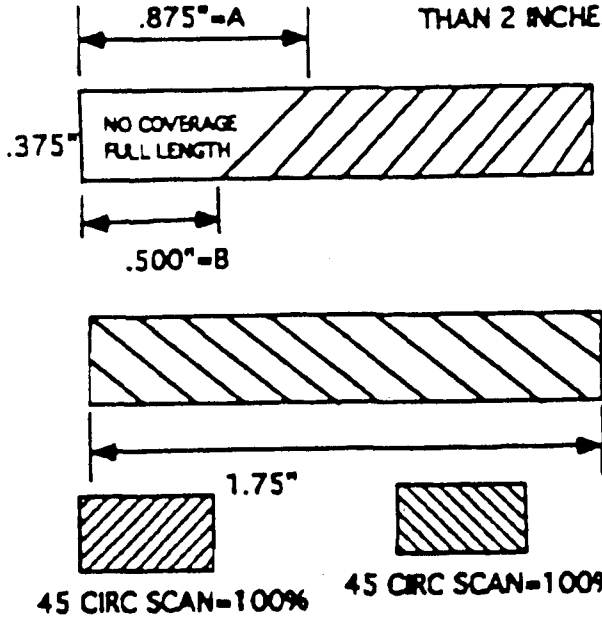
12" Schedule 140
Outside Diameter= 12.75"
Wall thickness= 1.125"
Circumference= 40.05"




TOTAL VOLUME= (.375)(1.75)(40.05)
TOTAL VOLUME= 26.28 cu. inches

ATTACHMENT 2A

ATTACHMENT 2A - PIPING/VESSELS-LESS THAN 2 INCHES IN THICKNESS




45 DEGREE COVERAGE DOWNSTREAM

45 DEGREE COVERAGE UPSTREAM

EXAMPLE 2
NO COVERAGE FOR 6 INCHES IN LENGTH DUE TO ATTACHMENT

A=.2578 SQ.IN
VOL.=(.2578)(6")
VOL.=1.5468 CU.IN.

NO COVERAGE=1.5468/26.28
NO COVERAGE=.0525(100)=5.88%
COVERAGE=100-5.25=94.75%

100%
100%
100%
94.75%

98.69% TOTAL COVERAGE

EXAMPLE 1
NO COVERAGE, FULL LENGTH ASSUME ALL OTHER SCANS =100%
100%+100%+100%+60.74=360.74

A=H/2(A+B)
A=.375/2(.875+.5)
A=.2578
VOL.=(.2578)(40.05)
VOL.=10.32CU.IN.

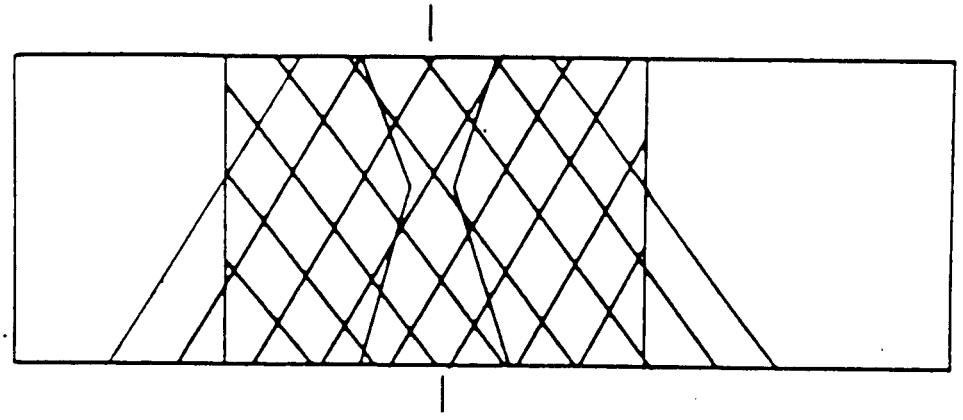
360.74/4= 90.185% TOTAL EXAM COVERAGE

EXAMPLE 1

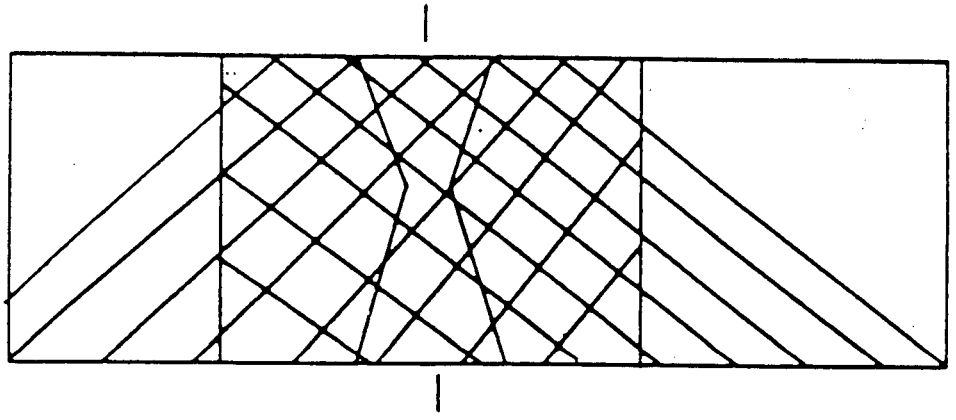
FULL COVERAGE=(.375)(1.75)(40.05)=26.28 CU.IN.

NO COVERAGE=10.32/26.28
NO COVERAGE=.3926 (100)=39.26%
COVERAGE=100-39.26=60.74%

ATTACHMENT 3



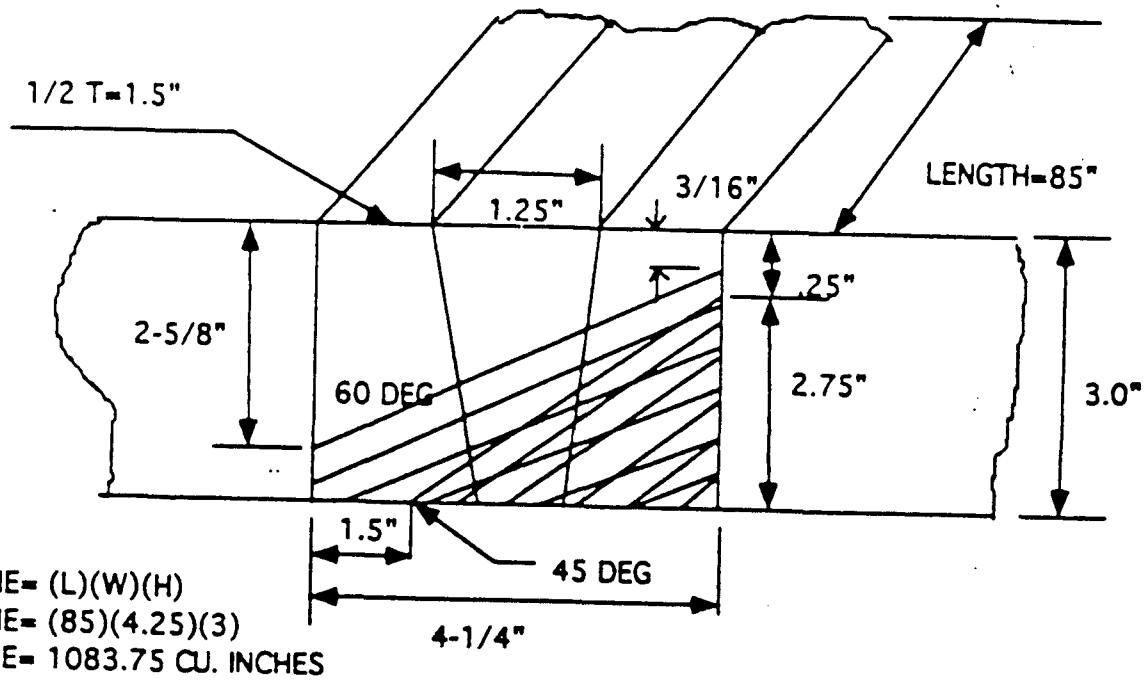
45 DEGREE-100% ASME SECTION XI COVERAGE (T-SCAN)



60 DEGREE-100% ASME SECTION XI COVERAGE (T-SCAN)

THE ASME SECTION XI CODE REQUIRES THE WELD TO BE COMPLETELY EXAMINED IN TWO DIRECTIONS. THE ABOVE ARE EXAMPLES OF100% BIDIRECTIONAL COVERAGE (T-SCANS).

ATTACHMENT 3A



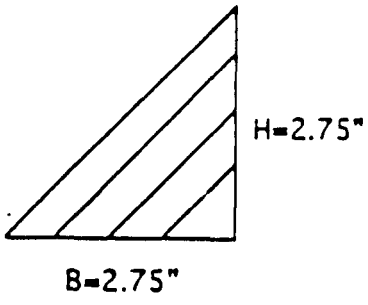

TOTAL VOLUME= (L)(W)(H)
TOTAL VOLUME= (85)(4.25)(3)
TOTAL VOLUME= 1083.75 CU. INCHES

EXAMPLE 1-45T AND 60T SCANS AS SHOWN LIMITED FOR FULL LENGTH.

EXAMPLE 2- 45T AND 60T SCANS AS SHOWN LIMITED FOR A LENGTH OF 12 INCHES.

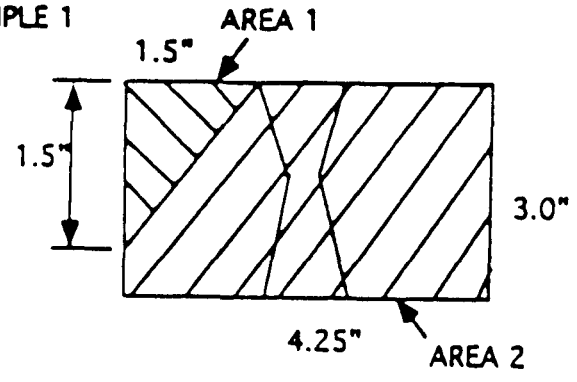
ATTACHMENT 3B

EXAMPLE 1




1.0-DETERMINE AREA EXAMINED.
A=1/2(B)(H)
A=1/2(2.75)(2.75)=3.78 SQ.IN.

VOL.=(3.78)(85IN.)= 321.3 CUBIC IN.




TOTAL AREA=(3)(4.25)=12.75
VOL.=(12.75)(85)=1083.75 IN

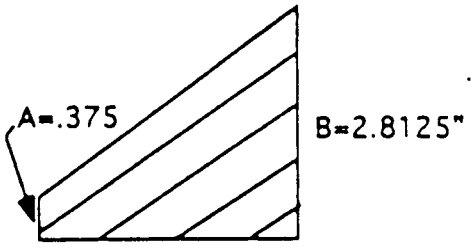
DETERMINE AREA REQUIRED TO BE EXAMINED BY THE CODE.

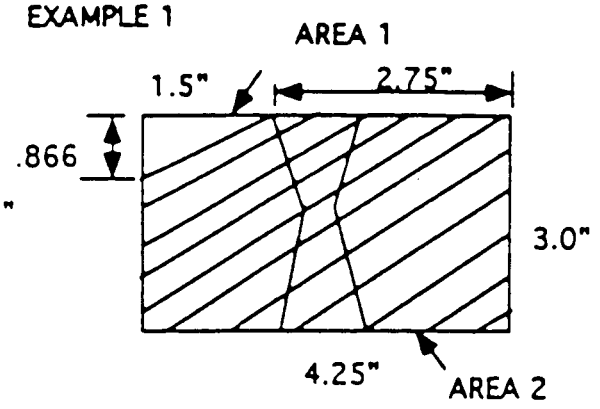
AREA 1=1/2BH=1/2(1.5)(1.5)=1.125
AREA 2= TOTAL AREA-AREA 1
AREA 2= 12.75-1.125 = 11.625 SQ.IN.
VOLUME AREA 2= (11.625)(85)
VOLUME AREA 2= 988.125 CU.IN.

2.0 DETERMINE 45 DEGREE COVERAGE
COVERAGE=VOLUME COVERED/VOLUME REQUIRED
45 DEGREE COVERAGE=321.3/988.125=.3251(100)= 32.51%

ATTACHMENT 3C

EXAMPLE 1




1.0-DETERMINE AREA EXAMINED.

A=H/2(A+B)

A=4.25/2(.375+2.8125)=6.77 SQ.IN.

VOL.=(6.77)(85IN.)= 575.45 CUBIC IN.

TOTAL AREA=(3)(4.25)=12.75

VOL.=(12.75)(85)=1083.75 CU.IN.

DETERMINE AREA REQUIRED TO BE EXAMINED BY THE CODE.

AREA 1=1/2BH=1/2(.866)(1.5)=

AREA= .649 SQ.IN.

VOL=(.649)(85)=55.165 CU.IN.

AREA 2= TOTAL AREA-AREA 1

AREA 2= 12.75 SQ.IN. - .649 SQ.IN.= 12.10 SQ.IN.

VOL_AREA2 = (12.10)(85)=1028.585 CU.IN.

DETERMINE TOTAL EFFECTIVE COVERAGE

0- 100%
45T-29.76%
45T-100%
60T-55.9%
60T-100%
45Pcw-100%
45Pccw-100%
60Pcw-100%
60Pccw-100%

TOTAL=785.66
AVERAGE=785.66/9
AVERAGE=87.29%

2.0 DETERMINE 45 DEGREE COVERAGE

COVERAGE=VOLUME COVERED/VOLUME REQUIRED

45 DEGREE COVERAGE=575.45/1028.585=.559(100)= 55.9%

ATTACHMENT 3D

## EXAMPLE 2

45 DEGREE
AREA NOT COVERED= (AREA 2)-(AREA EXAMINED)
AREA NOT COVERED= 11.625 SQ.IN.-3.78 SQ.IN=7.845 SQ.IN.
VOLUME NOT COVERED= (7.845 SQ.IN.)(12IN.)=94.14 CU.IN.
45 DEG. (NO COVERAGE)= 94.14/1083.75*100=8.68%
60 DEG. (NO COVERAGE)= 67.44/1083.75*100=6.22%

45 DEG. (COVERAGE)= 100-8.68=91.32%
60 DEG. (COVERAGE)=100-6.22=93.78%

DETERMINE TOTAL COVERAGE FOR WELD

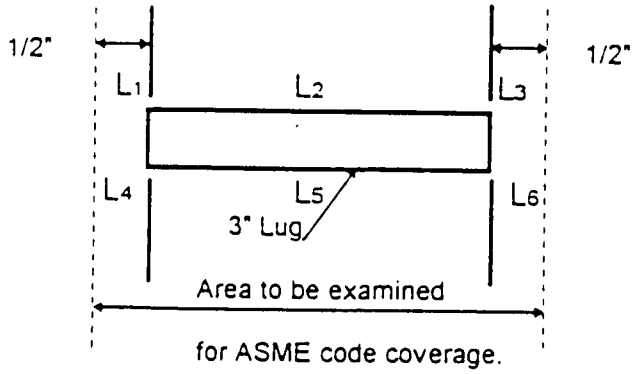
0= 100%
45T=91.32%
45T=100
60T=93.78%
60T=100%
45Pcw=100%
45Pccw=100%
60Pcw=100%
60Pccw=100%

TOTAL =885.1
TOTAL AVERAGE=88.5.1/9
TOTAL AVERAGE=98.34%

ATTACHMENT 4

Examples for calculating code coverage when examining integral attachments:

EXAMPLE 1: Lug welded on Two sides!



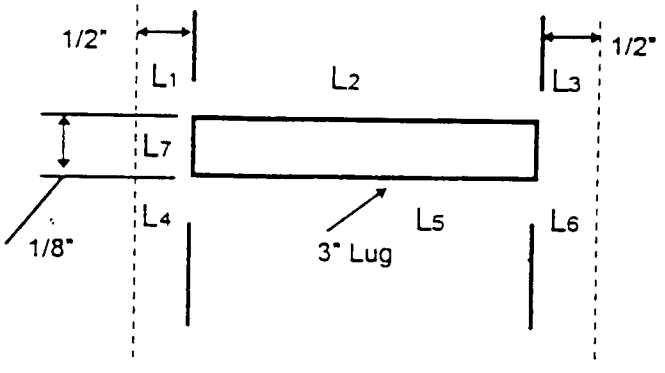

Hanger clamp around pipe on this side of Lug.

Total weld length to be examined = $L_1 + L_2 + L_3 + L_4 + L_5 + L_6$
Total weld length to be examined = 1/2 + 3 + 1/2 + 1/2 + 3 + 1/2 = 8"

Total weld length inaccessible = $L_3 + L_6$
Total weld length inaccessible = 1/2 + 1/2 = 1 "

Therefore, 7 inches were examined out of 8 giving a "per-cent coverage" of 7/8 = 87.5%

EXAMPLE 2: Lug welded on Three sides!




Clamp around pipe on this side of lug!

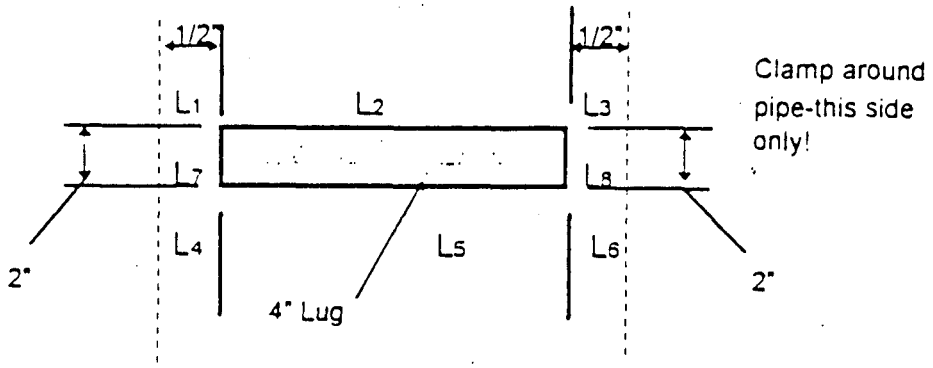
Total weld length to be examined = $L_1 + L_2 + L_3 + L_7 + L_4 + L_5 + L_6$
Total weld length to be examined = 1/2 + 3 + 1/2 + 1/8 + 1/2 + 3 + 1/2 = 8 1/8" (8.125")
Total weld length inaccessible = $L_3 + L_6$
Total weld length inaccessible = 1/2 + 1/2 = 1"

Therefore, 8.125 " were examined out of 9" so code coverage is 8.125/9 = 90.28%

ATTACHMENT 4A

Examples for calculating code coverage when examining integral attachments(cont.):

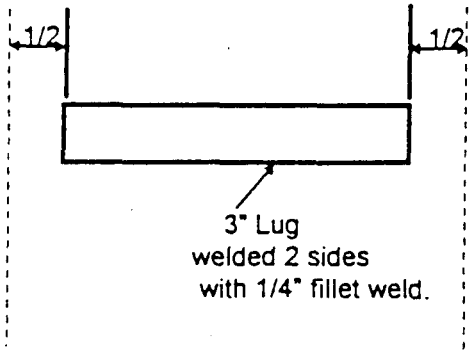
Example 3: Full penetration lugs




Total weld length to be examined = $L_1 + L_2 + L_3 + L_7 + L_4 + L_5 + L_6 + L_8$
Total weld length to be examined = 1/2 + 4 + 1/2 + 2 + 1/2 + 4 + 1/2 + 2 = 14"
Total weld length inaccessible = $L_3 + L_8 + L_6$
Total weld length inaccessible = 1/2 + 2 + 1/2 = 3"

Therefore, 11" were examined out of 14", so code coverage is 11/14 = 78.57%

Example 4: Lug coverage computation using **area** versus length. Use measurements in example 1 above!




From first example, total length = 8"
The width of weld face for this example is .350" plus 1/2" above and below weld toes, for a total of 1.350" weld width.
The required area of examination is then 8 long x 1.350 wide = 10.8 sq. in.
The length inaccessible is ( ½" + ½" = 1" length) so total area that is inaccessible is 1" x 1.350" (width) = 1.350 sq. in.
Therefore, calculate code coverage by dividing total area examined (9.45 sq in) by total area which should be examined (10.8 sq. in.) equals 87.5%. Same as in first example using length.