API 510 Preparatory Class

Lesson 1

Service Restrictions, Joint Efficiencies, Radiography

Lesson 1

Objectives

- Understand the service restrictions placed on weld joints based on service conditions.
- Identify weld joints by Categories (location in vessel).
- Identify welds by Types. (how made, double welded etc.).
- Determine the accept/reject values for weld imperfections located using radiography.
- Define the extent of radiography required by Code for a desired joint efficiency.

Lesson 1

Objectives

- Find weld joint efficiency (E) by using Table UW-12.
- Determine weld joint efficiencies based on RT markings.
- Determine the E to be used for calculating the required thickness or allowed pressure for Seamless Shell sections and Seamless heads.
- Understand the rules for using welded pipe and tubing.

UW-2 Service Restrictions
Page 114 Section VIII

(a) When vessels are to contain lethal **footnote 1** substances, either liquid or gaseous, all butt welded joints shall be fully radiographed, except under the provisions of UW-2(a)(2) and UW-2(a)(3) below, and UW-11(a)(4).

When fabricated of carbon or low alloy steel, such vessels shall be postweld heat treated.

footnote 1 When a vessel is to contain fluids of such a nature that a very small amount mixed or unmixed with air is dangerous to life…….

UW-2 Service Restrictions

If determined as lethal, ……

(1) The joints of various categories (see UW-3) shall be as follows.

(a) Except under the provisions of (a)(2) or (a)(3) below, *all joints of Category A shall be Type No. (1) of Table UW-12.*

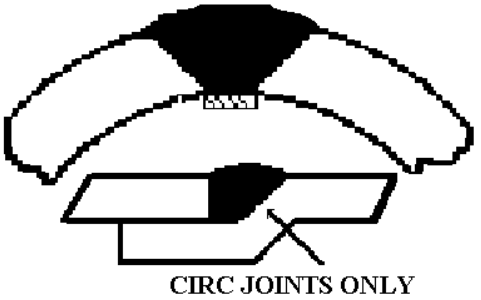
(b) *All joints of Categories B and C shall be Type No. (1) or No. (2) of Table UW-12.*

UW-2 Service Restrictions

These are the only two types which are considered acceptable for radiography by Section VIII Div.1

Type 1

Double Welded butt joint or equivalent. Backing if used must be removed.



Type 2

Single welded butt joint with backing which remains in place.

UW-3 Welded Joint Category Page 115

(a)The term "*Category*" as used herein defines the *location of a joint in a vessel,* ***but not the type of joint.***

(1) Category A. *Longitudinal welded joints within* the main shell, communicating chambers, transitions in diameter, or nozzles; any welded joint within a sphere, within a formed or flat head, or within the side plates of a flat-sided vessel; circumferential welded joints connecting hemispherical heads to main shells, to transitions in diameters, to nozzles, or to communicating chambers.

(2) Category B. *Circumferential welded joints within* the main shell, communicating chambers, nozzles, or transitions in diameter including joints between the transition and a cylinder at either the large or small end; circumferential welded joints connecting formed heads *other than hemispherical* to main shells, to transitions in diameter, to nozzles, or to communicating chambers.

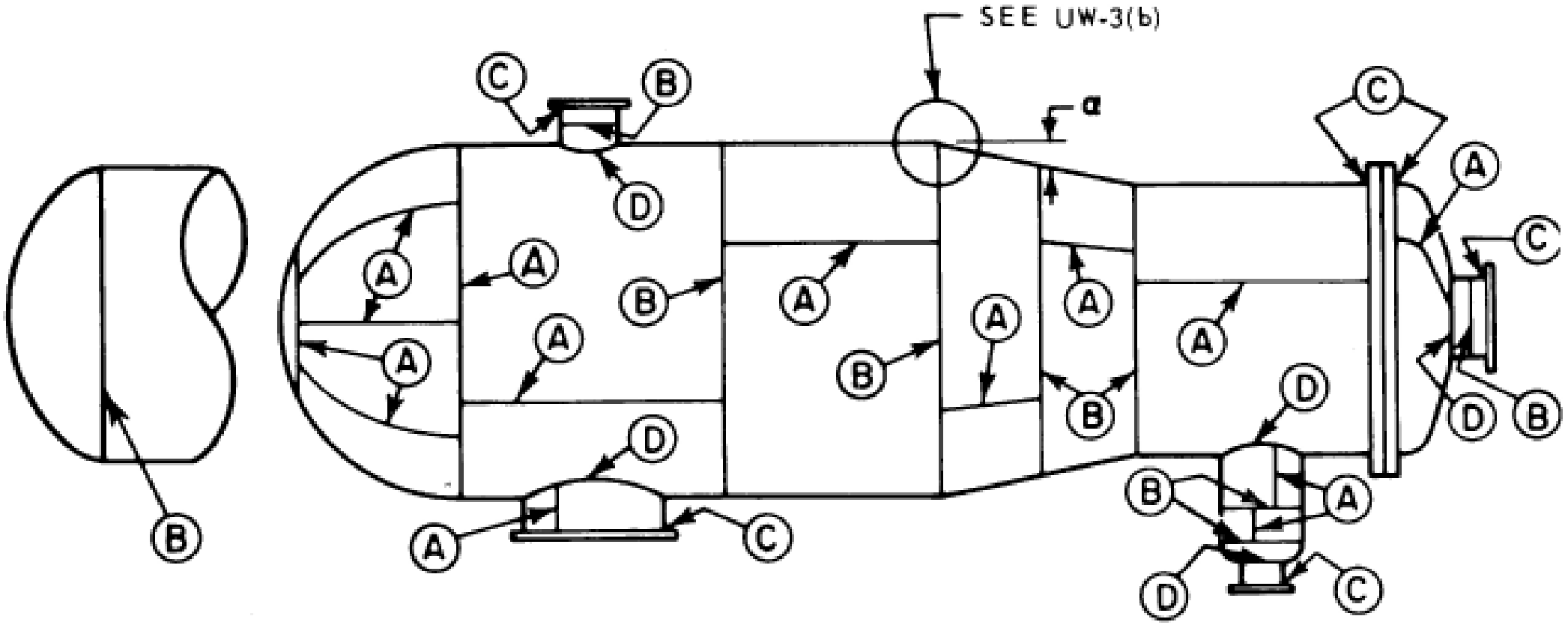
UW-3 Welded Joint Category

(3) Category C. Welded joints *connecting flanges*, Van Stone laps, tubesheets, or flat heads to main shell, to formed heads, to transitions in diameter, to nozzles, or to communicating chambers any *welded joint connecting one side plate to another side plate* of a flat sided vessel.

(4) Category D. Welded joints *connecting communicating chambers or nozzles* to main shells, to spheres, to transitions in diameter, to heads, or to flat-sided vessels, and those joints connecting nozzles to communicating chambers (for nozzles at the small end of a transition in diameter, see Category B).

UW-3 Welded Joint Category

(b) When butt welded joints are required elsewhere in this Division for Category B, *an angle joint* connecting a transition in diameter to a cylinder shall be considered as meeting this requirement *provided the angle* a (see Fig. UW-3) *does not exceed 30 deg*. All requirements pertaining to the butt welded joint shall apply to the angle joint.



UW-3 Welded Joint Category

One important note:

Hemispherical heads form a Category A joint between themselves and the other part, shell another hemispherical head etc.
Hemispherical Heads are **Never** considered Seamless by Code rules. The Category A weld made by attaching the Hemispherical Head to shell is considered part of the Head for calculation purposes.

Later on in this lesson we begin our discussion of formed Seamless Heads. The formed heads on the exam that are considered seamless are Torispherical and Ellipsoidal, Hemispherical is not seamless by Code.

Class Quiz

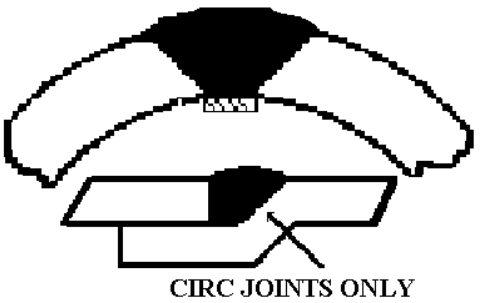
UW-2 Service Restrictions

1. Which of the following types of welds are required if a vessel is determined to be in lethal service?

a. Category A and B welds shall be of Type 1.
b. Category A and B welds must be of Type 1 or 2.
c. Category A shall be of Type 1 only, B and C can be of Type 1or Type 2.

2. Label these welds by Type.

_____ _____



Class Quiz

UW-2 Service Restrictions

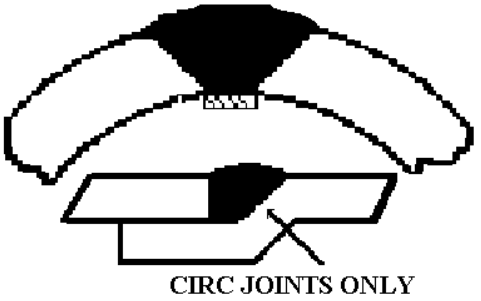
1. Which of the following types of welds are required if a vessel is determined to be in lethal service?

c. Category A shall be of Type 1 only, B and C can be of Type 1or Type 2.

2. Label these welds by Type.

Type 1

Type 2



Class Quiz

UW -3 Welded Joint Category

1. The category of a joint depends on:
   a. What kind of weld was made, fillet or butt.
   b. The process used to make the weld.
   c. Whether it is vertical or horizontal in the vessel
   d. None of the above.

2. A circumferential weld to attach a flange is what Category?
   a. D
   b. C
   c. E
   d. A

Class Quiz

UW -3 Welded Joint Category

1. The category of a joint depends on:
   d. None of the above.

2. A circumferential weld to attach a flange is what Category?
   b. C

Class Quiz

UW -3 Welded Joint Category

3. A circumferential weld used to attach a seamless head is of what Category?

a. B
b. C
c. E
d. A

4. The circumferential weld to attach a Hemispherical head to a shell is a Category ____.

Class Quiz

UW -3 Welded Joint Category

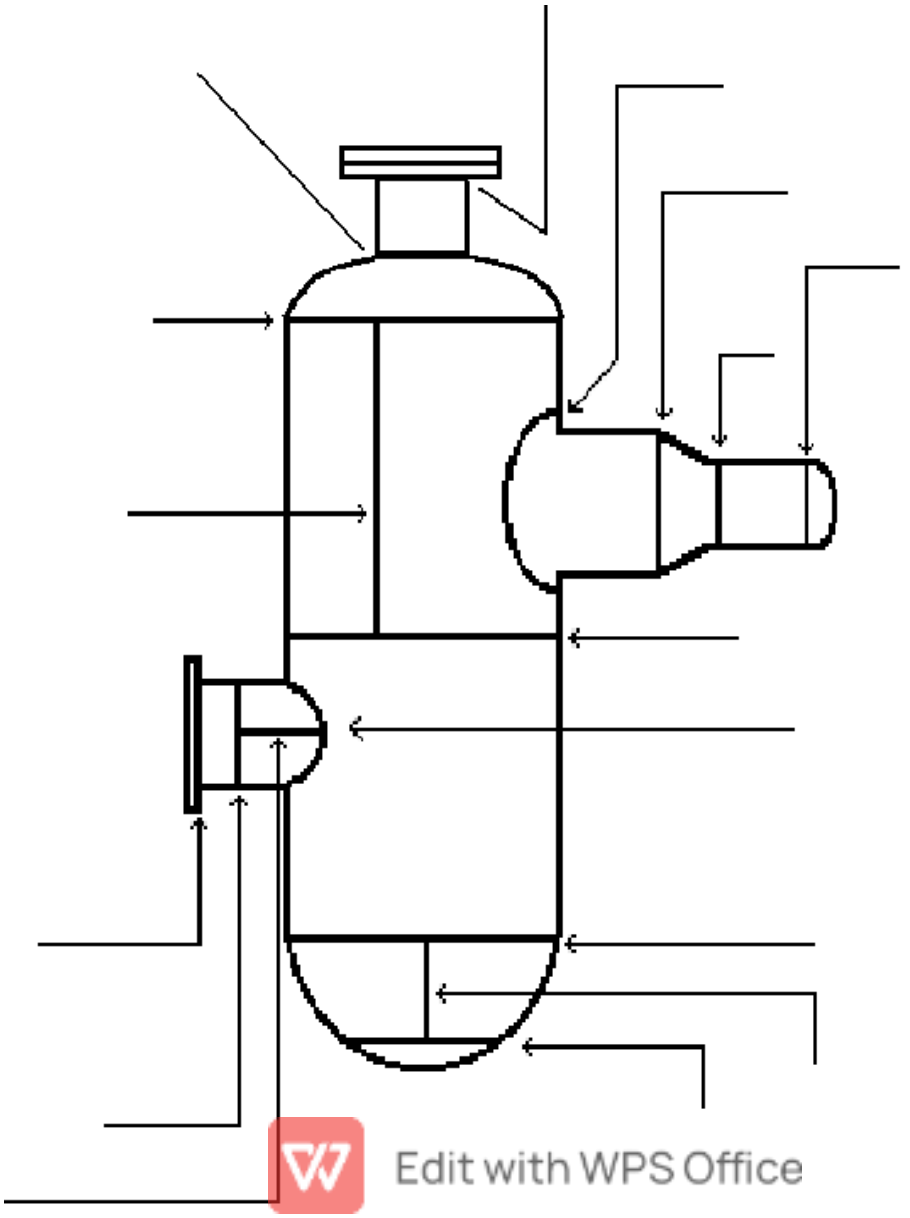
3. A circumferential weld used to attach a seamless head is of what Category?

   a. B

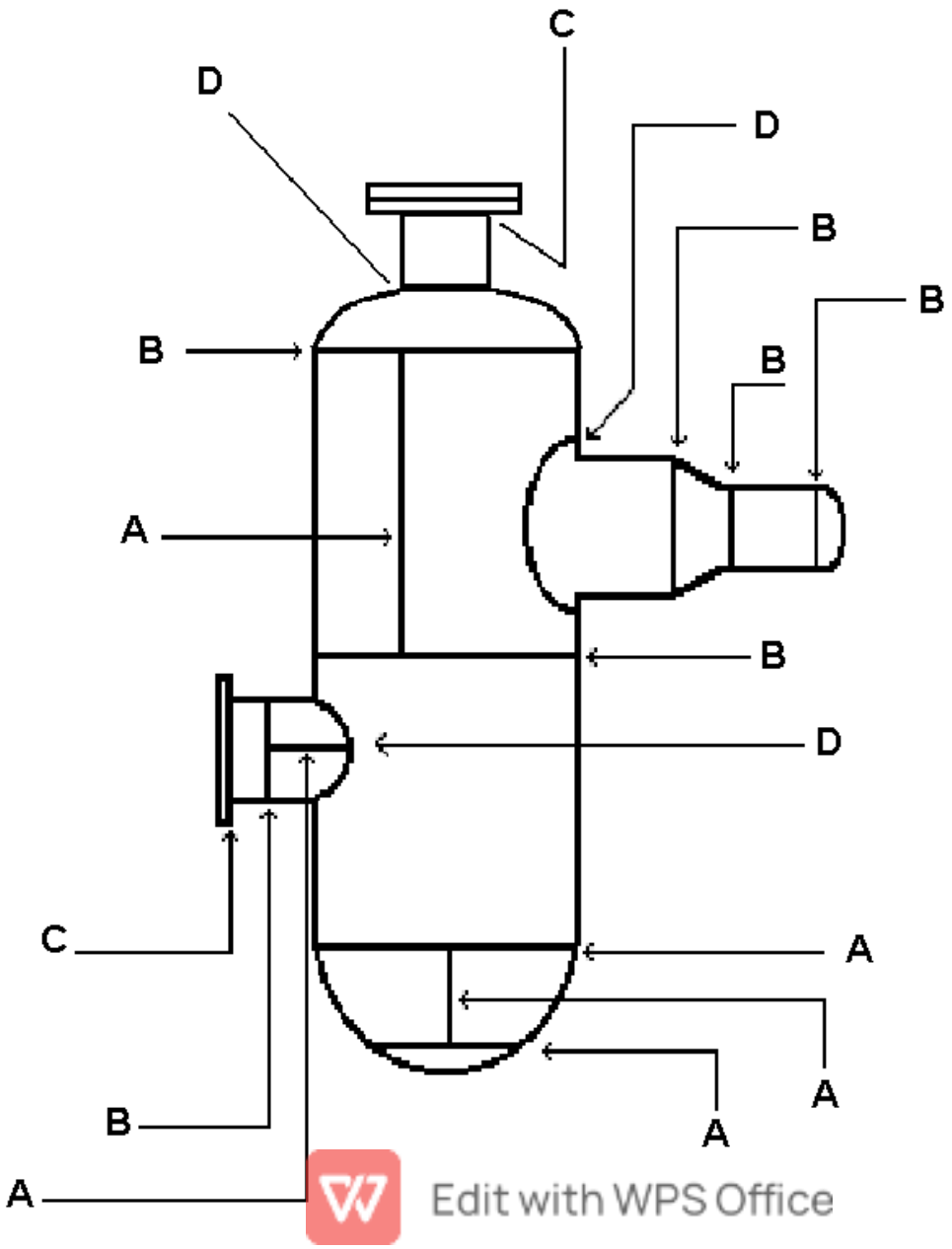
4. The circumferential weld to attach a Hemispherical head to a shell is a Category A .

5. Label these weld joints by Category

A,B, C or D



5. Label these weld joints by Category



UW-51 Radiographic and Radioscopic Examination of Weld Joints Page 152

(a) All welded joints to be radiographed shall be examined in accordance with Article 2 of Section V except as specified below.

(1) A complete set of radiographs and records, ……*shall be retained* by the Manufacturer *until the Manufacturer's Data Report has been signed by the Inspector*.

(2) The Manufacturer *shall certify that personnel have been qualified and certified* in accordance with their employer's written practice…… *SNT-TC-1A shall be used as a guideline.*

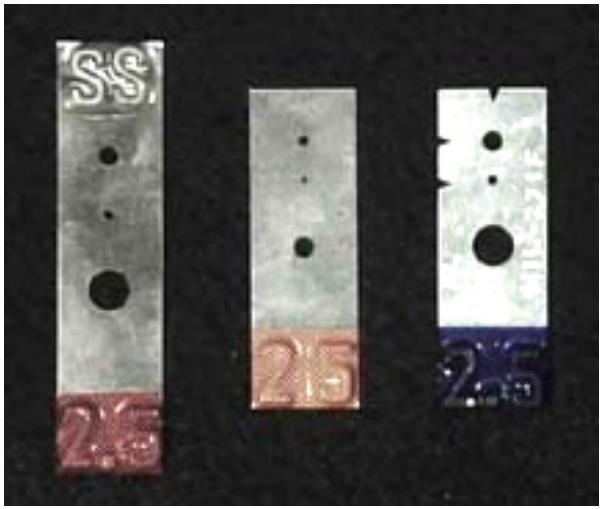
UW-51 Radiographic and Radioscopic Examination of Weld Joints

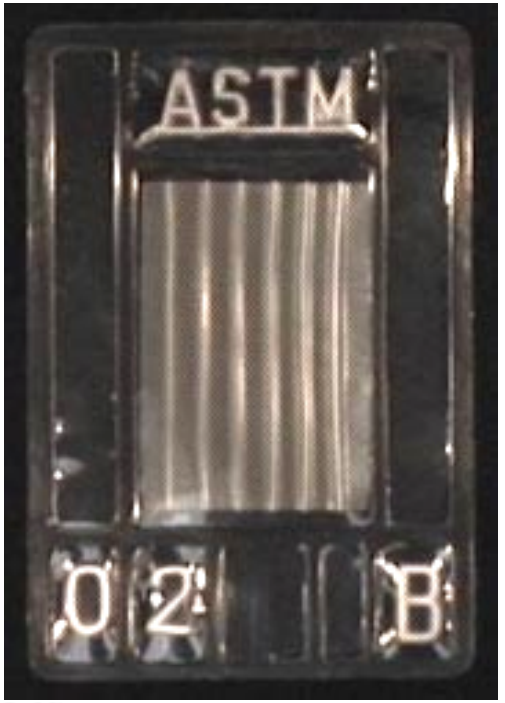
...Alternatively, the ASNT Central Certification Program (ACCP), or CP-189 may be used to fulfill the examination and demonstration requirements of SNT-TC-1A and the employer's written practice.

(3) A *written radiographic examination procedure is not required*. Demonstration of density and penetrameter image requirements on production or technique radiographs shall be considered satisfactory evidence of compliance.....

UW-51 Radiographic and Radioscopic Examination of Weld Joints

(4) The requirements of T-285 of Article 2 ….used only a guide. Final acceptance of radiographs shall be based on the *ability to see the prescribed penetrameter image and the specified hole or the designated wire of a wire penetrameter*.



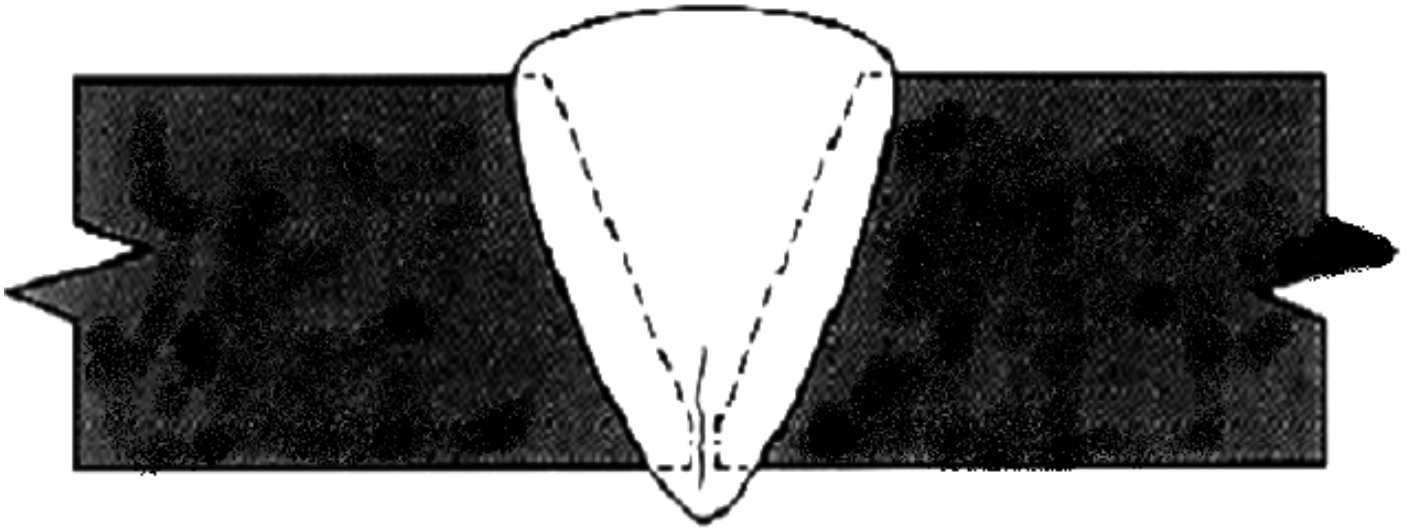


UW-51 Radiographic and Radioscopic Examination of Weld Joints

(b) Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the followingconditions and shall be repaired as provided in **UW-38**, and the repair radiographed to UW-51 or, at the option of the Manufacturer, ultrasonically examined in accordance with the method described in Appendix 12....

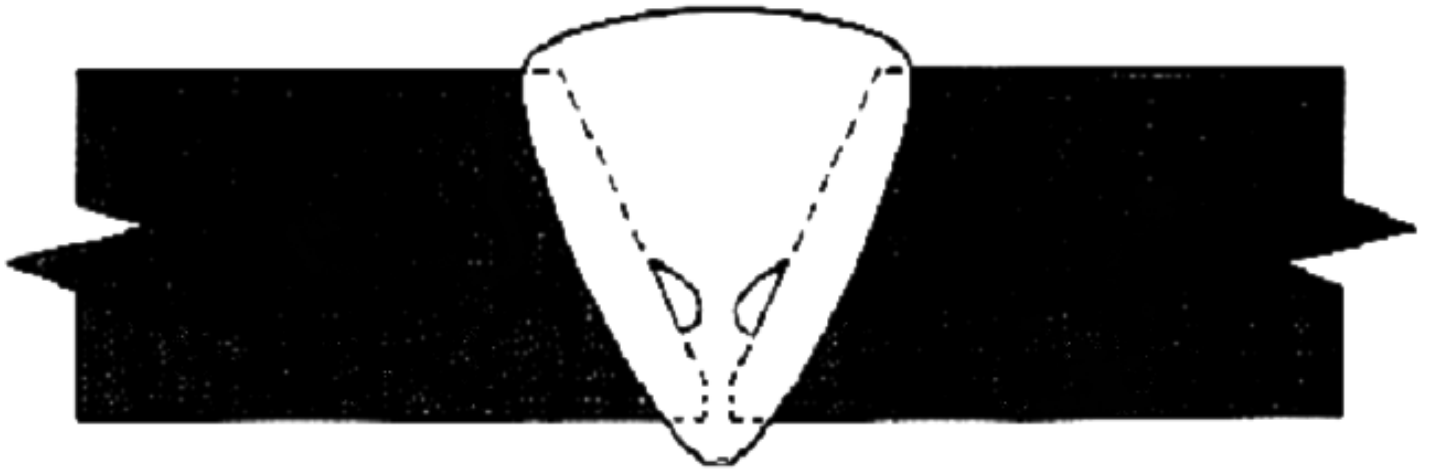
UW-51 Radiographic and Radioscopic Examination of Weld Joints

(1) any indication *characterized as a **crack** or zone of incomplete fusion or penetration* **;**



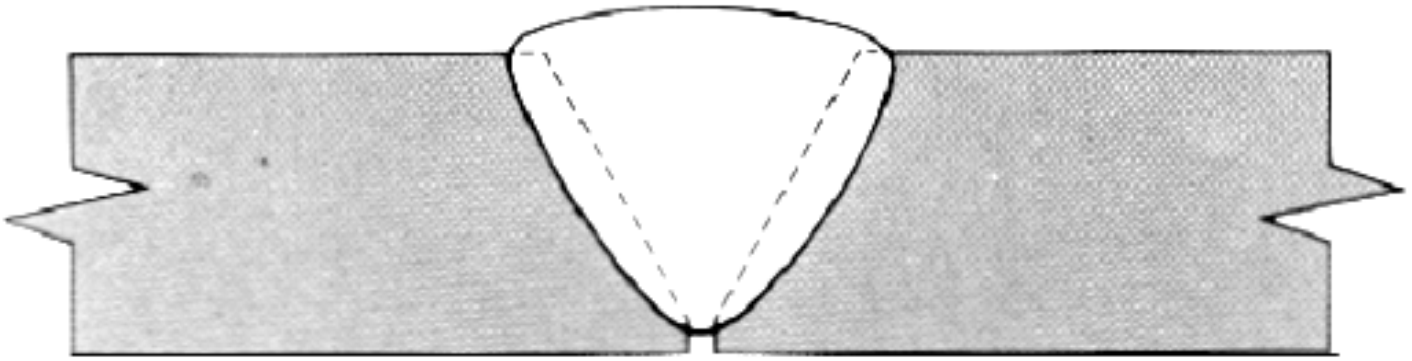
UW-51 Radiographic and Radioscopic Examination of Weld Joints

(1) any indication *characterized as a crack or zone of* ***incomplete fusion*** *or penetration* **;**



UW-51 Radiographic and Radioscopic Examination of Weld Joints

(1) any indication *characterized as a crack or zone of incomplete fusion or* ***penetration*** **;**



UW-51 Radiographic and Radioscopic Examination

(2) any other **elongated indication** on the radiograph which has length greater than:

(a) 1/4 in. for *t* up to 3/4 in.

(b) *1/3t* for *t* from 3/4 in. to 2-1/4 in.

(c) 3/4 in. for *t* over 2-1/4 in.

Where;

t = the thickness of the weld excluding any allowable reinforcement.

FLAW TYPE:

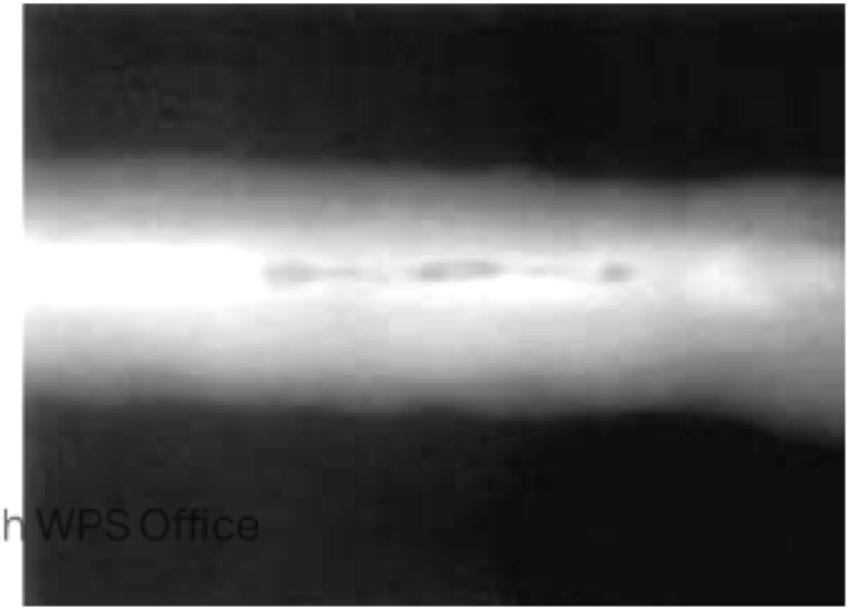
SLAG INCLUSION

DESCRIPTION:

Weld slag or the other foreign matter trapped in the weld metal. Usually formed by slag from a previous weld run that has not re-melted.

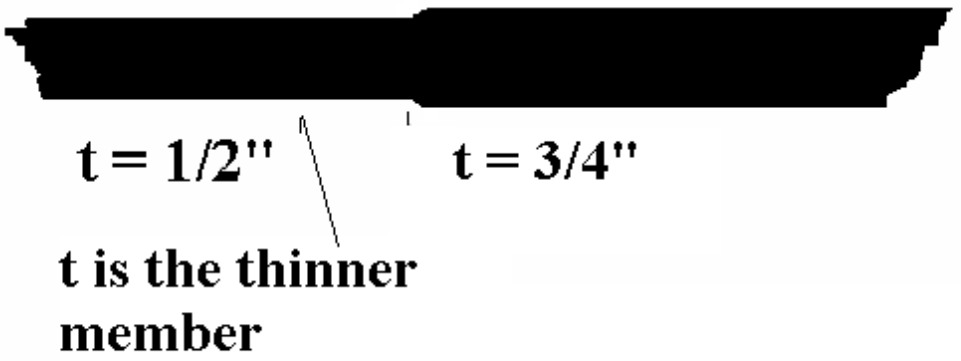
RADIOGRAPHIC IMAGE:

Dark indications with irregular shapes sometimes elongated with sharp pointed ends, usually following the line of the weld run.



UW-51 Radiographic and Radioscopic Examination of Weld Joints

For a butt weld joining two members having different thicknesses at the weld, *t* is the thinner of these two thicknesses. Since the value of t must be the lesser thickness this decreases the size of the maximum acceptable indication.



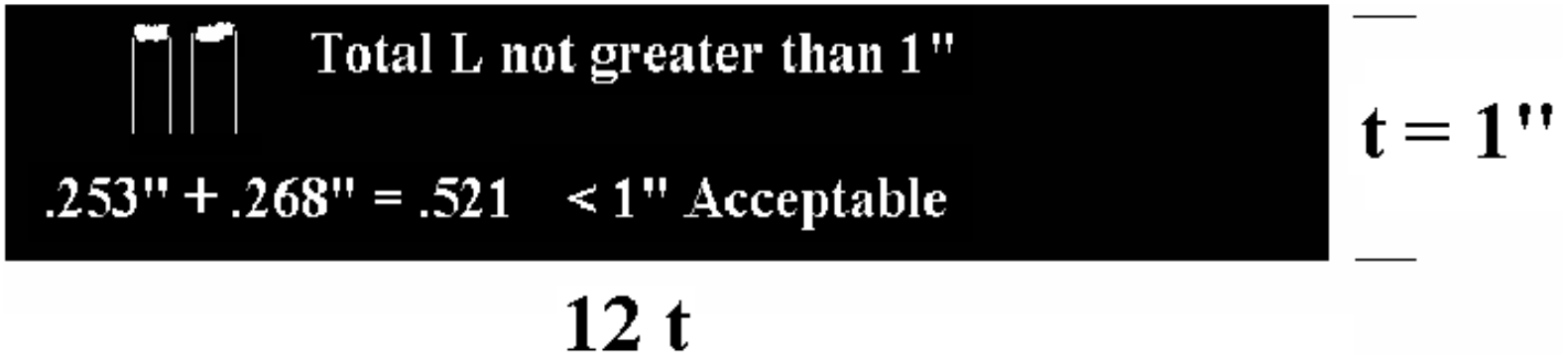
UW-51 Radiographic and Radioscopic Examination of Weld Joints

(3) any group of aligned indications that have an aggregate **(total)** length greater than *t* in a length of 12*t*,..

Example: t = 1” total length (L) cannot exceed 1” in 12”

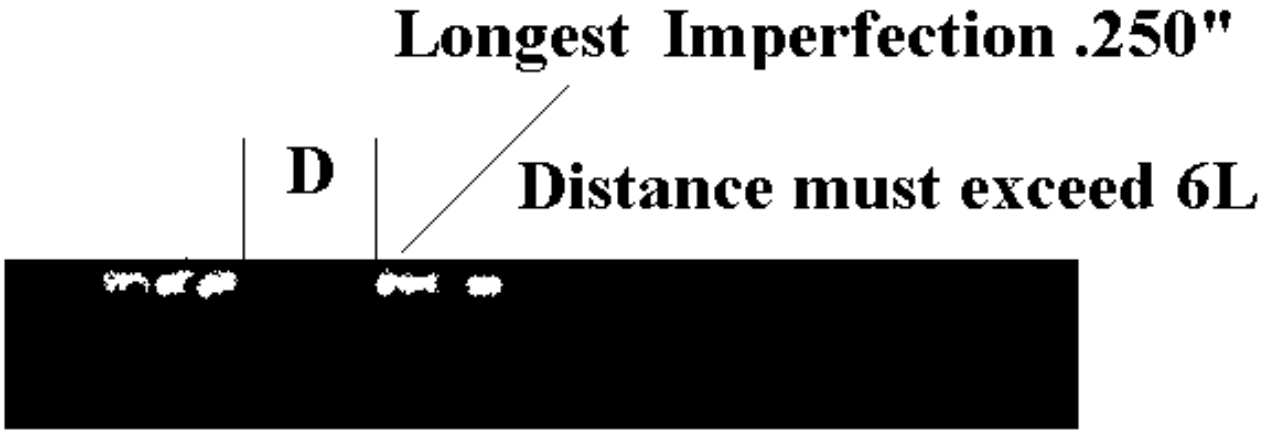
Also individual lengths cannot exceed the following:

(b)1/3*t* for *t* from 3/4 in. to 2-1/4 in. * In this example none of the individual indications can exceed 1/3 x 1” = 1/3” (.333”)



UW-51 Radiographic and Radioscopic Examination of Weld Joints

(3) ..*except* when the *distance between* the successive imperfections e*xceeds 6L where L is the length of the longest imperfection in the group*; * This means that if the two groups are isolated from each other they can be evaluated separately within a length of 12t.

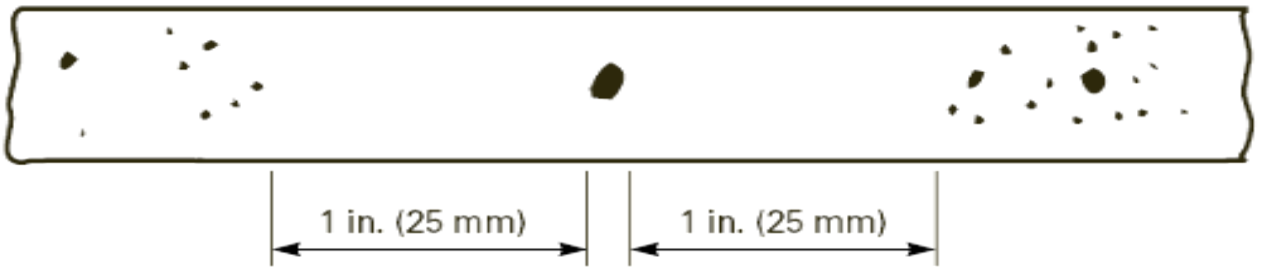


L = .250" 6L = 6 x .250 = 1.5"
D must be greater than 1.5" to consider the Imperfections separately

UW-51 Radiographic and Radioscopic Examination of Weld Joints

(4) *rounded indications* in excess of that specified by the acceptance standards given in *Appendix 4.*

Example from Appendix 4: More on this during the Section V Coverage.



(b) Isolated Indication [See Note (2)]

Class Quiz

UW-51 Radiographic and Radioscopic Examination of Weld Joints

1. All welded joints to be radiographed shall be examined in accordance with _____of Section _____except as otherwise specified.
2. A complete set of radiographs and records, shall be retained by the Manufacturer until the Manufacturer's Data Report has been signed by the_____.
   a. Manufacturer
   b. Inspector
   c. Manufacturer and Inspector
3. While reviewing a radiograph an elongated indication was found to have a length of .375" in a .750" thick plate weld. This indication is Rejectable because the maximum allowed is _____ for this thickness.

Solutions
UW-51 Radiographic and Radioscopic Examination of Weld Joints

1. All welded joints to be radiographed shall be examined in accordance with Article 2 of Section V except as otherwise specified.
2. A complete set of radiographs and records, shall be retained by the Manufacturer until the Manufacturer's Data Report has been signed by the Inspector.

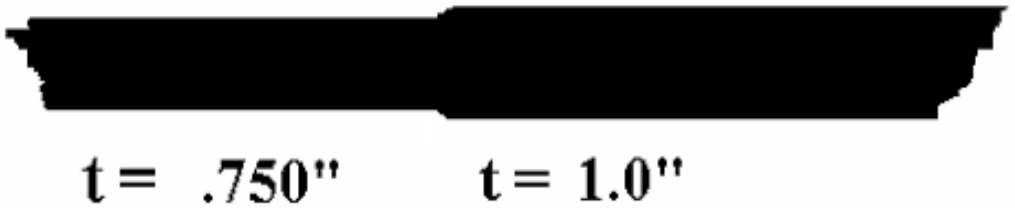
3. While reviewing a radiograph an elongated indication was found to have a length of .375" in a .750" thick plate weld. This indication is Rejectable because the maximum allowed is .250" for this thickness.

Class Quiz

Radiographic and Radioscopic Examination of Weld Joints

4. The welded joint below was radiographed and found to have an elongated indication that was .243” in length. The maximum allowable length of an indication for this combination of thicknesses is _____ and this weld considered _____.

a. 1/3 t and this weld is considered acceptable.
b. 1/4 in. and this weld is considered acceptable.
c. 1/4 in. and this weld is considered rejectable.

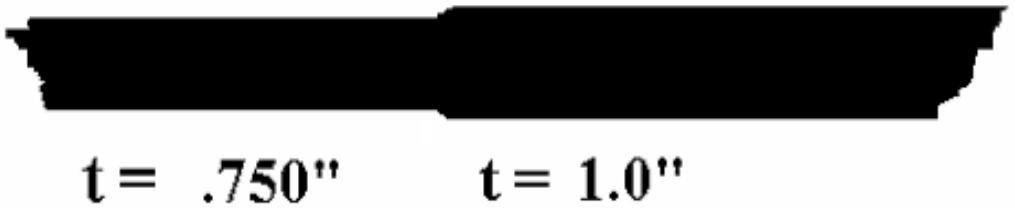


Class Quiz

Radiographic and Radioscopic Examination of Weld Joints

4. The welded joint below was radiographed and found to have an elongated indication that was .243” in length. The maximum allowable length of an indication for this combination of thicknesses is 1/4” and this weld considered acceptable.

b. 1/4 in. and this weld is considered acceptable.



Class Quiz

Radiographic and Radioscopic Examination of Weld Joints

5. The length L, of the longest imperfection in the figure below is .259”. Based on this value the largest imperfection is _____ and since the aggregate (total) length is .504” that is _____ but the weld is_____.

a. acceptable - also acceptable - acceptable
b. unacceptable - also unacceptable -rejectable
c. unacceptable – acceptable - rejectable

Class Quiz

Radiographic and Radioscopic Examination of Weld Joints

5. The length L, of the longest imperfection in the figure below is .259”. Based on this value the largest imperfection is unacceptable and since the aggregate (total) length is .504” that is acceptable but the weld is rejectable.

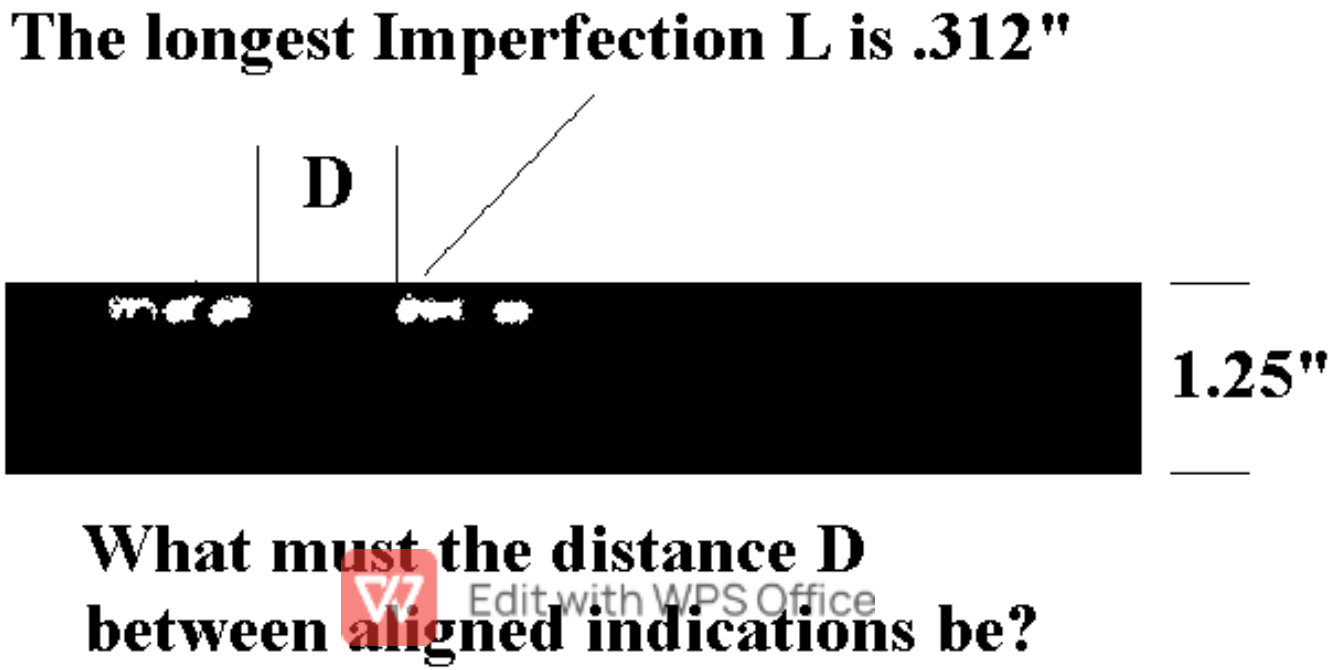
a. acceptable - also acceptable - acceptable
b. unacceptable - also unacceptable -rejectable
c. unacceptable – acceptable - rejectable

Class Quiz

Radiographic and Radioscopic Examination of Weld Joints

6. What is the minimum distance D, between these two groups of aligned imperfections for the groups to be evaluated separately?

a. 7.5”
b. 1.872”
c. .312”

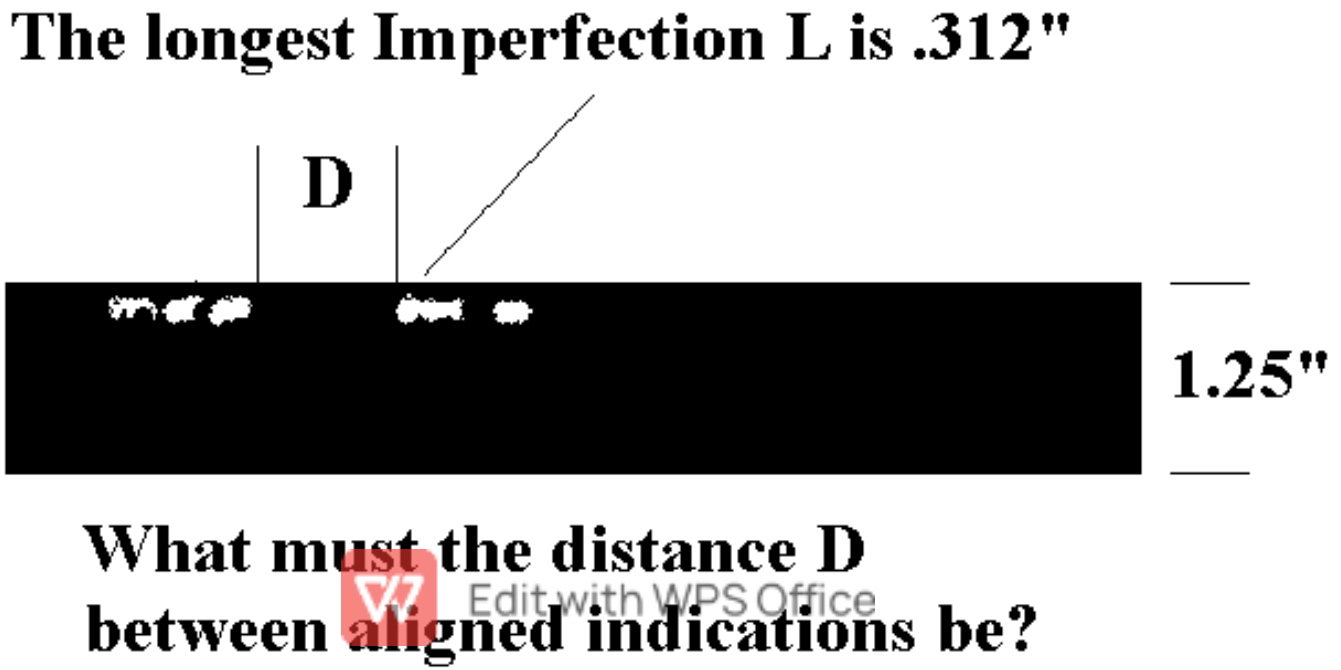


Class Quiz

Radiographic and Radioscopic Examination of Weld Joints

6. What is the minimum distance D, between these two groups of aligned imperfections for the groups to be evaluated separately?

b. 1.872”



UW-52 Spot Examinations of Weld Joints

Page 153

(b) ***Minimum Extent of Spot Radiographic Examination***

(1) *One spot* shall be examined on each vessel for *each 50 ft increment of weld or fraction thereof for which a joint* efficiency from column (b) of Table UW-12 is selected. However, for identical vessels, each with less than 50 ft of weld for which a joint efficiency from column (b) of Table UW-12 is selected, **50 ft increments of weld may be represented by one spot examination**.

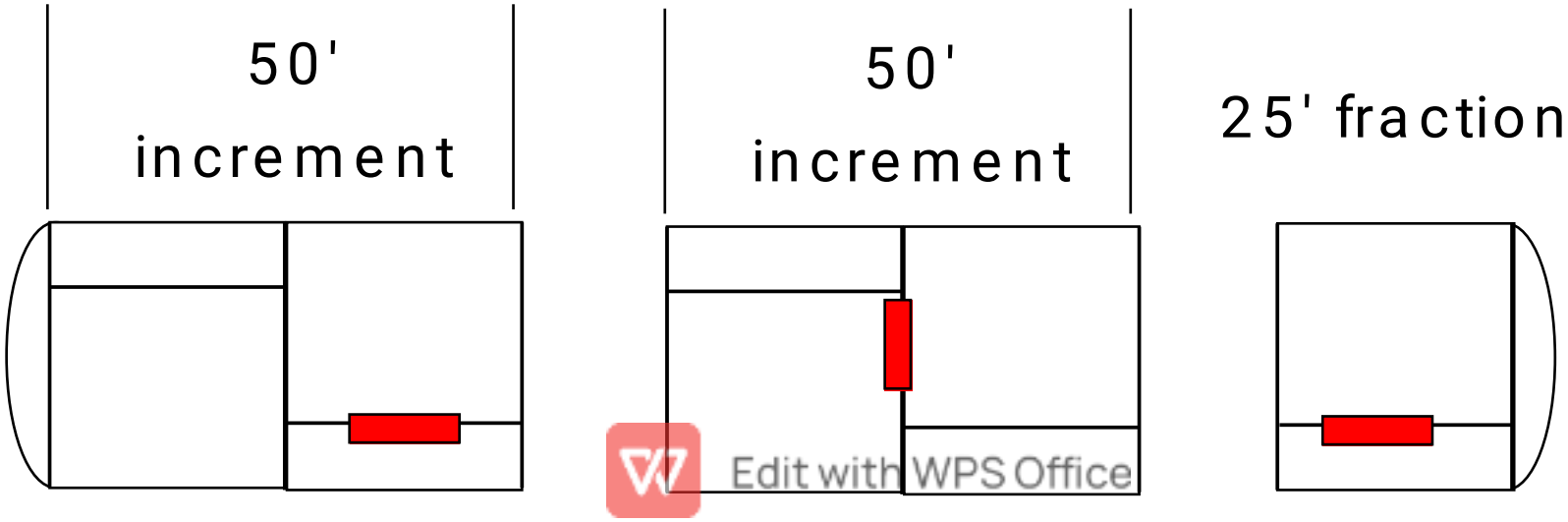
UW-52 Spot Examinations of Weld Joints

Page 153

(b) ***Minimum Extent of Spot Radiographic Examination***

(1) *One spot* shall be examined on each vessel for *each 50 ft increment ……..*

* The idea of this rule is that each 50’ increment is to be a hold point for approval, the next increment is not to be started until the previous one has been accepted. The drawing below is the simplest case, you will not see this often.



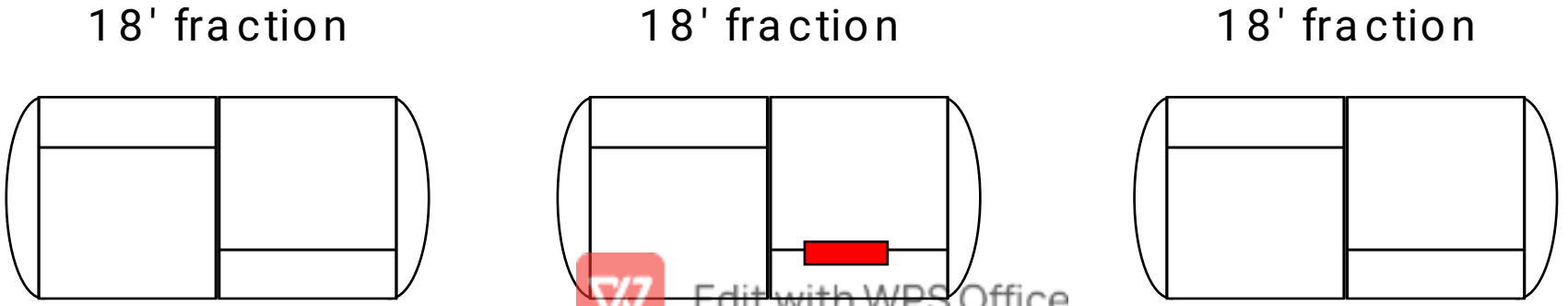
UW-52 Spot Examinations of Weld Joints

Page 153

(b) ***Minimum Extent of Spot Radiographic Examination***

(1) *One spot* shall be examined..... However, for identical vessels, each with less than 50 ft of weld for which a joint efficiency from column (b) of Table UW-12 is selected, 50 ft increments of weld may be represented by one spot examination.

* This rule addresses smaller, often machine welded vessels such as small air receivers. One is picked at random for spot radiography. If it passes all are approved.



UW-52 Spot Examinations of Weld Joints

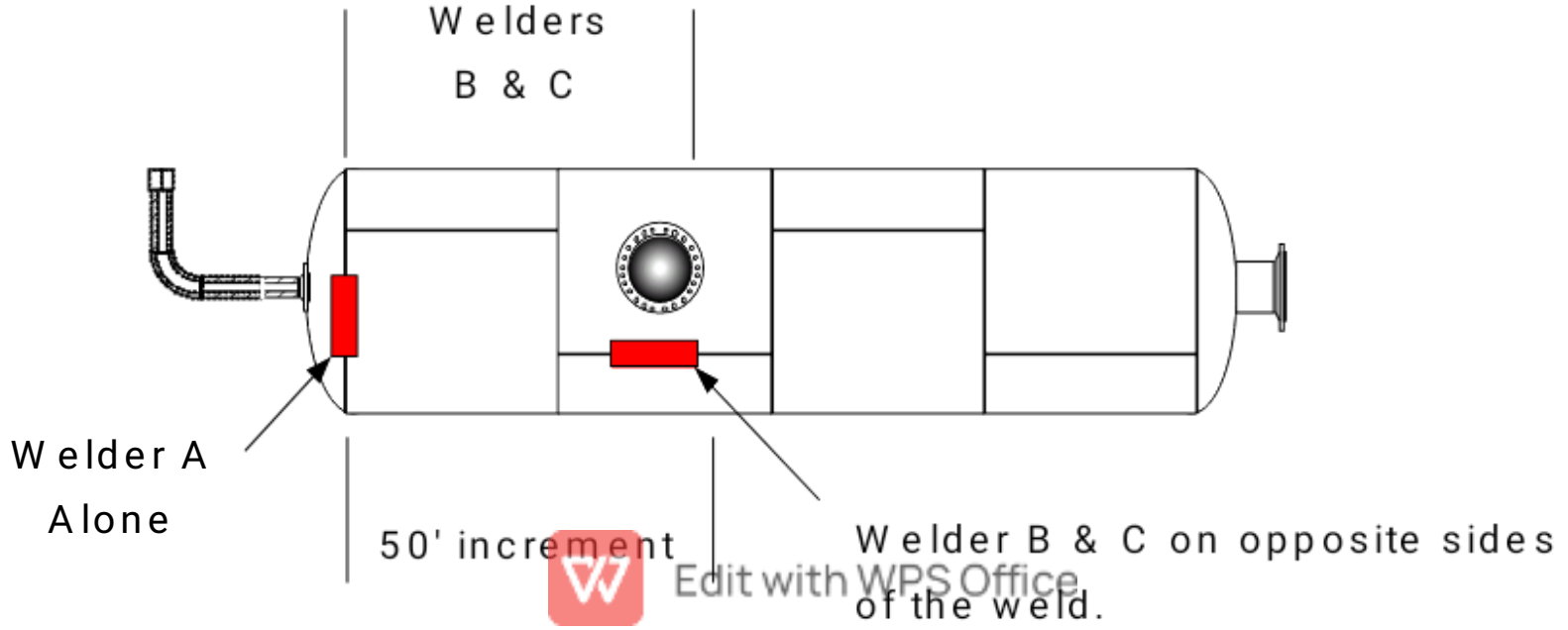
(2) For each increment of weld to be examined, a *sufficient number of spot radiographs shall be taken to examine the welding of each welder or welding operator.* Under conditions where two or more welders or welding operators make weld layers in a joint, or on the two sides of a double-welded butt joint, one spot may represent the work of all welders or welding operators.

(3) Each spot examination shall be made as soon as practicable..... *The location of the spot shall be chosen by the Inspector*,... except that when the Inspector cannot be present or otherwise make the selection, the fabricator may exercise his own judgment in selecting the spots.

UW-52 Spot Examinations of Weld Joints

(2) For an increment of weld to be examined, a *sufficient number of spot radiographs shall be taken to examine the welding of* ***each welder or welding operator****. ……*

* Every welder in a given 50’ increment must have his work radiographed. It can be a individual photo (radiograph) or a group picture. Here welder A was radiographed alone and B & C’s work was examined on the same radiograph.



UW-52 Spot Examinations of Weld Joints

(4) Radiographs required at specific locations to satisfy the rules of other paragraphs, such as *UW-9(d), UW-11(a)(5)(b), and UW-14(b), shall not be used to satisfy the requirements for spot radiography*.

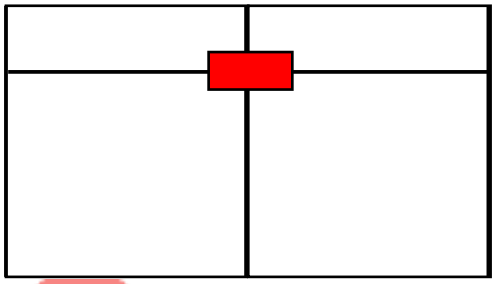
Note: *UW-11(a)(5)(b),* will be covered in depth later in this lesson.

UW-52 Spot Examinations of Weld Joints

UW-9(d)

(d) Except when the longitudinal joints are radiographed 4 in. each side of each circumferential welded intersection, vessels made up of two or more courses shall have the centers of the welded longitudinal joints of adjacent courses staggered or separated by a distance of at least five times the thickness of the thicker plate.

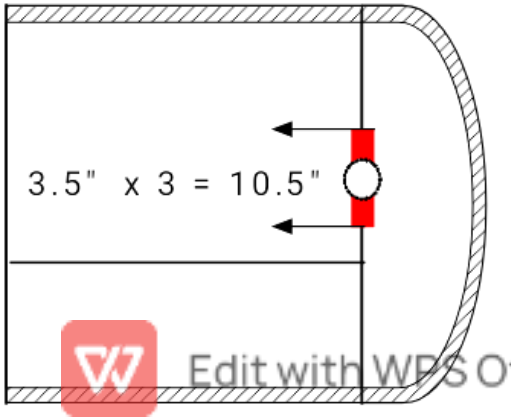
* Longitudinal Welds Aligned must be radiographed for at least 4 inches on each side of the joint.



UW-52 Spot Examinations of Weld Joints

UW-14(b) Single openings meeting the requirements given in UG-36(c)(3) may be located in head-to-shell or Category B or C butt welded joints, provided the weld meets the radiographic requirements in **UW-51** for a length equal to three times the diameter of the opening with the center of the hole at mid-length. Defects that are completely removed in cutting the hole shall not be considered in judging the acceptability of the weld. ** UW-51, not 52 to grade film.

* UG-36 (c)(3) addresses small opening which do not require reinforcement calculations.



UW-52 Spot Examinations of Weld Joints

Summary

The special radiography requirements given in UW-9 (d), UW-11(a)(5)(b) and UW-14 (b) cannot be substituted for any of the spot radiography required by UW-52.

***** We will see why this is significant when we commence our studies of “Joint Efficiencies” later.

UW-52 Spot Examinations of Weld Joints

(c) *Standards for Spot Radiographic Examination*.

Spot examination by radiography shall be made in accordance with the technique prescribed in UW-51(a). The *minimum length of spot radiograph shall be 6 in.*

(c)(3) Rounded indications are not a factor in the acceptability of welds that are not required to be fully radiographed.

UW-52 Spot Examinations of Weld Joints

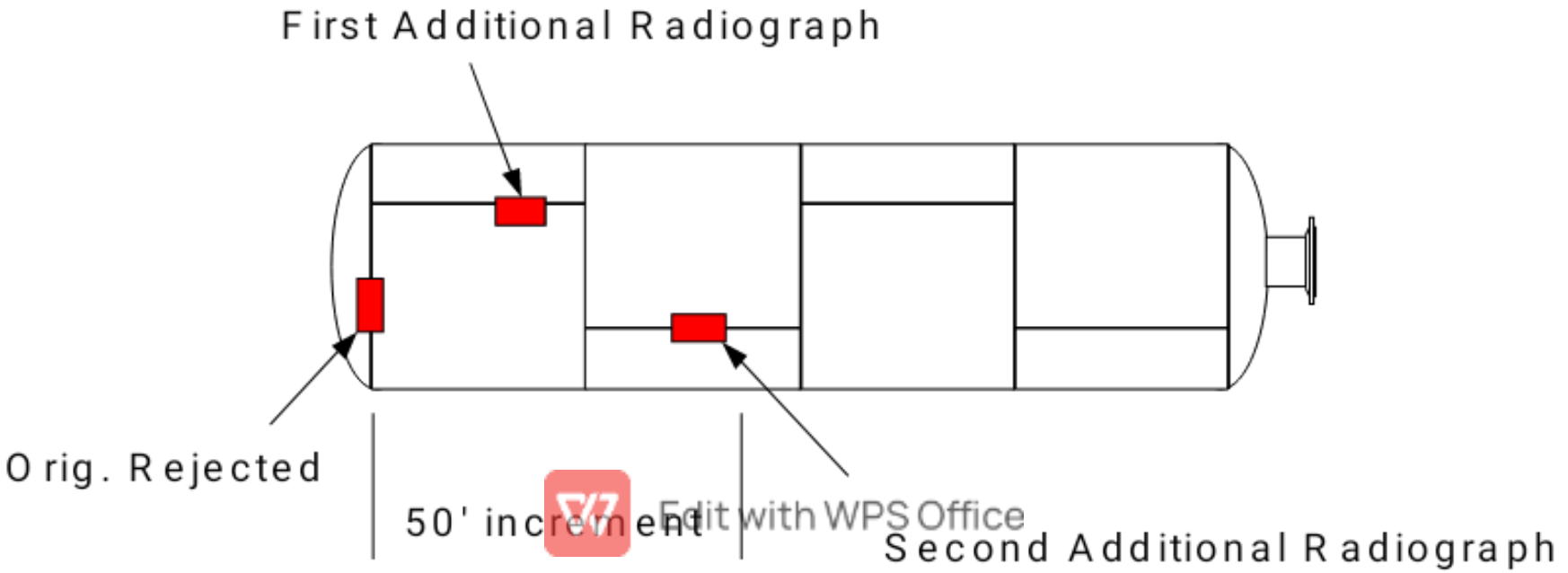
(d) Evaluations and Retests

When a spot, radiographed as required in (b)(1) or (b)(2) above has been examined and the radiograph discloses welding which **does not comply**.....The locations shall be determined by the Inspector... if the two additional **pass, repair the failed spot**, if either of the two additional spots **fail** the entire rejected weld **shall be removed** and the joint re-welded **or the entire increment completely radiographed and all defects corrected.**

UW-52 Spot Examinations of Weld Joints

(d) Evaluations and Retests

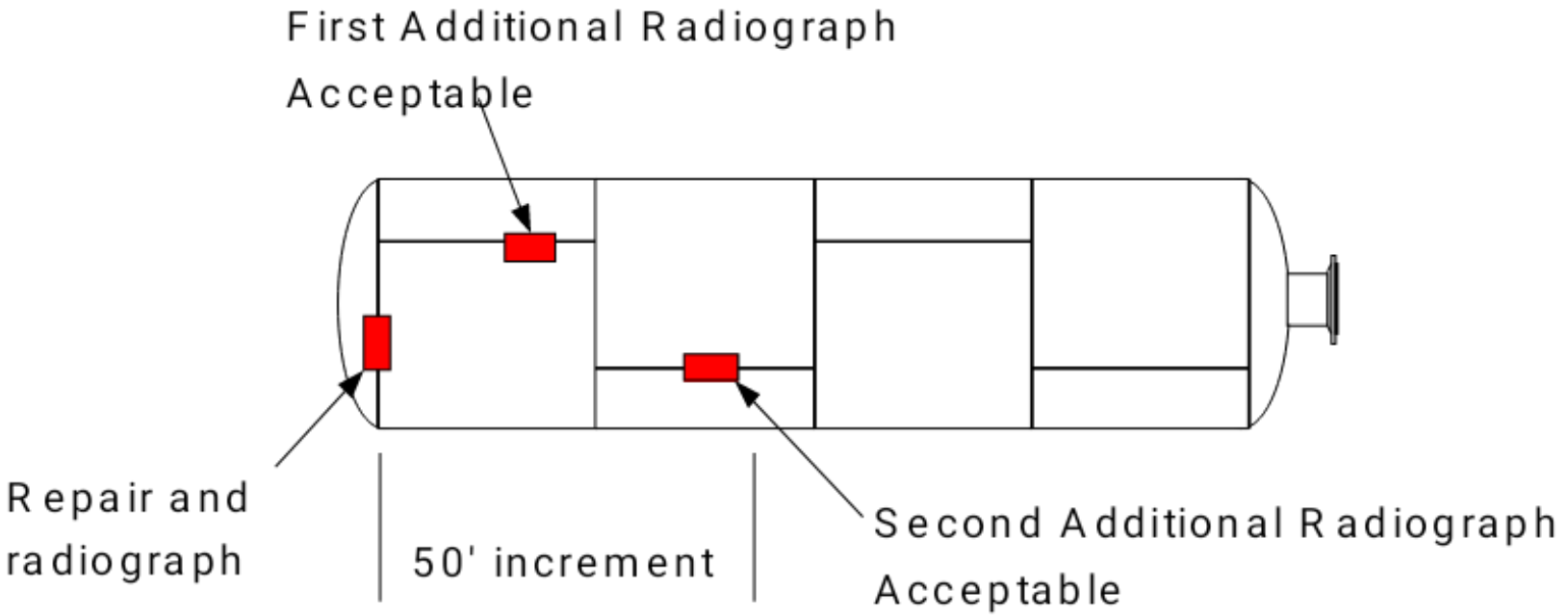
When a spot, radiographed as required in (b)(1) or (b)(2) above has been examined and the radiograph discloses welding which **does not comply**.....**two additional spots shall be examined** at locations away from the original spot.



UW-52 Spot Examinations of Weld Joints

(d) Evaluations and Retests

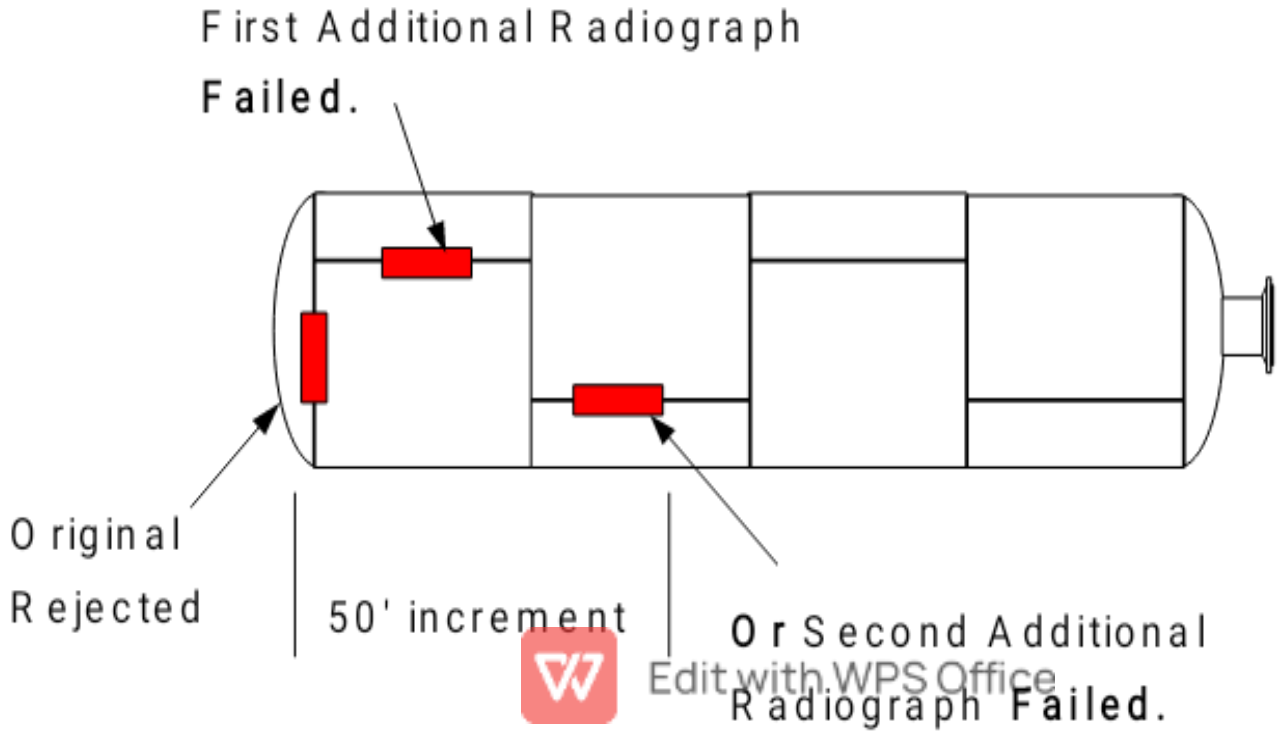
…The locations shall be determined by the Inspector… if the two additional **pass, repair the failed spot**, ….



UW-52 Spot Examinations of Weld Joints

(d) Evaluations and Retests

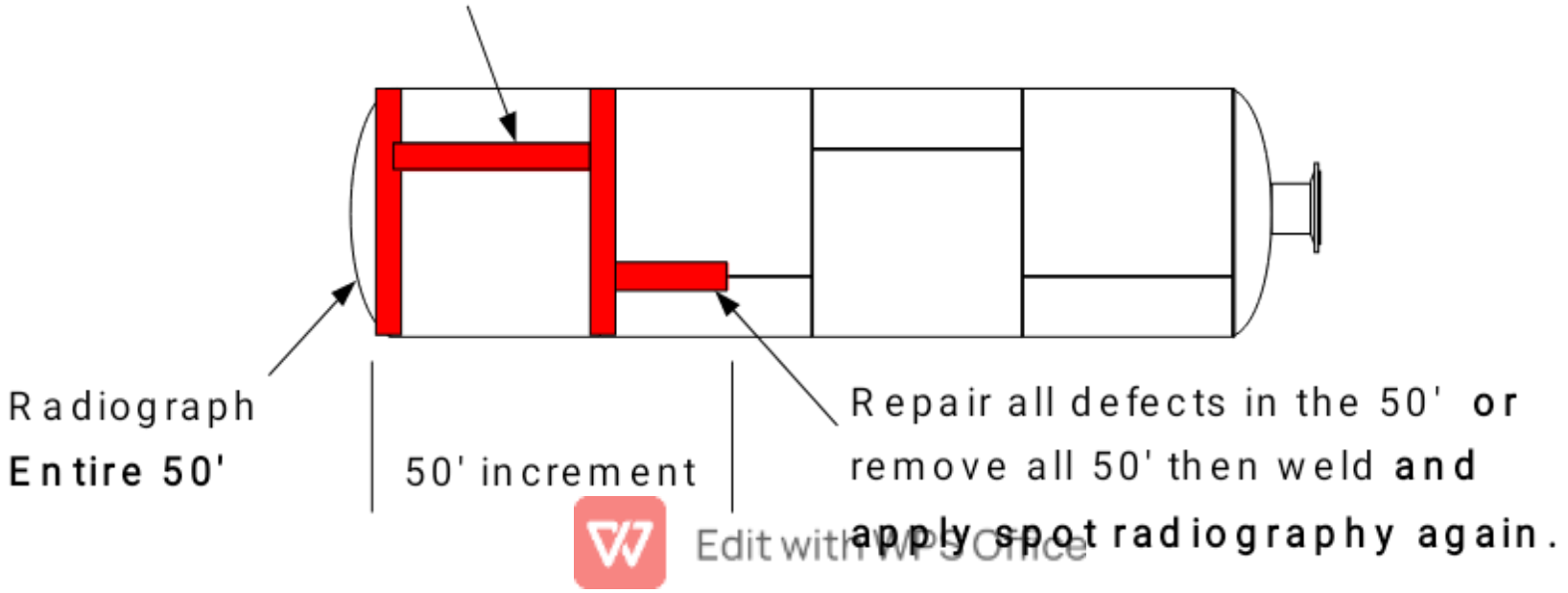
…, if **either** of the two additional spots **fail** the entire rejected weld **shall be removed** and the joint rewelded **or the entire increment completely radiographed and all defects corrected.**



UW-52 Spot Examinations of Weld Joints

(d) Evaluations and Retests

…, if **either** of the two additional spots **fail** the entire rejected weld **shall be removed** and the joint rewelded **or the entire increment completely radiographed and all defects corrected.**



Class Quiz

Spot Radiography

1. Minimum number of Spot Radiographs is/are __spot (s), this rule must be applied on each vessel for each _____ ft increment of weld or fraction thereof for which a joint efficiency from column (b) of Table UW-12 is selected.
2. Who shall choose the location of Spot Radiographs?

a. The manufacturer and the Inspector will agree on the locations.
b. The manufacturer or the Inspector depending on the type of welds made.
c. The Inspector shall choose unless he is not available and then the Manufacturer may do so.

Class Quiz

Spot Radiography

1. Minimum number of Spot Radiographs is **one** spot, this rule must be applied on each vessel for each **50** ft increment of weld or fraction thereof for which a joint efficiency from column (b) of Table UW-12 is selected.
2. Who shall choose the location of Spot Radiographs?

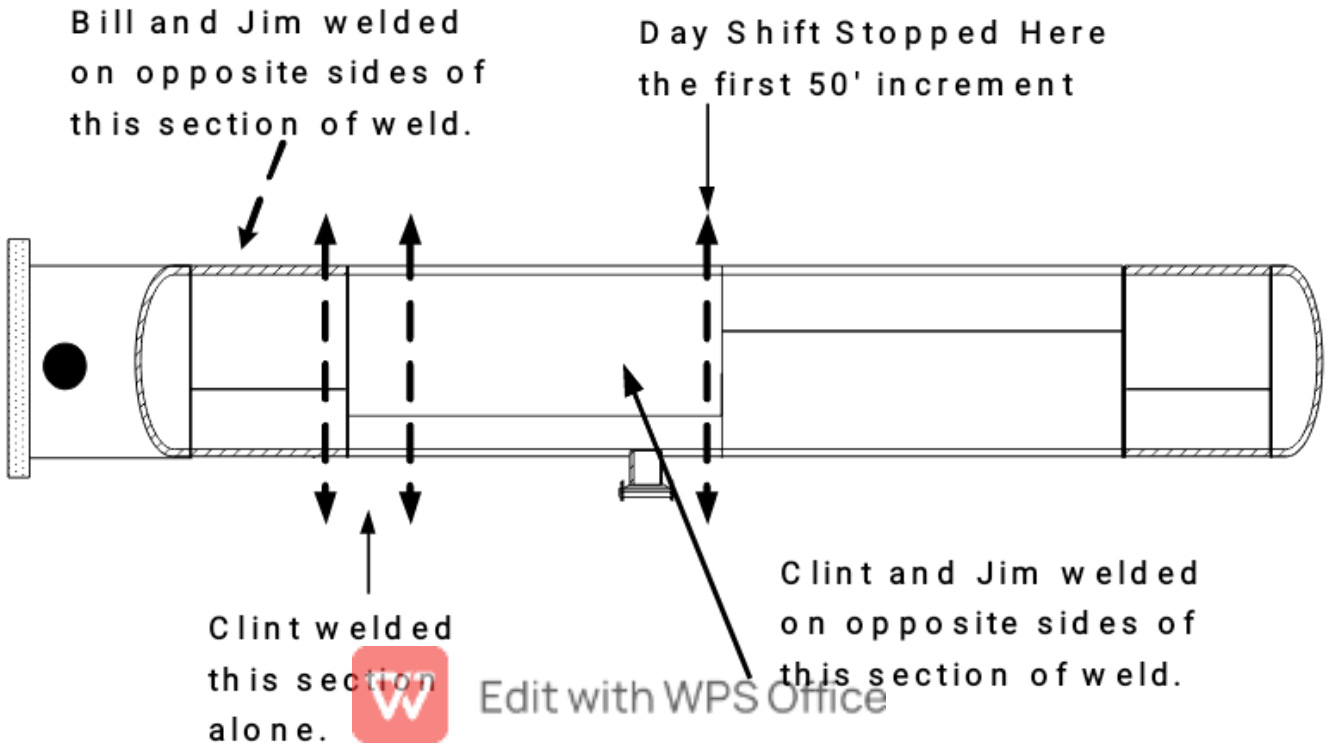
c. The Inspector shall choose unless he is not available and then the Manufacturer may do so.

Class Quiz

Spot Radiography

3. In the drawing below the total number of spot radiographs needed to meet the minimum requirements is/are ____?

* Keep in mind the goal is to Radiographically Test every welder's work in a 50' increment.

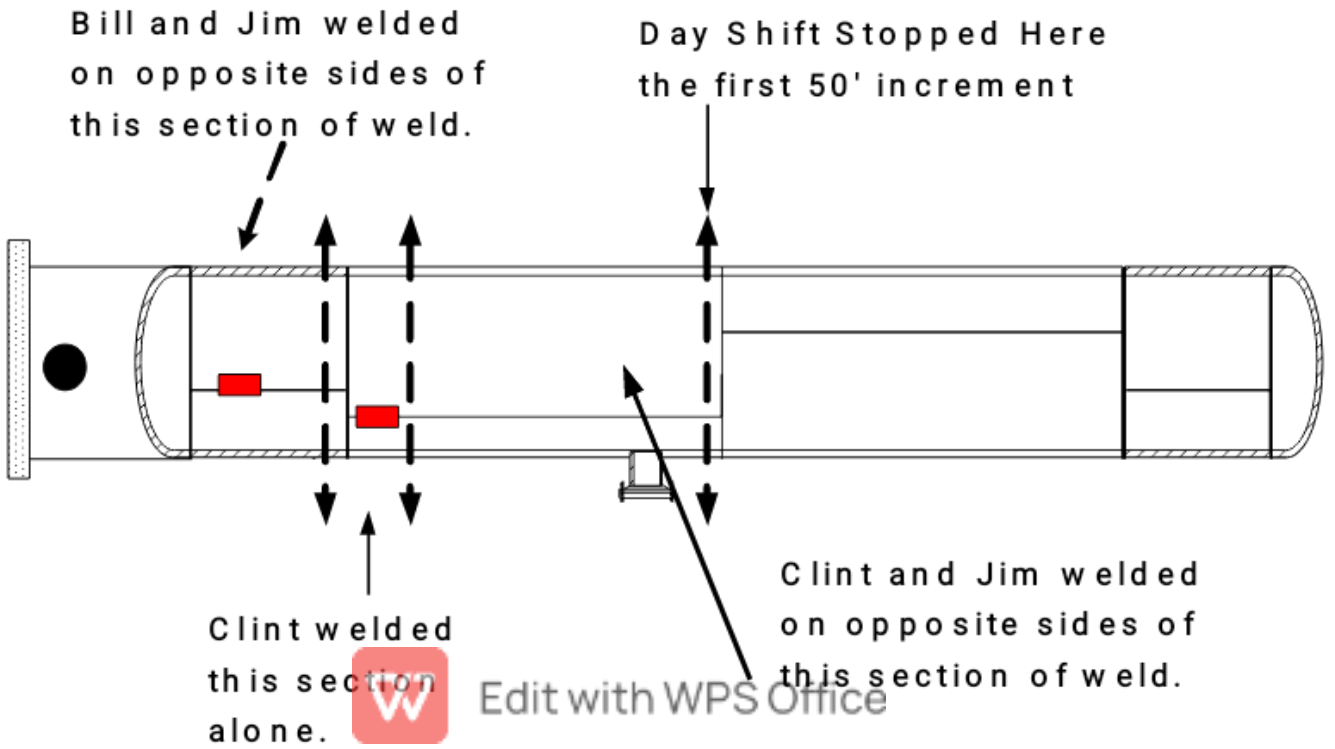


Class Quiz

Spot Radiography

3. In the drawing below the total number of spot radiographs needed to meet the minimum requirements are <u>2.</u>

* Keep in mind the goal is to Radiographically Test every welder's work in a 50' increment.



UW-11 Radiographic and Ultrasonic Examinations of Weld Joints Page 117

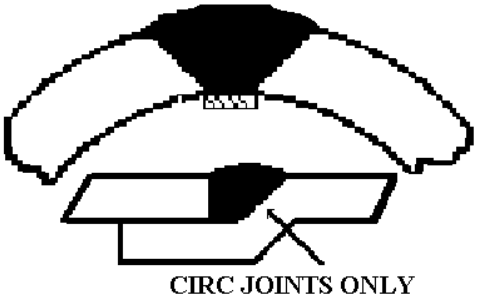
(a) ***Full Radiography***. The following welded joints shall be examined radiographically for their full length ....

(1) all butt welds in the shell and heads of vessels used to contain *lethal substances* [see UW-2(a)];

* Remember, UW-2(a) demands that in lethal service the welds be of Type 1 for Category A and must be of either Type1 or 2 for Categories B and C.

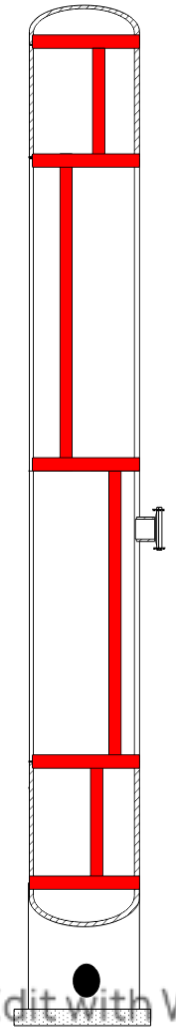
Type 1

Type 2



UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

Lethal Service



Full Radiography

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints Page 117

(a) ***Full Radiography***. The following welded joints shall be examined radiographically for their full length ….

(2) all butt welds in vessels in which the *nominal thickness* [**see (g) below**] at the welded joint exceeds 1-1/2 in. (38mm), or exceeds the lesser thicknesses prescribed in *UCS-57*…. * This paragraph is on the examination.

(g) For radiographic and ultrasonic examination of butt welds, the definition of nominal thickness at the welded joint under consideration **shall be the nominal thickness of the thinner of the two parts joined**. Nominal thickness is defined in 3-2.

From Mandatory Appendix 3
Definitions

(c) *nominal thickness* – …….For plate material, the nominal thickness shall be, at the Manufacturer's option, either the thickness shown on the Material Test Report {or material Certificate of Compliance [UG-93(a)(1)]} before forming, or the measured thickness of the plate at the joint or location under consideration.

*** Information only this is not on the exam.**

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints Page 117

(a) ***Full Radiography***. The following welded joints shall be examined radiographically for their full length ….

(2) all butt welds in vessels in which the nominal thickness [see (g) below] at the welded joint exceeds 1-1/2 in. (38 mm), or exceeds the lesser thicknesses prescribed in UCS-57, UNF-57, UHA-33, UCL-35, or UCL-36 for the materials covered therein, or as otherwise prescribed in UHT-57, ULW-51, ULW-52(d), ULW-54, or ULT-57; however, except as required by UHT-57(a), Categories B and C butt welds in nozzles and communicating chambers that **neither** exceed NPS10 nor 1-1/8 in. (29 mm) wall thickness do not require any radiographic examination;

** If none of the rules in the paragraphs above apply then use the default thickness of 1-1/2".*

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

This means that;

If the material of construction is not one of those referenced UW-11(a)(2) then the default value for the thinner thickness exceeded becomes 1-1/2”. Since the API 510 examination is restricted to UCS materials (carbon and low alloy steels) this rule will be demonstrated using a Carbon Steel that is classified as a P-Number 1.

Turn now to page 187 of Section VIII

UCS-57
Section VIII Page 187

From paragraph UCS-57:

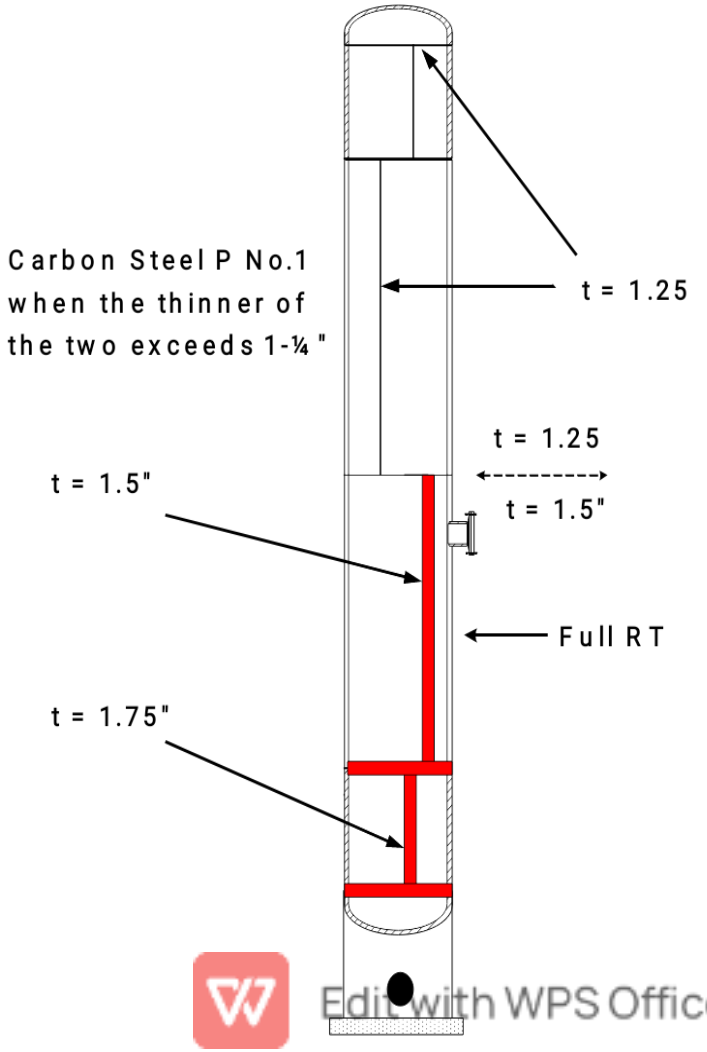
In addition to the requirements of UW-11, complete radiographic examination is required for each butt welded joint at which the **thinner** of the plate or vessel wall thicknesses at the welded joint exceeds the thickness limit above which full radiography is required in Table UCS-57.

TABLE UCS-57
THICKNESS ABOVE WHICH FULL RADIOGRAPHIC EXAMINATION OF BUTT WELDED JOINTS IS MANDATORY

P-No. & Gr. No. Classification of Material	Nominal Thickness Above Which Butt Welded Joints Shall Be Fully Radiographed, in. (mm)
1 Gr. 1, 2, 3	1¼ (32)
3 Gr. 1, 2, 3	¾ (19)
4 Gr. 1, 2	⅝ (16)
5A, 5B Gr. 1	0 (0)
9A Gr. 1	⅝ (16)
9B Gr. 1	⅝ (16)
10A Gr. 1	¾ (19)
10B Gr. 2	⅝ (16)
10C Gr. 1	⅝ (16)
10F Gr. 6	¾ (19)

UCS-57

For P No.1 materials the thinner of the two must exceed 1.25” The girth weld at the 1.25 to 1.5” joint and all above it are exempt.



UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

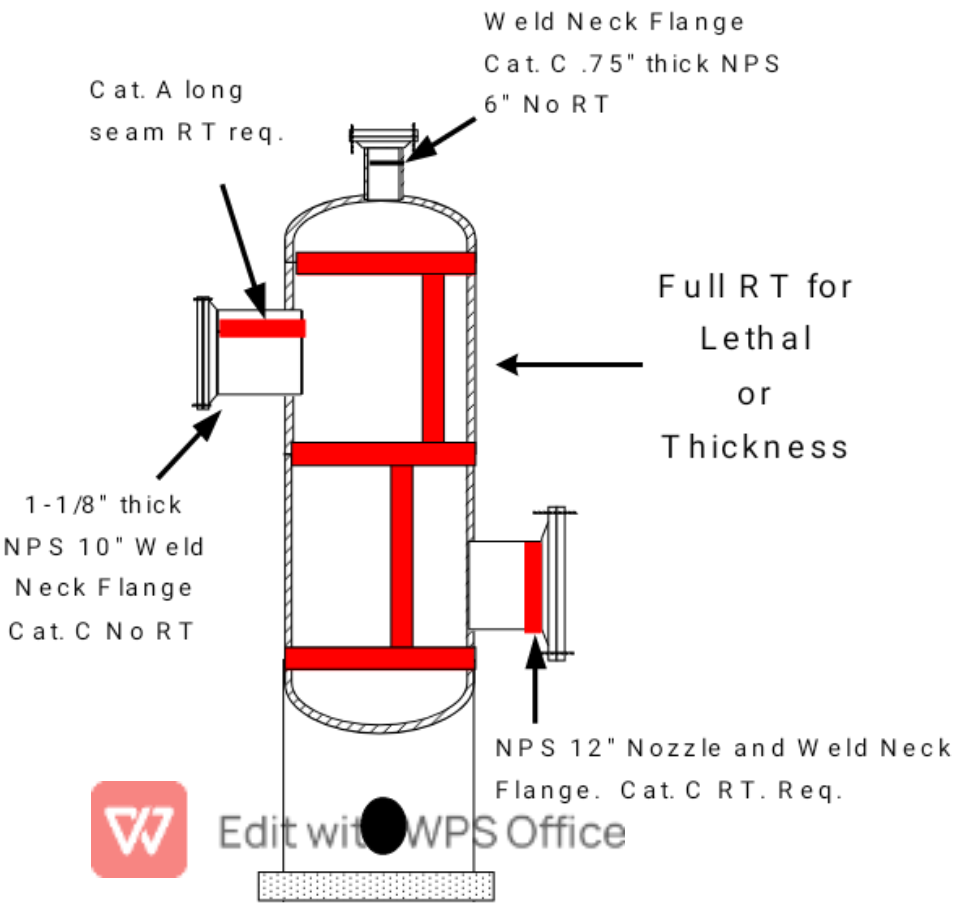
(3) all butt welds in the shell and heads of unfired steam boilers ……*Steam Boilers are NOT on the Exam.*

(4) all butt welds in nozzles, communicating chambers, etc. , attached to vessel sections or heads that are required to be fully radiographed under (1) or (3) above; however, ... Categories B and C butt welds in nozzles and communicating chambers that ***neither exceed NPS 10* (DNS 250) *nor 1-1/8 in.* (29mm) *wall thickness* do not require any radiographic examination;

** This only applies to circumferential welds in small (*NPS 10 / 1-1/8" thick.)* nozzles and chambers. Longitudinal seams are not exempted by this rule.

UW-11

(4) all butt welds in nozzles, communicating chambers, etc., attached to vessel sections or heads that are required to be fully radiographed under (1) or (3) above; however, Categories B and C butt welds in nozzles and communicating chambers that *neither exceed NPS 10* (DNS 250) *nor 1-1/8 in.* (29mm) *wall thickness* do not require any radiographic examination;



UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

Now for the hardest rule to understand!

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

(5) all Category A and D butt welds in vessel sections and heads where the design of the joint or part is based on a joint efficiency permitted by *UW - 12(a), in which case:*

(a) Category A and B welds connecting the vessel sections or heads shall be of *Type No. (1) or Type No. (2) of Table UW-12;* **** Just means they must be radiographable.***

(b) Category B or C butt welds [but not including those in nozzles or communicating chambers except as required in (2) above] which intersect the Category A butt welds in vessel sections or heads or connect seamless vessel sections or heads shall, *as a minimum*, meet the requirements for spot radiography in accordance with UW-52.

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

(5) all Category A and D butt welds in vessel sections and heads where the design of the joint or part is based on a joint efficiency permitted by *UW - 12(a), in which case:*

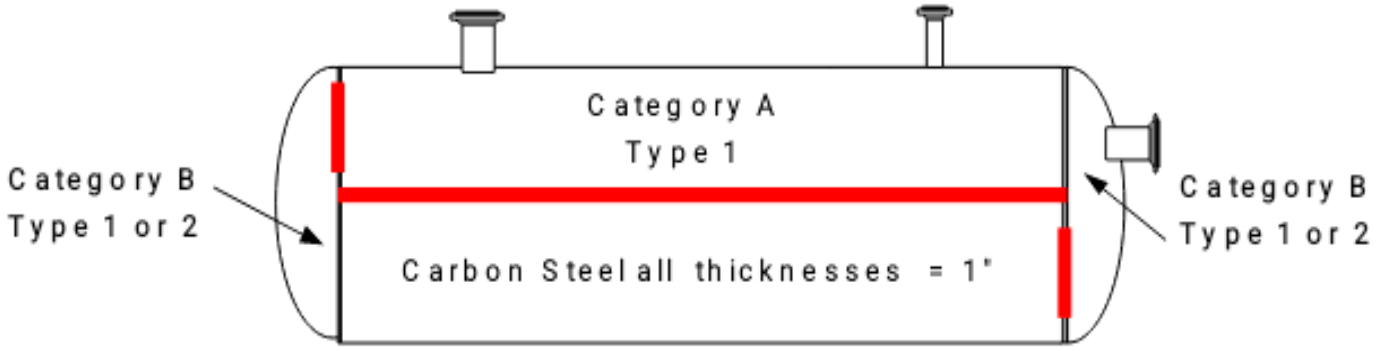
* This paragraph is **only mandatory** when it is desired by the designer to use the highest joint efficiency possible for calculations of thickness required or pressure allowed.

It is a **choice** the designer makes when there **are no mandatory** requirements based on service or material as found in UW-11 (a) (1)*Lethal Service, (2)*Thickness exceeded

Class Quiz
UW-11 Radiographic and Ultrasonic Examinations

1. In the drawing below the paragraph that applies is;

a. UW-11(a)(1) Lethal Service
b. UW-11(a)(2) Thickness limit exceeded
c. UW-11(a)(5) The desire to take E from Column A of Table UW-12



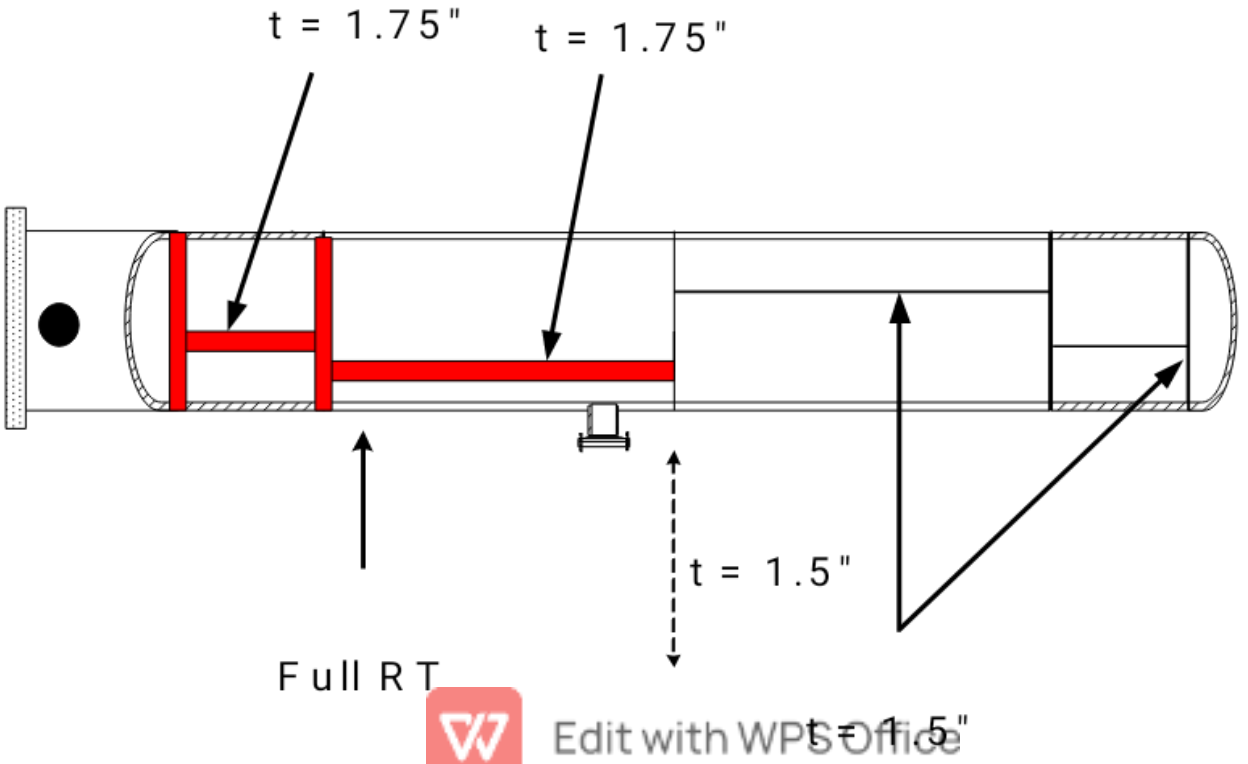
Shell and Heads

E = 1.0

Class Quiz
UW-11 Radiographic and Ultrasonic Examinations

2. In the drawing below the paragraph that applies is;

a. UW-11(a)(1) Lethal Service
b. UW-11(a)(2) Thickness exceeded
c. UW-11(a)(5) Design using E from Col. A Table UW-12



UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

(6) all butt welds joined by… *electrogas welding is not on the exam.*

7) ultrasonic examination in accordance with UW- 53 may be substituted for radiography for the final closure seam of a pressure vessel if the construction of the vessel does not permit interpretable radiographs in accordance with Code requirements. The absence of suitable radiographic equipment shall not be justification for such substitution.

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

(8) exemptions from radiographic examination for certain welds in nozzles and communicating chambers as described in *(2), (4), and (5) above take precedence over the radiographic requirements of Subsection C of this Division.*

Note: This means that even though P-No. 5 for example requires RT in all thicknesses the small/thin nozzles are exempt.

(b) *Spot Radiography*. Except as required in (a)(5)(b) above, butt welded joints made in accordance with Type No. (1) or (2) of Table UW-12 which are not required to be fully radiographed by (a) above, may be examined by spot radiography. Spot radiography shall be in accordance with UW-52. * If full RT is not mandatory Spot Radiography done because the the designers choose it.

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

If spot radiography is specified for the entire vessel, radiographic examination *is not required* of Category B and C butt welds in nozzles and communicating chambers that *exceed neither NPS 10 nor 1-1/8 in. wall thickness*

(c) *No Radiography*. Except as required in (a) above, no radiographic examination of welded joints is required when the vessel or vessel part is designed for external pressure only, or when the joint design complies with UW-12(c).

* The designer can choose not to do RT if there is no mandatory requirement such as lethal, thickness, or desire for a higher joint E.

UW-12 Radiographic and Ultrasonic Examinations of Weld Joints

Before starting shell and head calculations let's have a look at the types of welds and the weld joint efficiencies that apply based on the amount of radiography applied.

These E values are found on Table UW-12 of Section VIII Division 1.

* The following is a simplification for the API Exam, it **does not** reflect all of the possible combinations of radiography, weld types and the resulting joint efficiencies.

UW-12 Joint Efficiencies Page 119

Table UW-12 gives the joint efficiencies *E* to be used in the formulas of this Division for joints completed by an arc or gas welding process. *Except* as required by *UW-11(a)(5)*, a joint efficiency depends only on the type of joint and on the degree of examination of the joint and does not depend on the degree of examination of any other joint.

(a) A *value of E not greater* than that given in *column (a)* of Table UW-12* shall be used in the design calculations for *fully radiographed butt joints* [seeUW-11(a)], except that when the requirements of UW-11(a)(5) **are not met**, a value of *E* not greater than that given in column (b) of Table UW-12 shall be used. *** Known as Full Radiography**

So now we are sent back to UW-11(a)(5).....

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints Page 117

UW-11(a)(5) all Category A and D butt welds in vessel sections and heads where the design of the joint or part is based on a joint efficiency permitted by *UW -12(a), in which case:*

(a) Category A and B welds connecting the vessel sections or heads shall be of ***Type No. (1) or Type No. (2) of Table*** *UW-12; * (simply means it can be radiographed)*

(b) Category B or C butt welds [but not including those in nozzles or communicating chambers except as required in (2) above ****(excludes small/thin nozzles)***] which intersect the Category A butt welds in vessel sections or heads or connect seamless vessel sections or heads shall, ***as a minimum***, meet the requirements for **spot radiography in accordance with UW-52.**

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints Page 117

Background

UW-11(a)(5) This rule is pointed toward Code manufacturers who buy parts from other “Code Shops” and basically assemble a vessel. The concern is as follows;

Code Shop A buys a rolled and welded shell from Code Shop B, Shop B fully radiographs the Type 1 weld and the shell part will be delivered to Shop A with a joint **E of 1.0. which is essentially equal to a seamless shell.**

Code Shop A welds on two seamless formed heads. Unless Shop A performs at least Spot RT on the Category B welds connecting the heads to the shell there will have been no radiographic testing of Code Shop A’s welders. A graphical representation follows.

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

UW-11(a)(5)

Example 1: The longitudinal seam weld is of Type 1. It has received **Full RT** at Code Shop B. Shop A **has not performed** the required Spot RT on the head to shell welds.

Fully Radiographed Type 1 by Shop B Heads welded on by Shop A. **Without** the spot RT as described in **UW-11(a)(5)(b)** the shell would be calculated at **E = .85**

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

UW-11(a)(5)

Example 2: Now the Spot RT **has been** performed by Shop B. Therefore and E = 1.0 is allowed for the shell.

Fully Radiographed Type 1 by Shop B Heads welded on by Shop A. With the spot RT as described in **UW-11(a)(5)(b)** the shell would be calculated at **E = 1.0**

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints Page 117

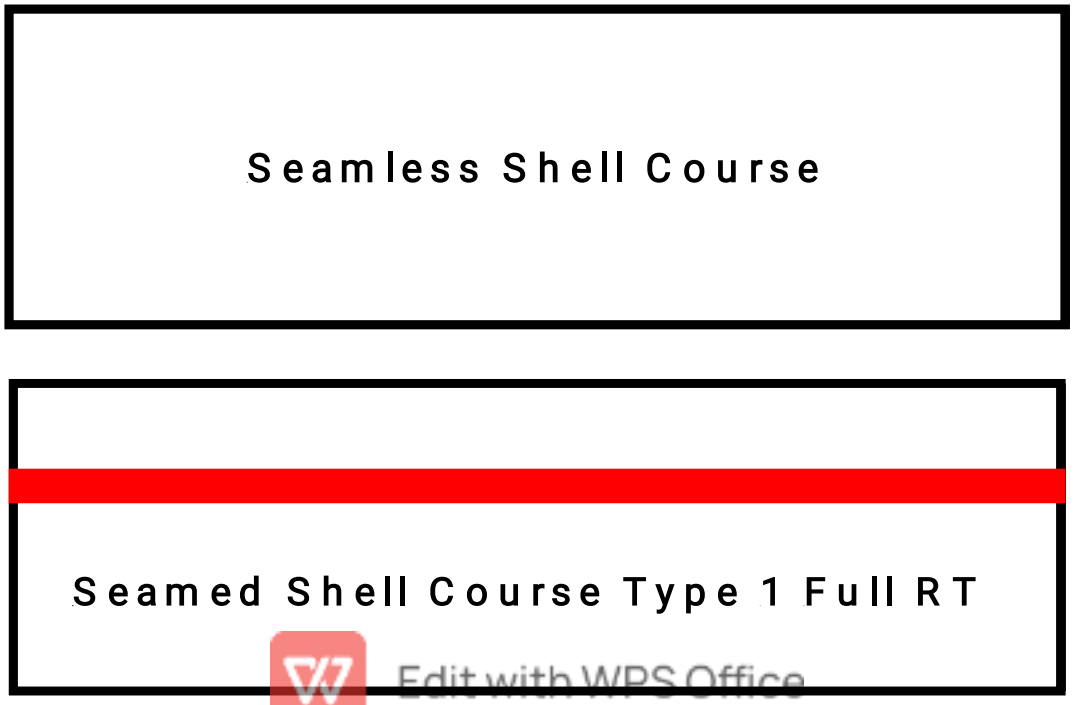
UW-11(a)(5) *So this* means that Shop A cannot simply weld the heads, nozzles etc. and never do any radiographic testing of the Shop A welders. To make things consistent this rule applies **even if** the **entire vessel** is made by one Code Shop.

So no matter what the circumstances this Spot RT must be performed to take a joint efficiency from Col. A of to Table UW-12 for seamed shell course.

UW-11 Radiographic and Ultrasonic Examinations of Weld Joints

UW-11(a)(5)

Example 3: One last comment. On the shop floor these two shells both have the potential for a **Joint E of 1.0** . You will see this again in **UW-12(d) Seamless Shells and Heads.**



UW-12 Joint Efficiencies

(b) A *value of E not greater* than that given in ***column (b) of Table UW-12*** shall be used in the design calculations for *spot radiographed* butt welded joints [see UW-11(b)].

*** Known as Spot Radiography**

(c) A *value of E* not greater than that given in ** column (c) of Table UW-12* shall be used in the design calculations for welded joints that are neither fully radiographed nor spot radiographed [see UW-11(c)]. *** No Radiography**

Now let's examine the first three Types listed on Table UW-12 and examine the joint types, the amount of radiography and the resulting Joint Efficiencies.

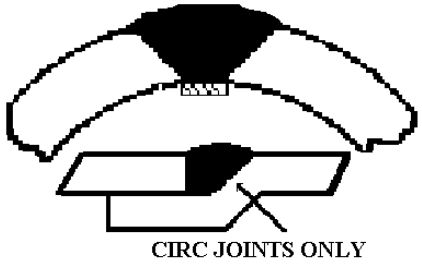
TABLE UW-12
MAXIMUM ALLOWABLE JOINT EFFICIENCIES [1,5] FOR ARC AND GAS WELDED JOINTS

Type No.	Joint Description	Limitations	Joint Category	Degree of Radiographic Examination (a) Full[2]	(b) Spot[3]	(c) None
(1)	Butt joints as attained by double-welding or by other means which will obtain the same quality of deposited weld metal on the inside and outside weld surfaces to agree with the requirements of UW-35. Welds using metal backing strips which remain in place are excluded.	None	A, B, C, & D	1.00	0.85	0.70
(2)	Single-welded butt joint with backing strip other than those included under (1)	*(a)* None except as in (b) below	A, B, C, & D	0.90	0.80	0.65
		(b) Circumferential butt joints with on plate offset; see UW-13(b)(4) and Fig. UW-13.1, sketch (k)	A, B, & C	0.90	0.80	0.65
(3)	Single-welded butt joints without the use of backing strip	Circumferential butt joints only, not over 5/8 in.(16 mm) thick and not over 24 in. (600 mm) outside diameter	A, B, & C	NA	NA	NA

Type 1-Cat. A,B,C,&D

Butt Joints as attained by double-welding or by other means which will obtain the same quality on the inside and outside. Backing strip if used must be removed after welding is completed.

Type 2-Cat. A,B,C,&D



Single-welded butt joint with backing strip which remains in place after welding is completed. Limitations apply see table UW-12.

Full Col. A	Spot Col. B	None Col. C
Full RT E = 1.0	Spot RT E = .85	No RT E = .70
E = .90	E = .80	E = .65

Class Quiz
UW-12 Joint Efficiencies

1. A Type 1 weld has received Spot Radiographic Testing the resulting Joint E _____?

a. 1.0
b. 0.80
c. 0.85

2. A Type 3 weld can be spot radiographed.

___True ___False

3. A Type 2 weld has been Fully Radiographed, the Weld Joints E is _____.

a. 0.85
b. 0.90
c. 0.80

Class Quiz
UW-12 Joint Efficiencies

1. A Type 1 weld has received Spot Radiographic Testing the resulting Joint E _____?

c. 0.85

2. A Type 3 weld can be spot radiographed.

___False

3. A Type 2 weld has been Fully Radiographed, the Weld Joints E is _____.

b. 0.90

Class Quiz
UW-12 Joint Efficiencies

4. A Type 2 weld has received Spot Radiographic Testing resulting in a Joint E of 0.80, this E could be improved to a 1.0 by _____.

a. applying full radiography

b. removing the backing and double welding and then applying Spot RT.

c. removing the backing, double welding thus creating a Type 1, and then applying Full RT.

Class Quiz
UW-12 Joint Efficiencies

4. A Type 2 weld has received Spot Radiographic Testing resulting in a Joint E of 0.80, this E could be improved to a 1.0 by _____.

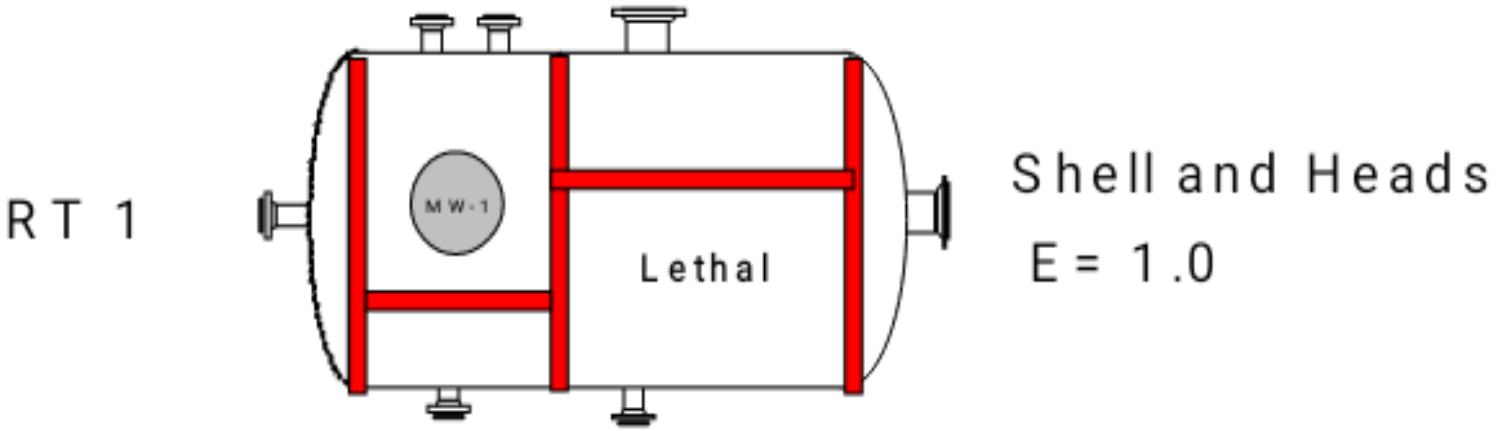
c. removing the backing, double welding thus creating a Type 1, and then applying Full RT.

Joint Efficiencies based on RT Marking

Next we will discuss Nameplate RT markings and how to determine the joint E to be used in the thickness or pressure calculations to follow. These RT markings and their descriptions are found in paragraph **UG-116 on page**. We will now discuss these accompanied by graphical representations.

Joint Efficiencies based on RT Marking

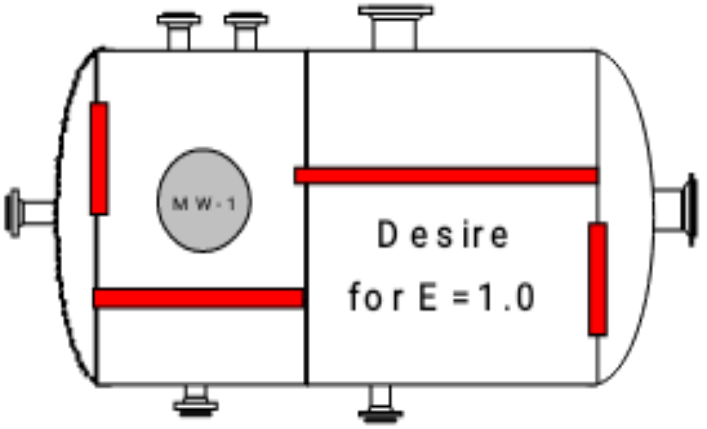
"RT 1" when all pressure retaining butt welds, other than B and C associated with nozzles and communicating chambers that neither exceed NPS 10 nor 1-1/8 inch thickness have been radiographically examined for their full length in a manner prescribed in UW 51, full radiography of the above exempted Category B and C butt welds if performed, may be recorded……



Joint Efficiencies based on RT Marking

"RT 2" Complete vessel satisfies UW-11(a)(5) and **UW-11(a)(5)(b) has been applied**. The spot RT rules of UW-52 must be applied to the spot RT and the Full RT rules of UW-51 to the long seams. So the 50' increments apply and all welders in that increment must be examined by radiography.

RT 2

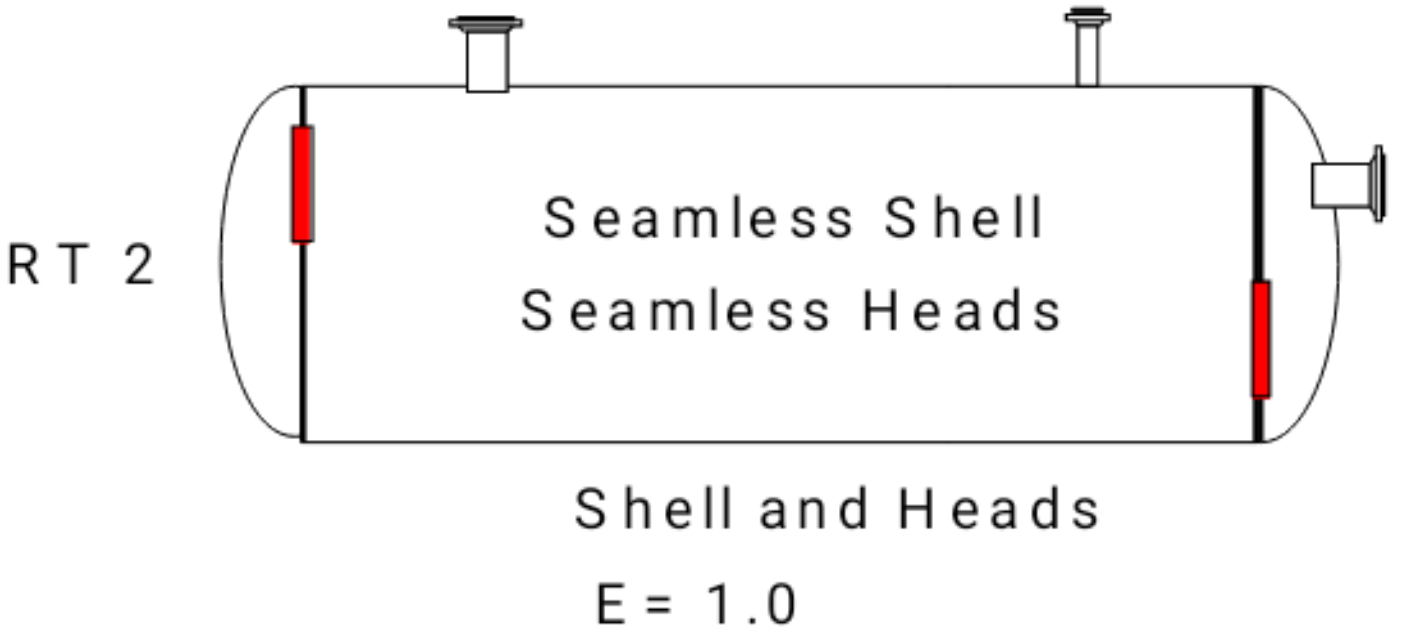


Shell and Heads
E = 1.0

Joint Efficiencies based on RT Marking

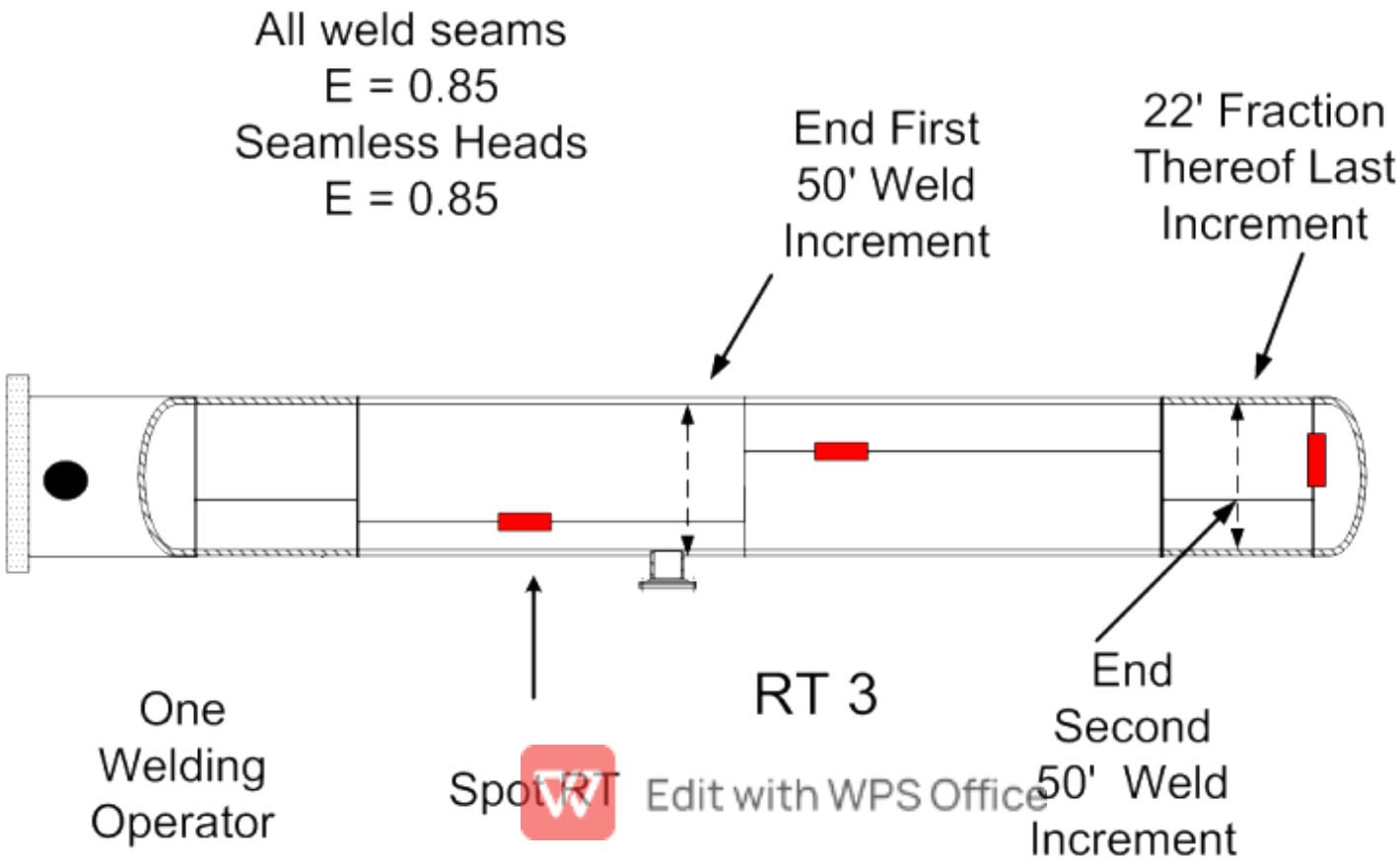
"RT 2" Complete vessel satisfies UW-11(a)(5) and **UW- 11(a)(5)(b) has been applied**.

This is the second Case of RT 2 resulting in E = 1.0, again the rules of UW-52 apply.



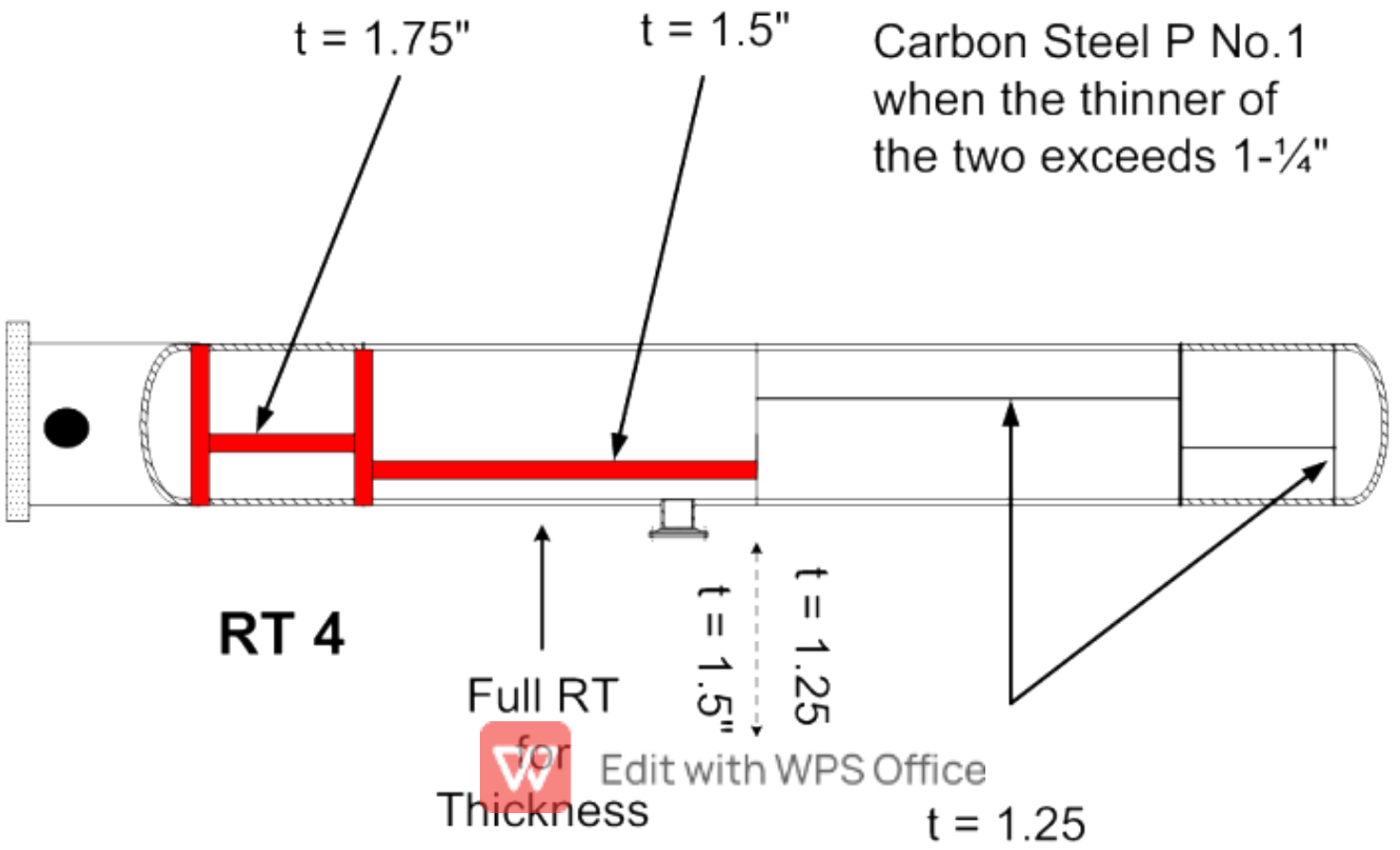
Joint Efficiencies based on RT Marking

"RT 3" Complete vessel satisfies spot radiography of UW-11(b). The simplest example, one welding operator and only three radiographs in 122’ of weld. The following assumes Type 1 welds for all weld seams.



Joint Efficiencies based on RT Marking

"RT 4" When only part of the vessel satisfies any of the above. * Only part of the vessel has been radiographed due to a thickness limit being exceeded as listed in UCS 57 or the desire to use E = 1.0 .



UW-12 Joint Efficiencies

The next consideration are the shells and heads of vessels which are considered seamless. The Efficiencies used to calculate these vessel parts are not found on Table UW-12 but are instead listed in paragraph UW-12(d).

UW-12 Joint Efficiencies

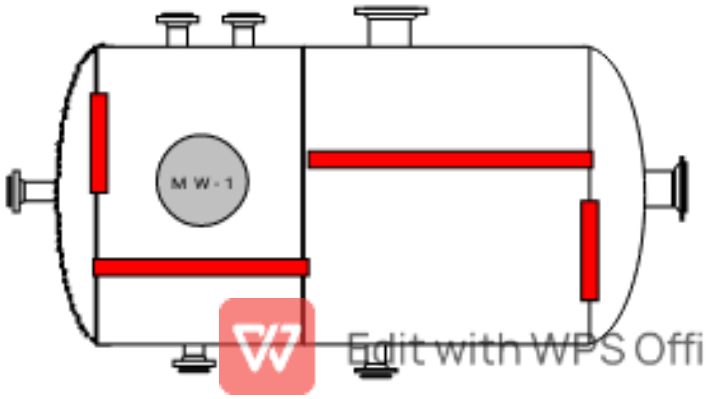
(d) *Seamless vessel sections or heads* shall be considered *equivalent to welded parts of the same geometry* in which all Category A welds are Type No. 1.

For *calculations involving* ***circumferential stress in seamless vessel sections*** or for *thickness of seamless heads,* ***E=1.0*** when the spot radiography requirements of ***UW-11(a)(5)(b) are met***. **E= 0.85** when the spot radiography requirements of **UW-11(a)(5)(b)** ***are not met***, or when the Category A or B welds connecting seamless vessel sections or heads are Type No. 3, 4, 5, or 6 of Table UW-12.

UW-12 Joint Efficiencies

(d) *Seamless vessel sections or heads* shall be considered *equivalent to welded parts of the same geometry* in which all Category A welds are Type No. 1. For *calculations involving* ***circumferential stress in seamless vessel sections*** or for ***thickness of seamless heads, E = 1.0*** when the spot radiography requirements of *UW-11(a)(5)(b)* ***are met****.*

* Note this rule applies to the Code Shop A and B issue.



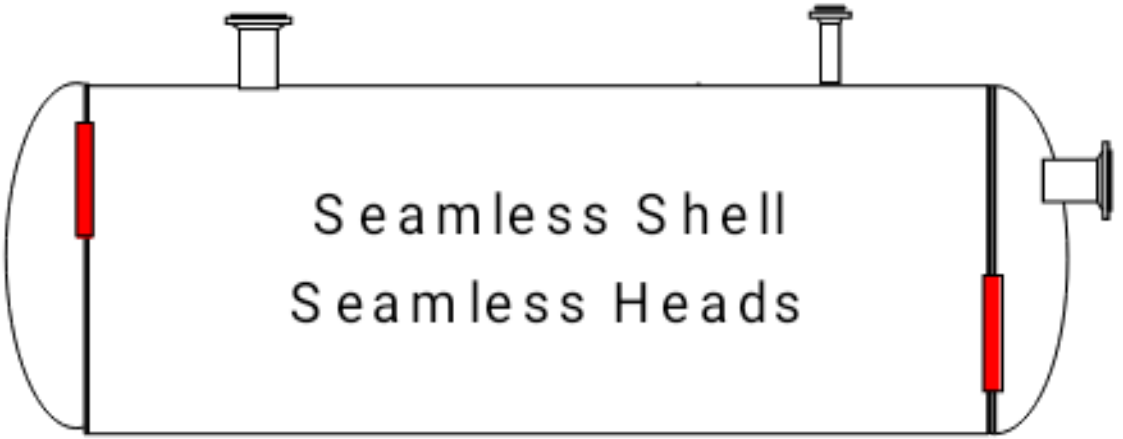
RT 2

Shell and Heads

E = 1.0

UW-12 Joint Efficiencies

(d) *Seamless vessel sections or heads* shall be considered *equivalent to welded parts of the same geometry* in which all Category A welds are Type No. 1. For *calculations involving* ***circumferential stress in seamless vessel sections*** or for *thickness of seamless heads,* ***E=1.0*** when the spot radiography requirements of ***UW-11(a)(5)(b) are met****.*



Shell and Heads

E = 1.0

UW-12 Joint Efficiencies

(d) *Seamless vessel* ..... **E= 0.85** when the spot radiography requirements of **UW-11(a)(5)(b)** ***are not met***, or when the Category A or B welds connecting seamless vessel sections or heads are Type No. 3, 4, 5, or 6 of Table UW-12.

*** 3 to 6 are can not be radiographed by Code rules.**

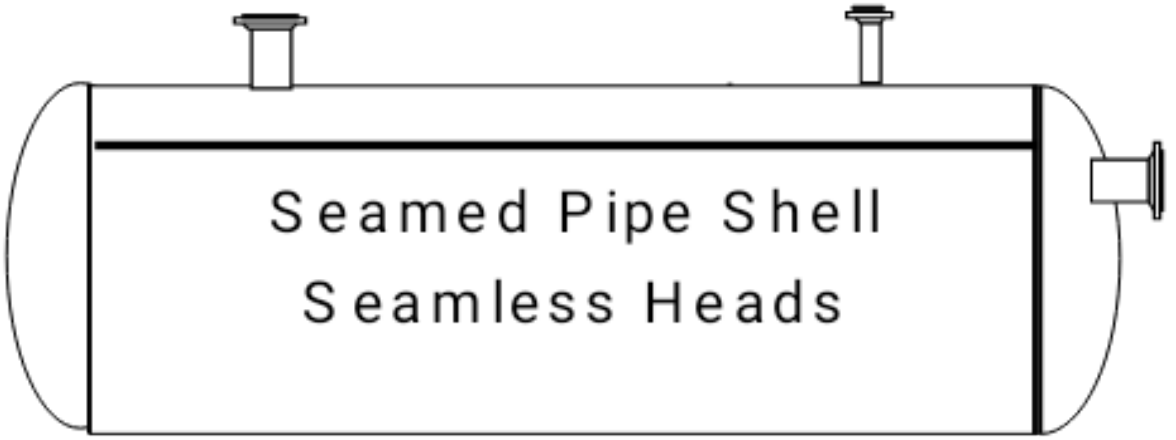
Shell and Heads

E = 0.85

UW-12 Joint Efficiencies

(e) **Welded pipe or tubing** shall be treated in the same manner as seamless, but with allowable tensile stress taken from the welded product values of the stress tables, and the requirements of UW-12(d) applied.

* If the spot RT is applied use **E = 1.0**, if not **E = 0.85**



UW-12 Joint Efficiencies

For the purposes of choosing joint efficiencies when doing vessel section or head calculations on the API 510 Examination the following can be said.

RT 1

Full Use 1.0 if joints are of Type 1 or 0.90 if Type 2

RT 2

Case 1: Use 1.0 with Seamless Heads and Shells

Case 2: Seamed Shells/Seamless Heads

- Shells Use 1.0 if joints are Type 1or if Type 2 Use 0.90
- Use 1.0 for seamless heads

UW-12 Joint Efficiencies

RT 3

Use 0.85 if Joints are of Type 1 or 0.80 if of Type 2
Use 0.85 for Seamless heads

RT 4

*** Special case of selective radiography ***

Use Table UW-12 based on Joint Type and RT described in the exam question.

No RT

Go to Table UW-12 and look up the E to be used for the type of weld under consideration.

Case1: Type 1 Use 0.70
Case 2: Type 2 Use 0.65
Seamless heads use 0.85 Per UW-12(d)

UW-12 Joint Efficiencies

Remember that there only two (2) joint efficiencies possible for Seamless Shell and Seamless Heads they are;

1.0 or 0.85

1.0 when the rules of UW-11(a)(5)(b) have been applied (UW-52 Spot RT **applied**).

0.85 when the rules have not been applied.
(UW-52 Spot RT **not applied**)

DO NOT GO TO TABLE UW-12 FOR THE E TO USE IN SEAMLESS HEADS OR SEAMLESS SHELLS