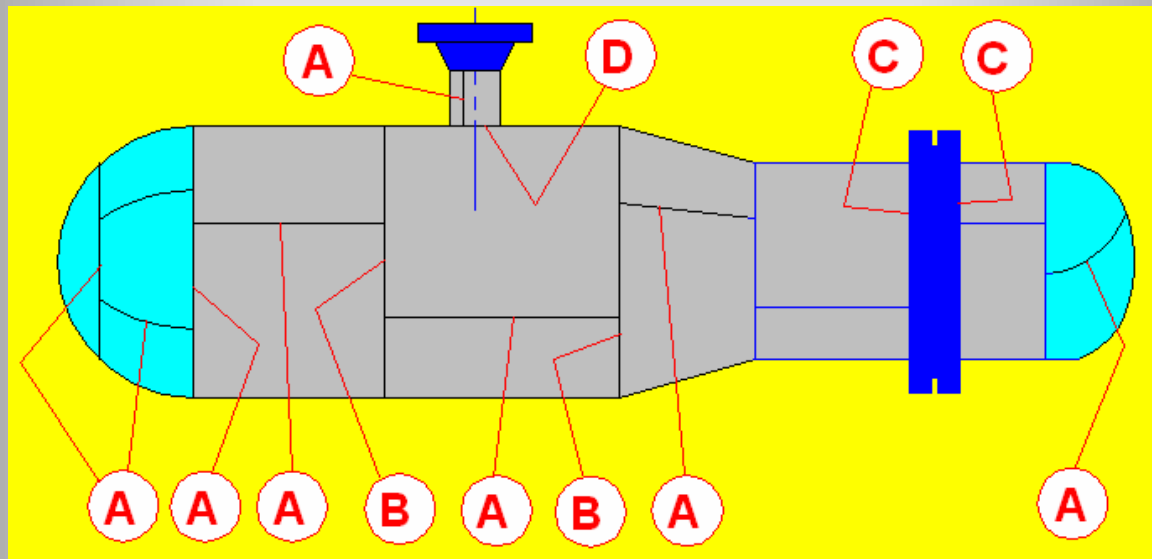


The meaning of Joint Efficiency



ASME UW-3 and UW-12

Weld Category

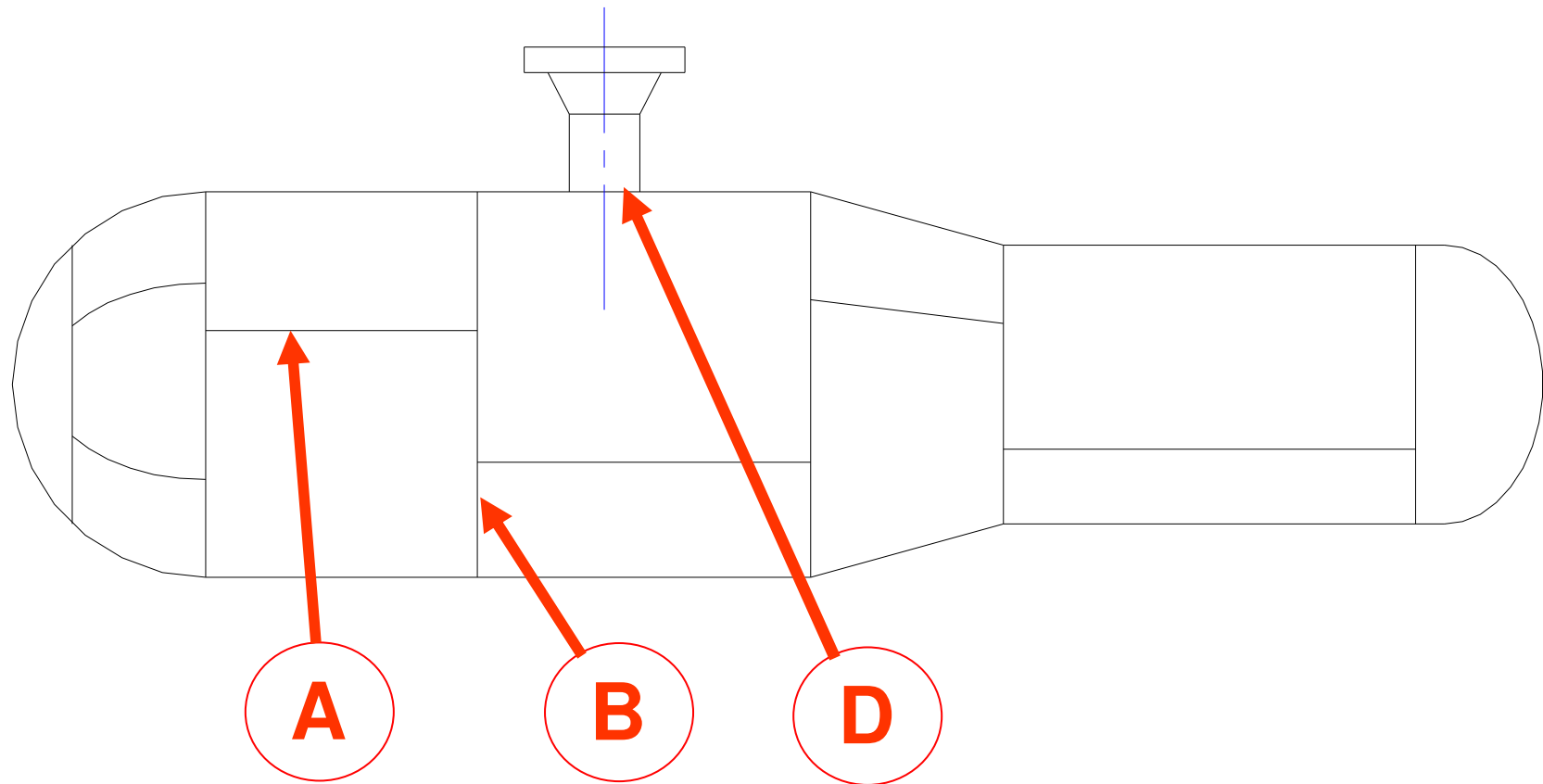
Weld Type

Joint Efficiency

**We Must Understand the Meanings
of These Terms**

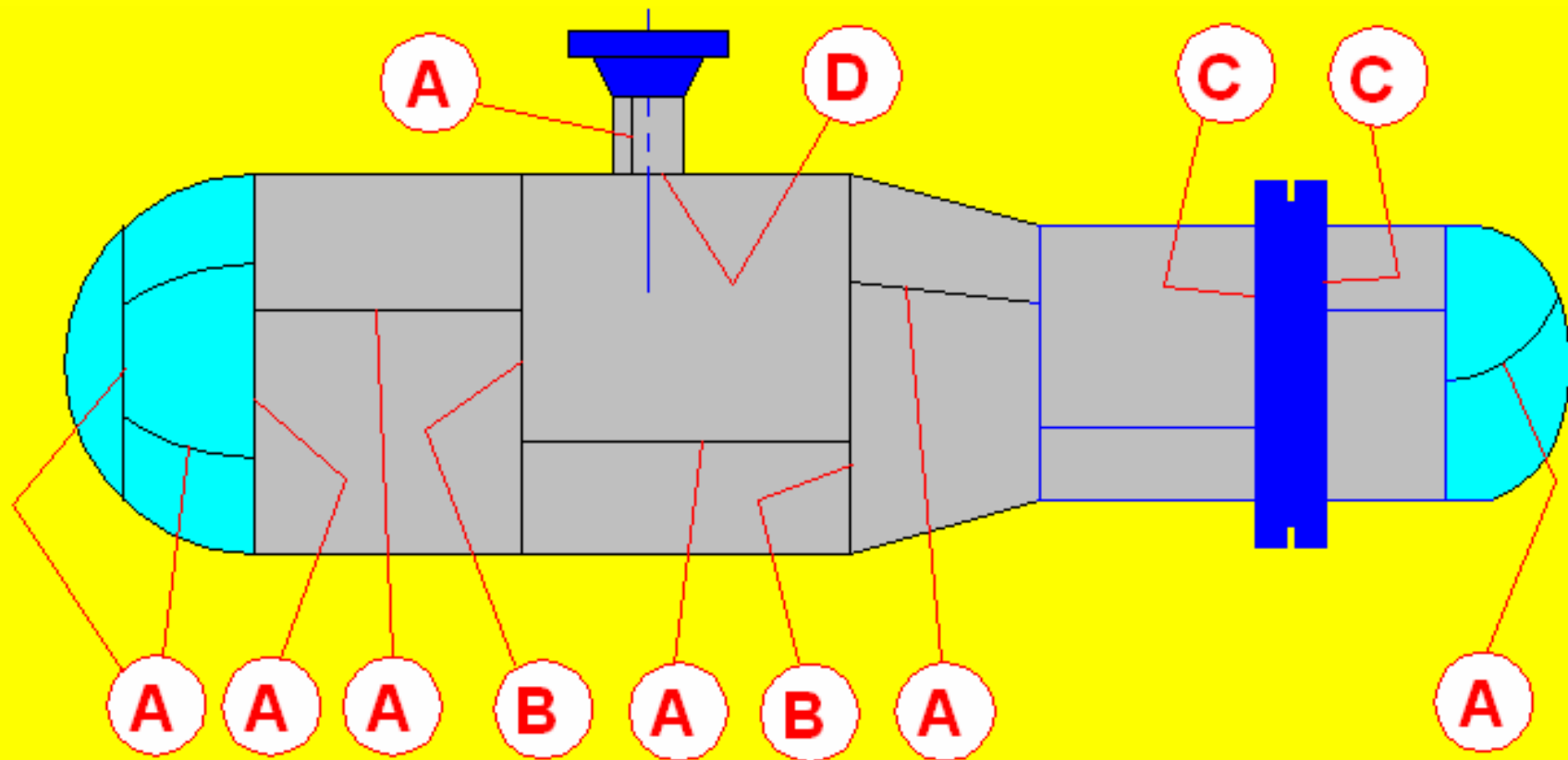
Pressure Envelope

However Parts Must be Welded Together



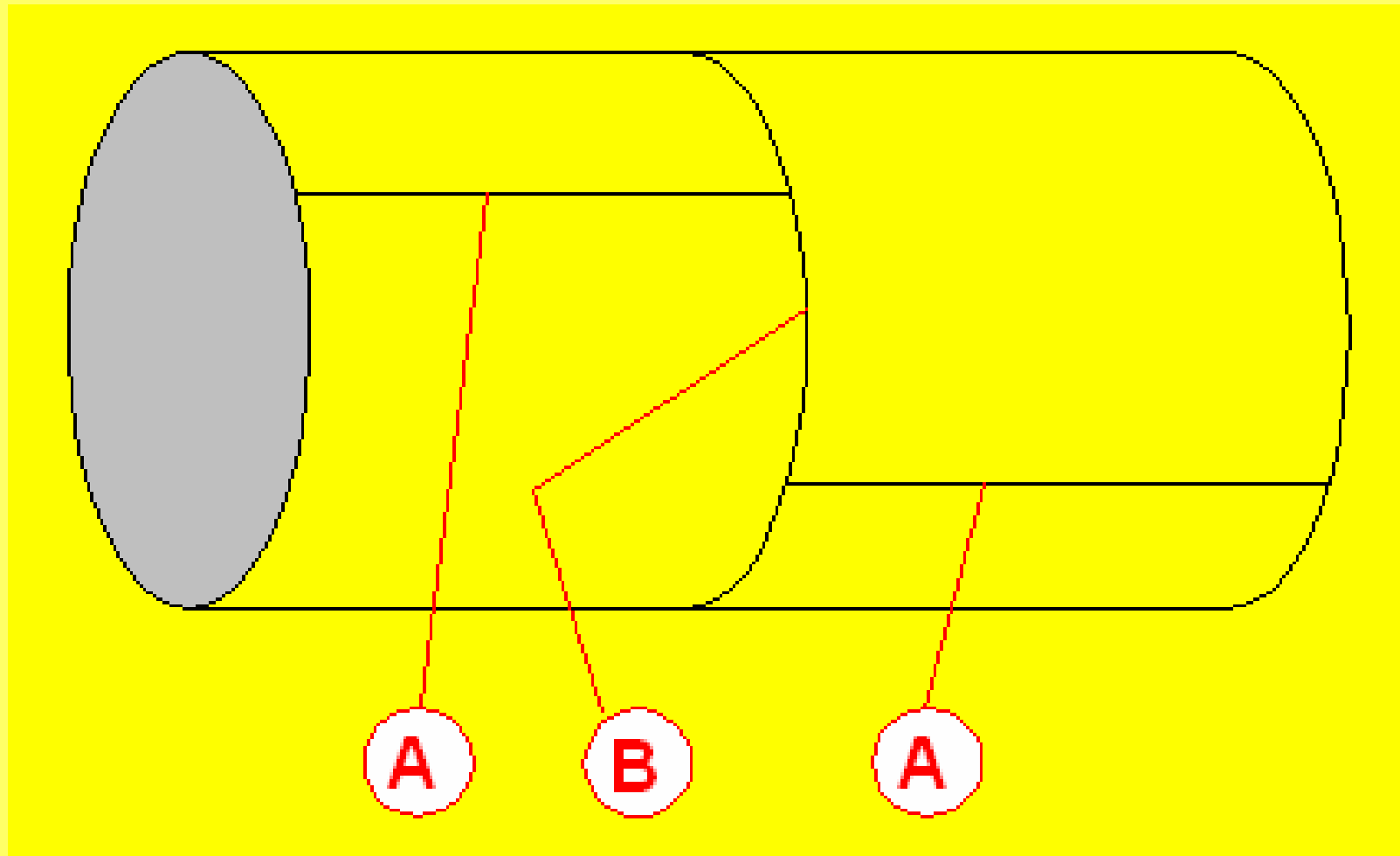
Location of any Weld is its *Category*

Weld Categories

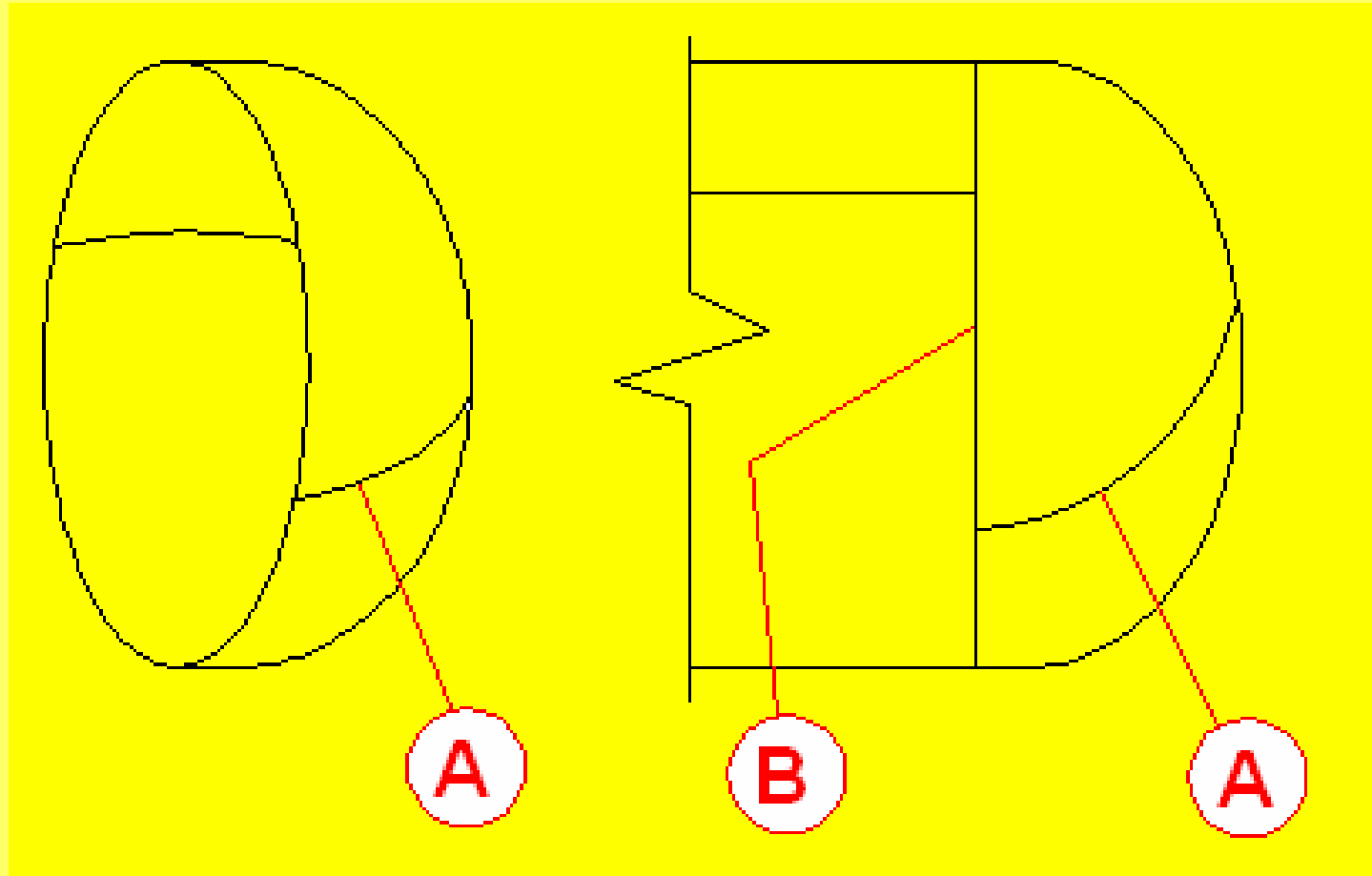


Category = Location

Categories in a Cylindrical Shell

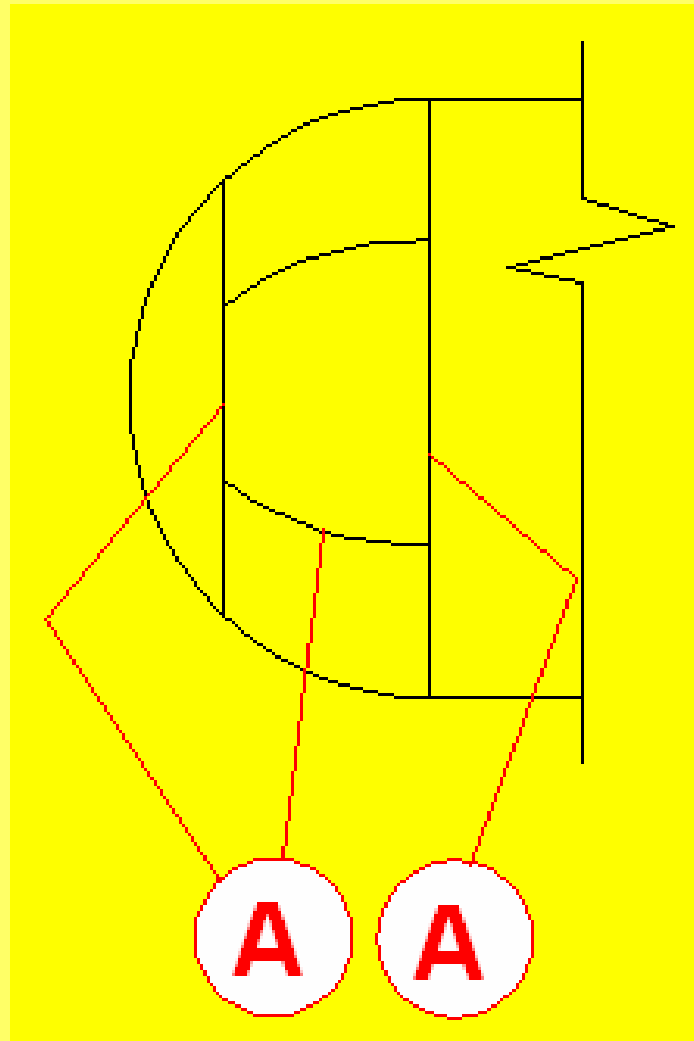


Categories in a Head



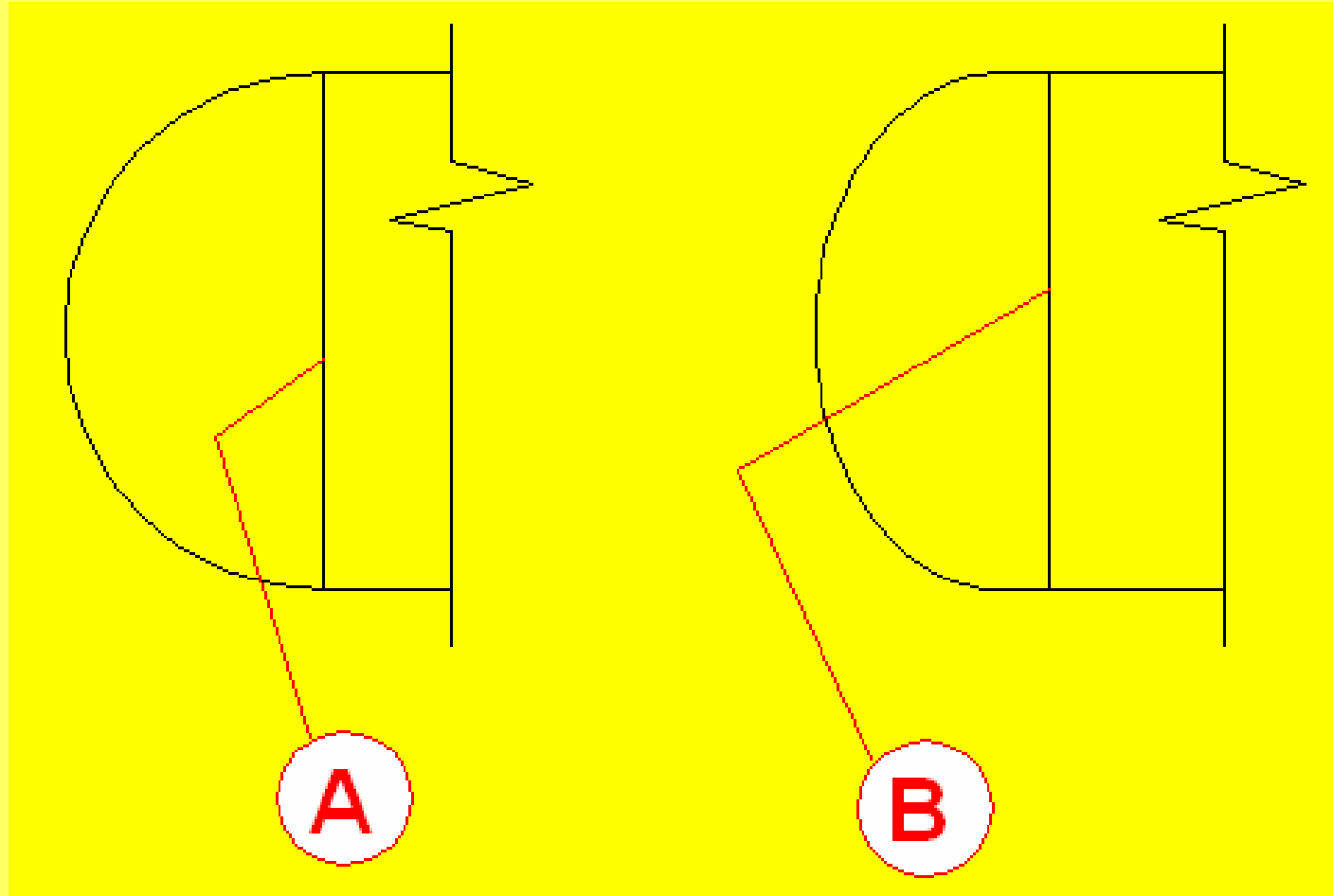
Any Weld Within a Head is Category A

Categories in a Head



Any Weld Within a Head is Category A

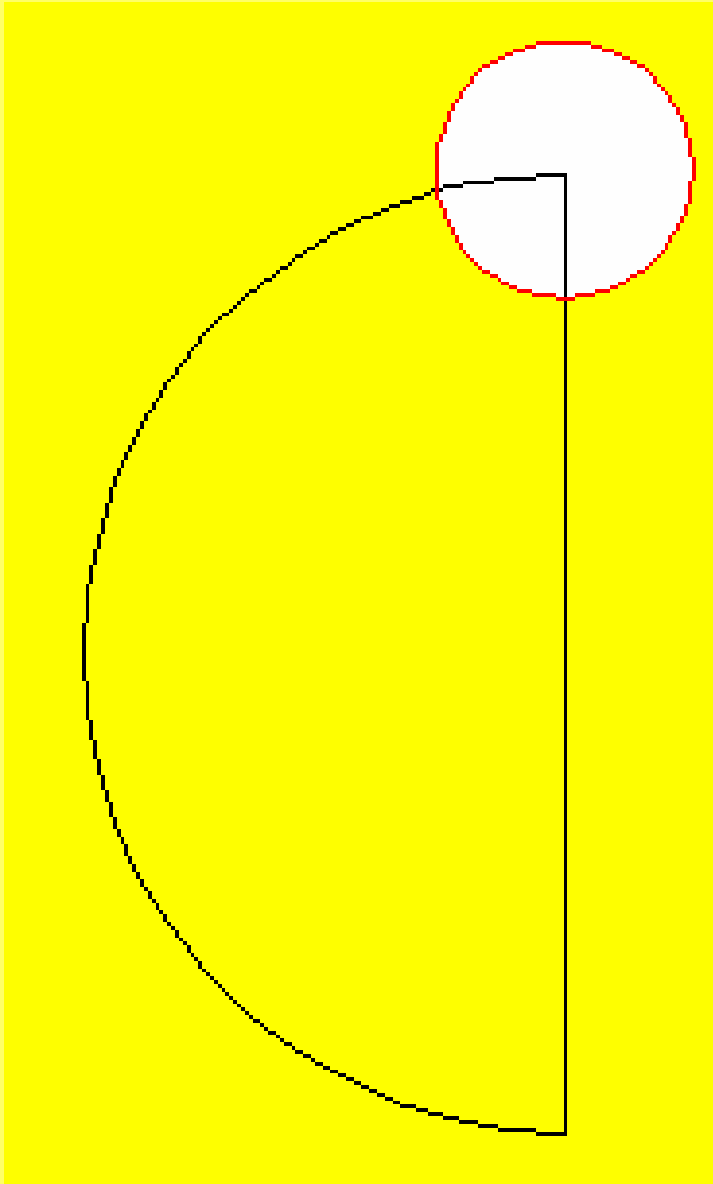
Difference Between Hemisphere Head and Ellipse / Torispherical Head



Hemisphere

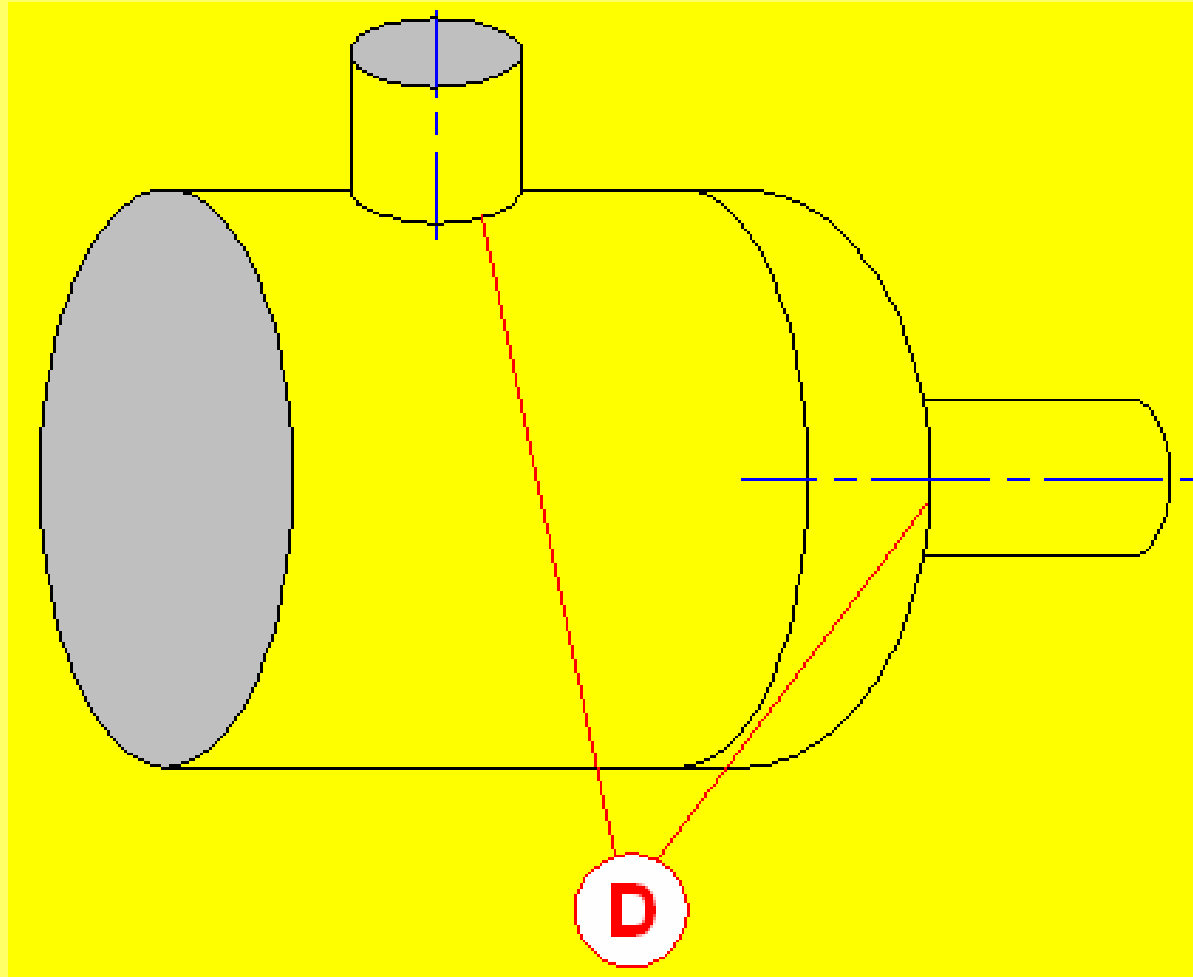
Ellipse / Torisphere

Hemisphere - Special Requirements



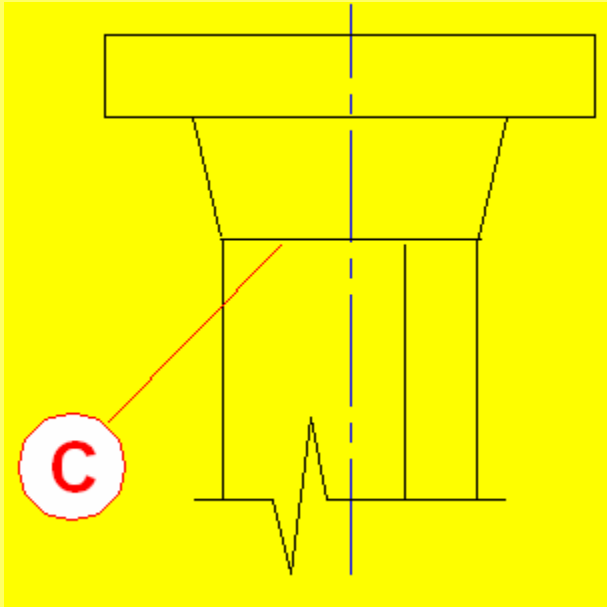
**It is not Permitted to
Have a Straight
Flange on a
Hemispherical Head**

Nozzle Installed in a Chamber

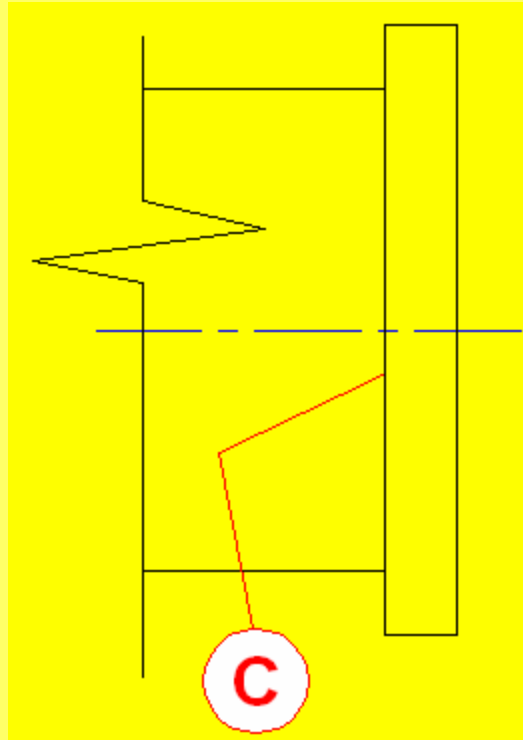


This is a Category D Weld

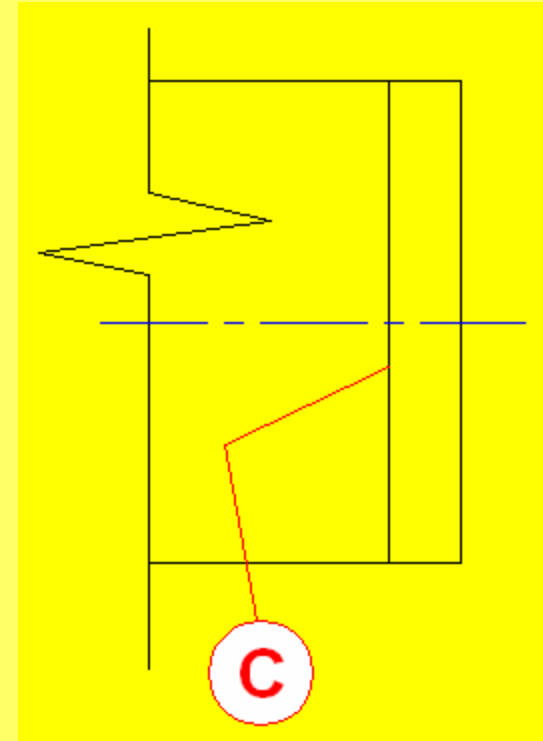
Category C Weld



**Flange
Weld**



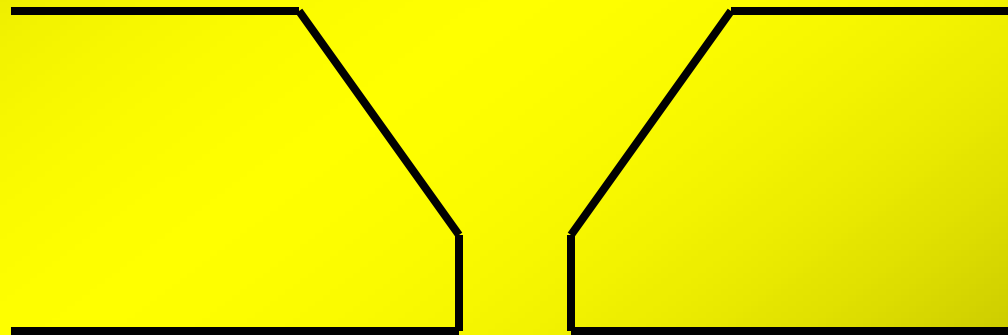
**Tubesheet
Weld**



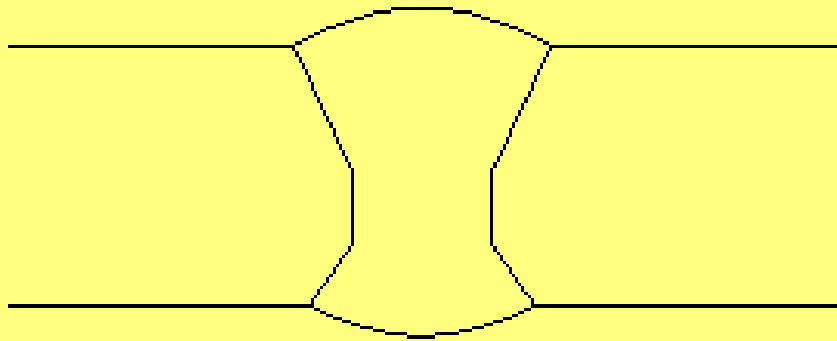
**Flat Head
Weld**

Weld Type = Joint Geometry

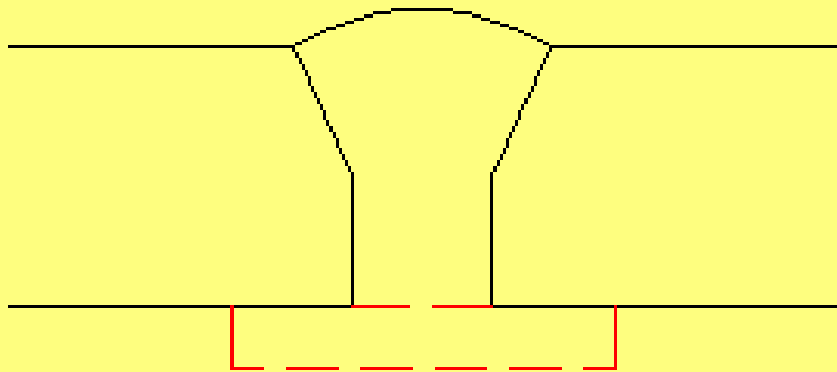
**Is the Method of Welding and
Marking the Joint**



Type 1

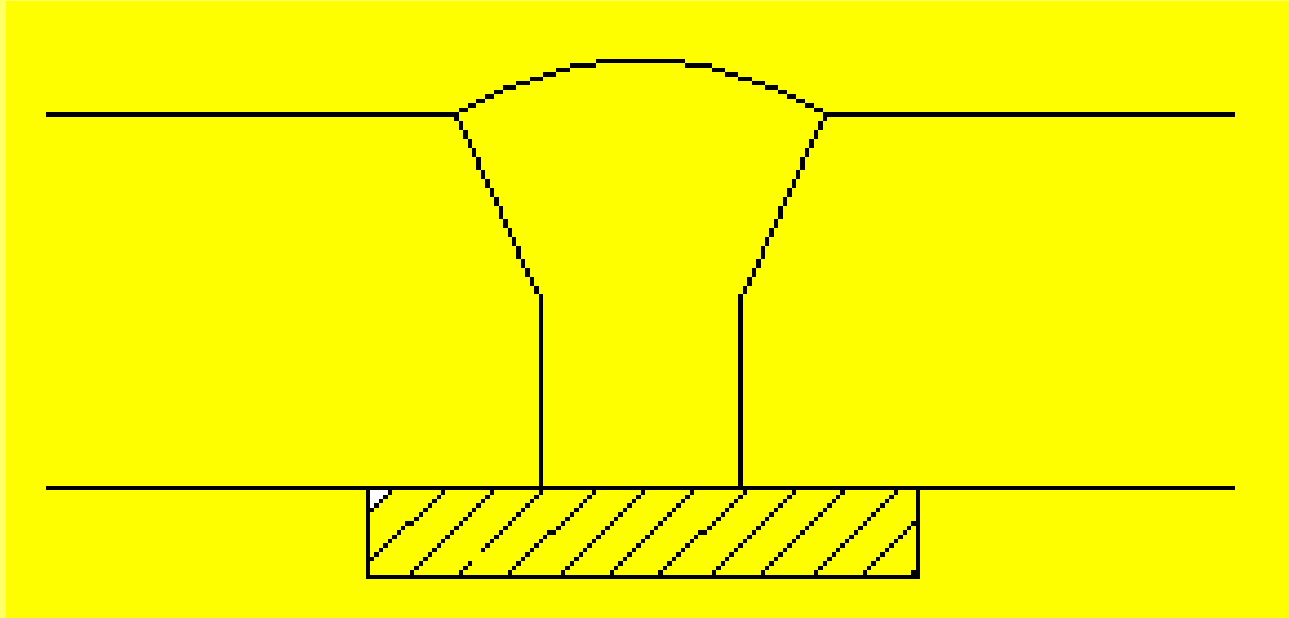


**Welded From Both
Sides**



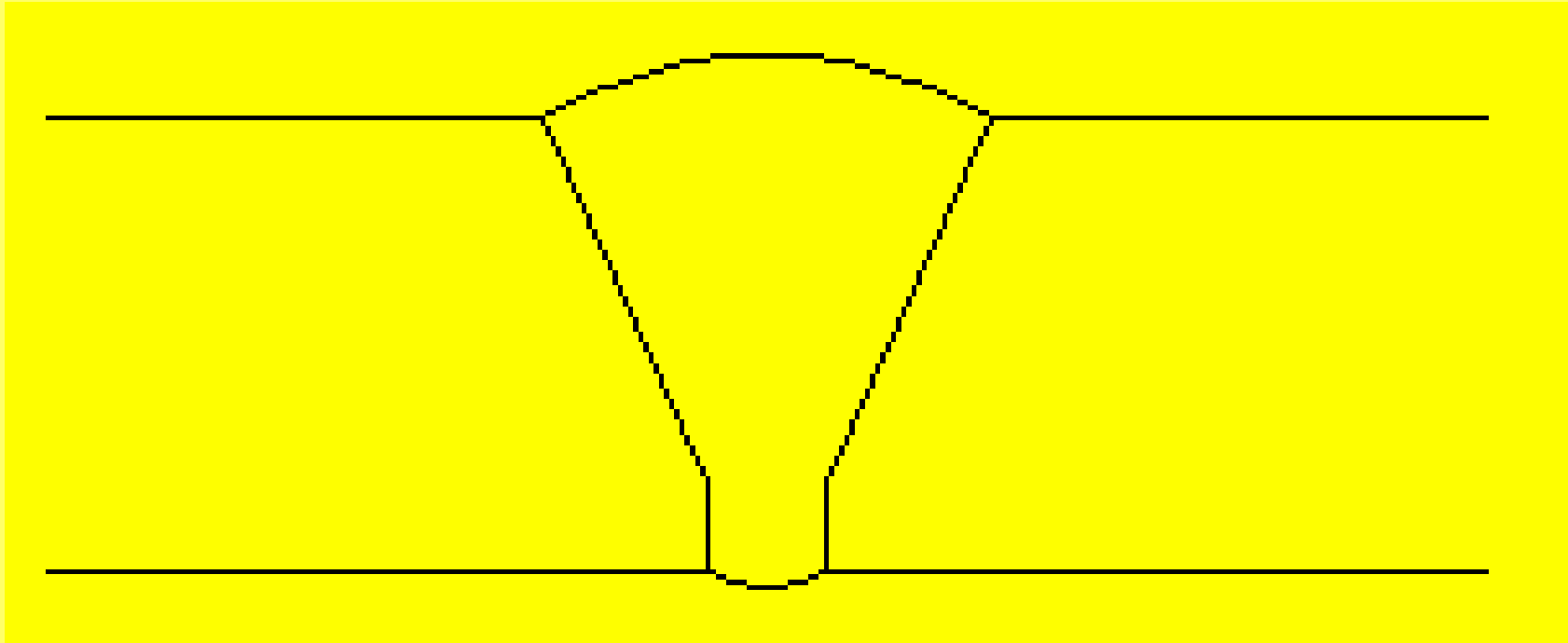
**Welded From One Side
With Removable
Backing**

Type 2



Backing That Remains in Place

Type 3



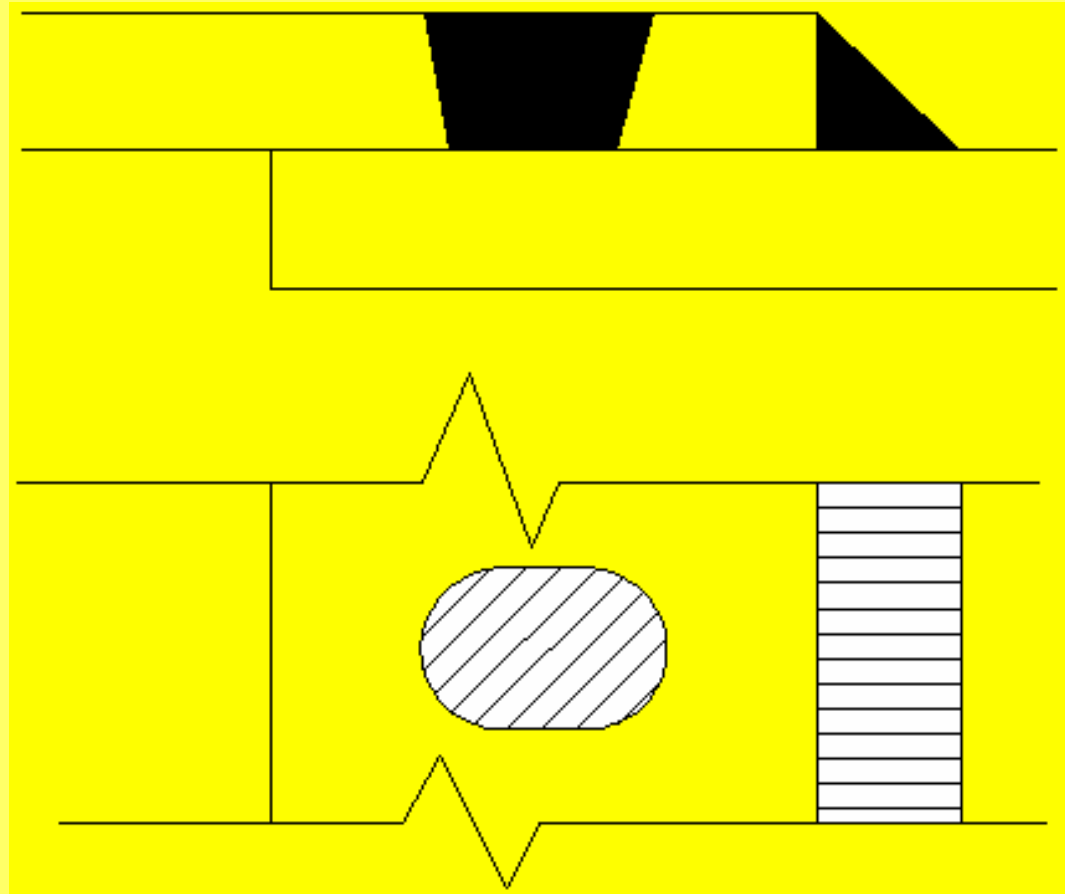
Welded From One Side Only

Type 4



Double Fillet Welded

Type 5



Single Fillet With Plug Welds

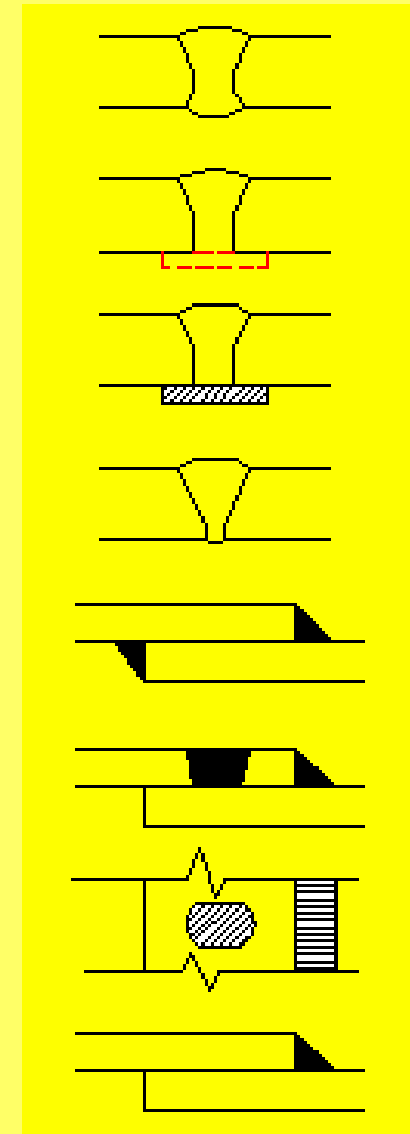
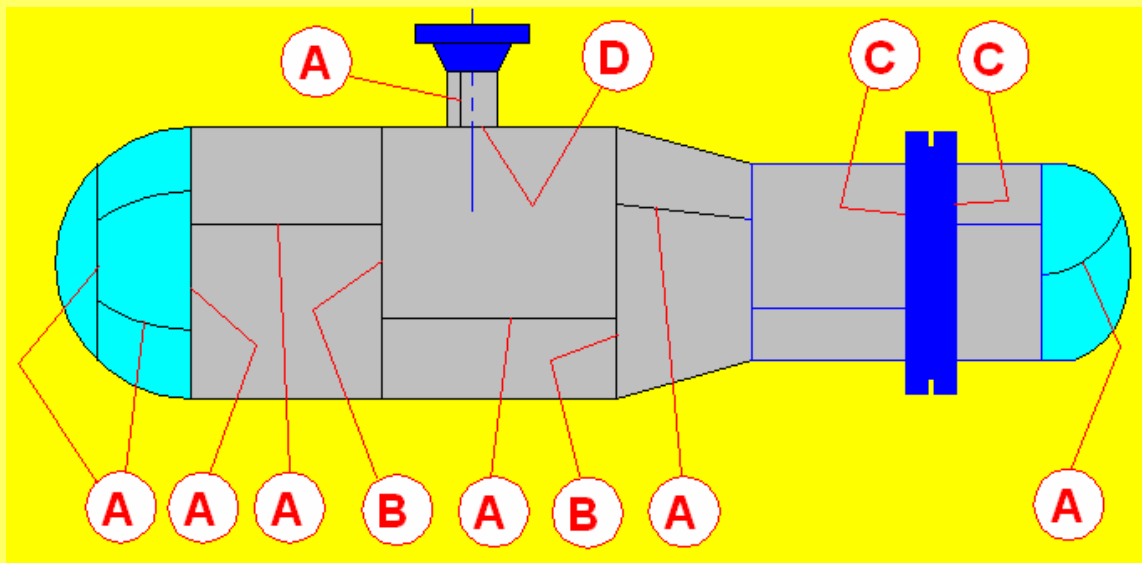
Type 6



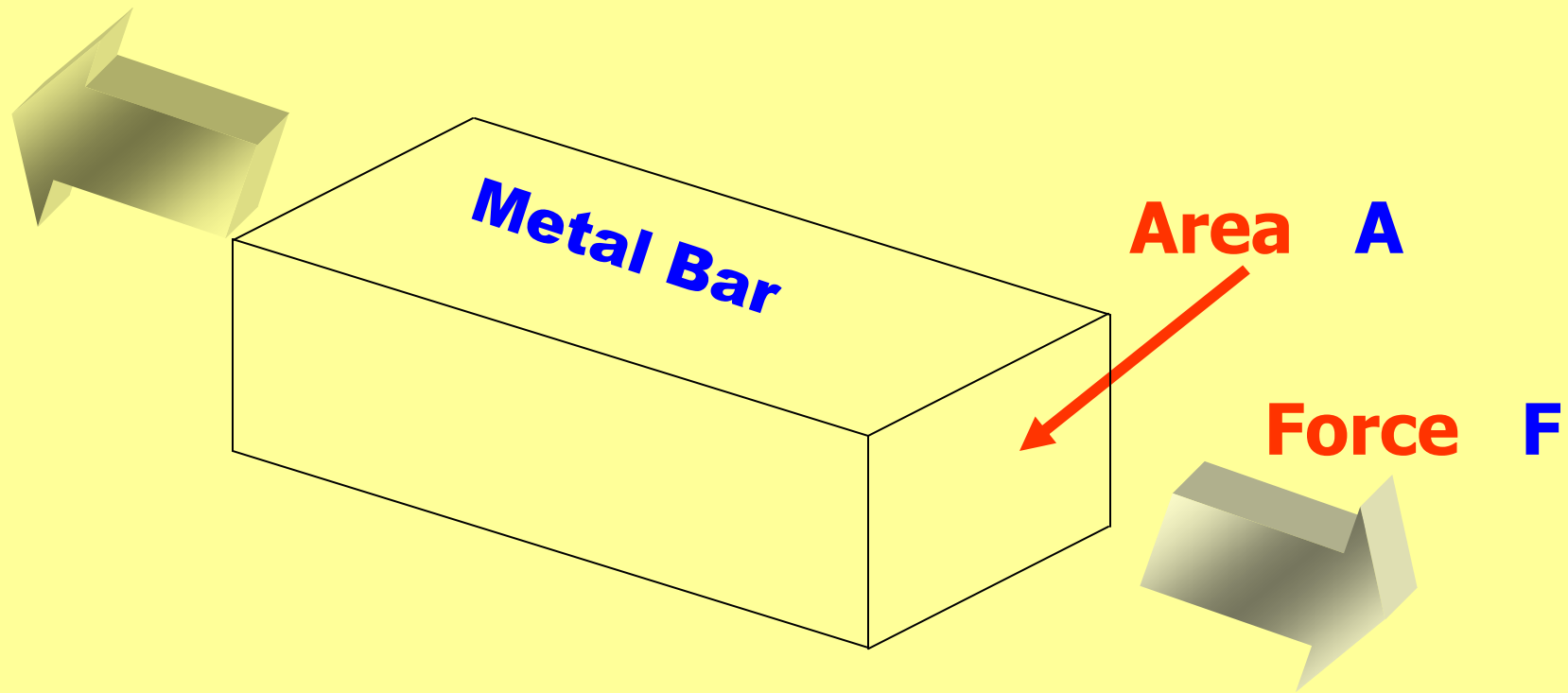
Single Fillet Weld

Type = Geometry

Category = Location



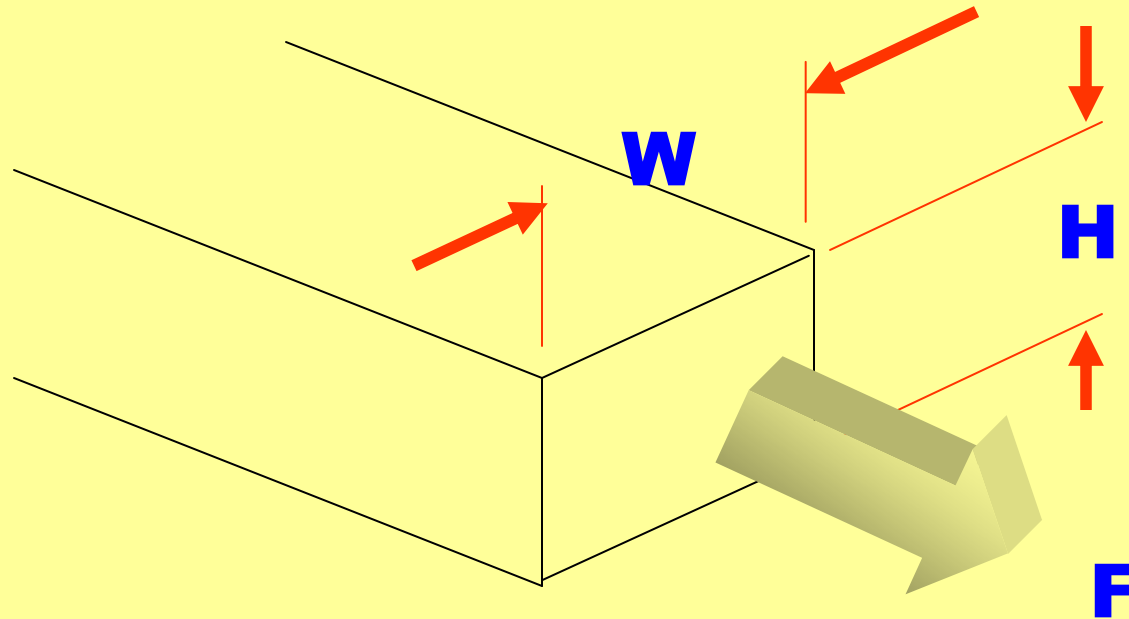
Definition of Stress: **S**



$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$S = \frac{F}{A}$$

Simple Stress Calculation



W = 15 mm

H = 10 mm

F = 6 000 N

$$S = \frac{F}{A} = \frac{6\,000\text{ N}}{15 \times 10\text{ mm}^2} = 40\text{ N/mm}^2$$

CALCULATING FORCE

$$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}}$$

CHANGING THE FORMULA AROUND TO FIND FORCE

$$\text{FORCE} = \text{STRESS} \times \text{AREA}$$

STRESS IS THE SAME AS PRESSURE

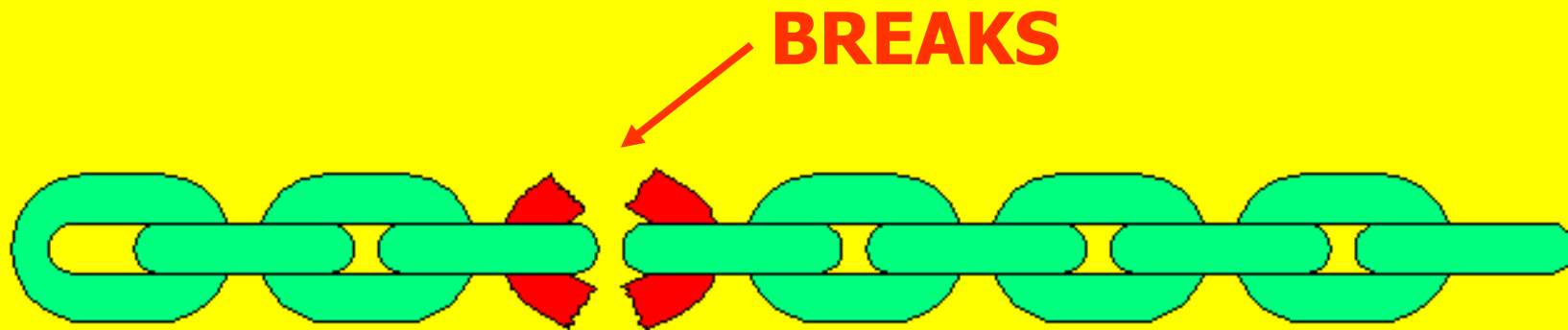
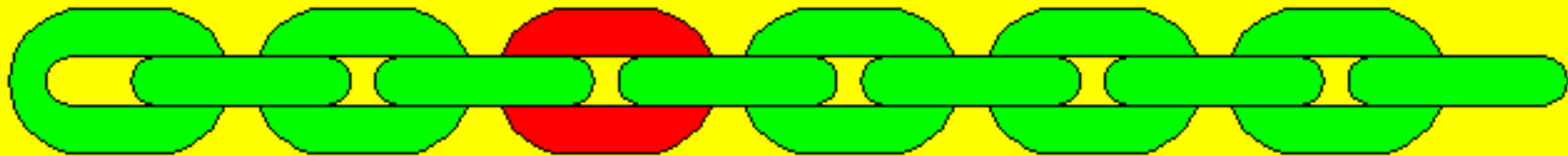
$$\text{FORCE} = \text{STRESS} \times \text{AREA}$$

AND

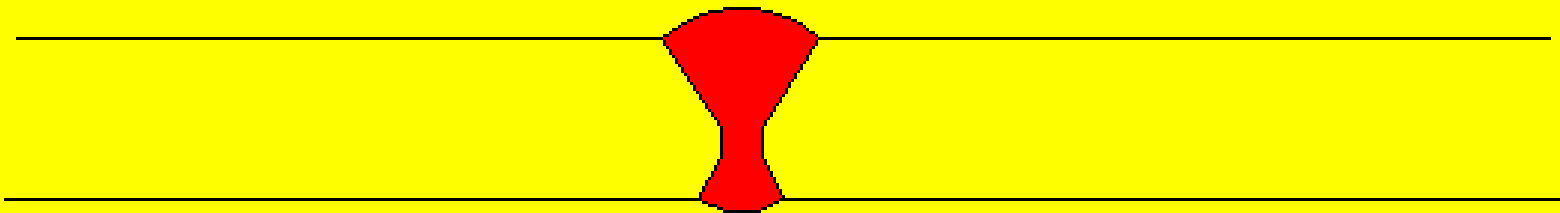
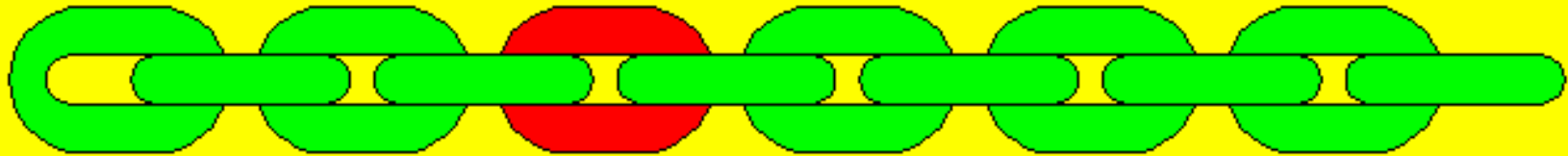
$$\text{FORCE} = \text{PRESSURE} \times \text{AREA}$$

DEFINITION OF JOINT EFFICIENCY E

A CHAIN IS AS STRONG AS ITS WEAKEST LINK !



Note the Similarity



The Weld Can Also be the Weakest Link

**How Much Faith to we Have in a Weak Link, or
the Weld. This is a Matter of Confidence**

DEFINITION OF JOINT EFFICIENCY E

**QUESTION: HOW CONFIDENT ARE WE IN
THE QUALITY OF THE WELD ?**

**IF THE WELD IS WEAKER THAN PARENT
METAL WE NOW INTRODUCE JOINT
EFFICIENCY E**

$$E = \frac{\text{STRENGTH OF THE WELD}}{\text{STRENGTH OF PARENT METAL}}$$

JOINT EFFICIENCY E

$$E = \frac{\text{STRENGTH OF THE WELD}}{\text{STRENGTH OF PARENT METAL}}$$

IF WELD IS AS GOOD AS PARENT METAL

$$E = 1.00$$

IF WELD IS WEAKER THAN PARENT METAL

$$E = < 1.00$$

JOINT EFFICIENCY E

**QUESTION: HOW DO WE DETERMINE THE
QUALITY OF THE WELD**

BY USING RADIOGRAPHY

FOR A TYPE 1 WELD

FULL RADIOGRAPHY OF JOINT	E = 1.00
SPOT RADIOGRAPHY OF JOINT	E = 0.85
NO RADIOGRAPHY OF JOINT	E = 0.70

TAKEN FROM TABLE UW-12

JOINT EFFICIENCY 'E' IS DETERMINED BY TWO THINGS:

1 WELD TYPE

2 DEGREE OF RADIOGRAPHY

**THE FULL DETAILS ARE FOUND IN
TABLE UW-12 OF ASME**

LET US LOOK AT TABLE UW-12.....

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) 100% 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		0.85	0.70
(2)	Single-welded butt joint with backing strip other than those included in (1)	One exception in (a) below: circumferential butt joints with offset; see UW-3.1, sketch	A, B, C, & D A, B, & C	0.90 0.90	0.80 0.80	0.65 0.65
(3)	Single-welded butt joint with backing strip	Circumferential butt joints only, not over 5 in. in nominal thickness and not over 4 in. outside diameter	A, B, & C	NA	NA	0.60
	Double full penetration	(a) Longitudinal joints not over 3/8 in. thick (b) Circumferential joints not over 5/8 in. thick	A B & C ⁶	NA NA	NA NA	0.55 0.55
(5)	Single full penetration lap joints with plug welds conforming to UW-17	(a) Circumferential joints ⁴ for attachment of heads not over 24 in. outside diameter to shells not over 1/2 in. thick (b) Circumferential joints for the attachment to shells of jackets not over 5/8 in. in nominal thickness where the distance from the center of the plug weld to the edge of the plate is not less than 1 1/2 times the diameter of the hole for the plug.	B C	NA NA	NA NA	0.50 0.50

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 (b) Circumferential butt joint with plate offset; see UW-13(b) and Fig. W-13.1	A, B, C, & D A, B, & C	0.90 0.90	0.80 0.70	0.65 0.65
(3)	Single-welded lap joint with or without use of backing strip	(a) Longitudinal joints not over 3/8 in. thick (b) Circumferential joints not over 5/8 in. thick	A B & C ⁶	NA NA	NA NA	0.60 0.55
(4)	Double full fillet lap joint	(a) Longitudinal joints not over 3/8 in. thick (b) Circumferential joints not over 5/8 in. thick	A B & C ⁶	NA NA	NA NA	0.55 0.55
(5)	Single full fillet lap joints with plug welds conforming to UW-17	(a) Circumferential joints ⁴ for attachment of heads not over 24 in. outside diameter to shells not over 1/2 in. thick (b) Circumferential joints for the attachment to shells of jackets not over 5/8 in. in nominal thickness where the distance from the center of the plug weld to the edge of the plate is not less than 1 1/2 times the diameter of the hole for the plug.	B C	NA NA	NA NA	0.50 0.50

TABLE UW-12

Type	Joint Category	Degree of Radiography		
		(a) Full	(b) Spot	(c) None
1	A,B,C, & D	1.00	0.85	0.70
2	A,B,C, & D	0.90	0.80	0.65
3	A,B, & C	N/A	N/A	0.60
Etc.....				

THE ABOVE TABLE IS ABBREVIATED

**THE TABLE IN THE CODE CONTAINS A LOT OF
IMPORTANT INFORMATION - MUST BE CONSULTED**

LET US LOOK AT AN EXAMPLE

Type	Joint Category	Degree of Radiography		
		(a) Full	(b) Spot	(c) None
1	A,B,C, & D	1.00	0.85	0.70
2	A,B,C, & D	0.90	0.80	0.65
3	A,B, & C	N/A	N/A	0.60
Etc.....				

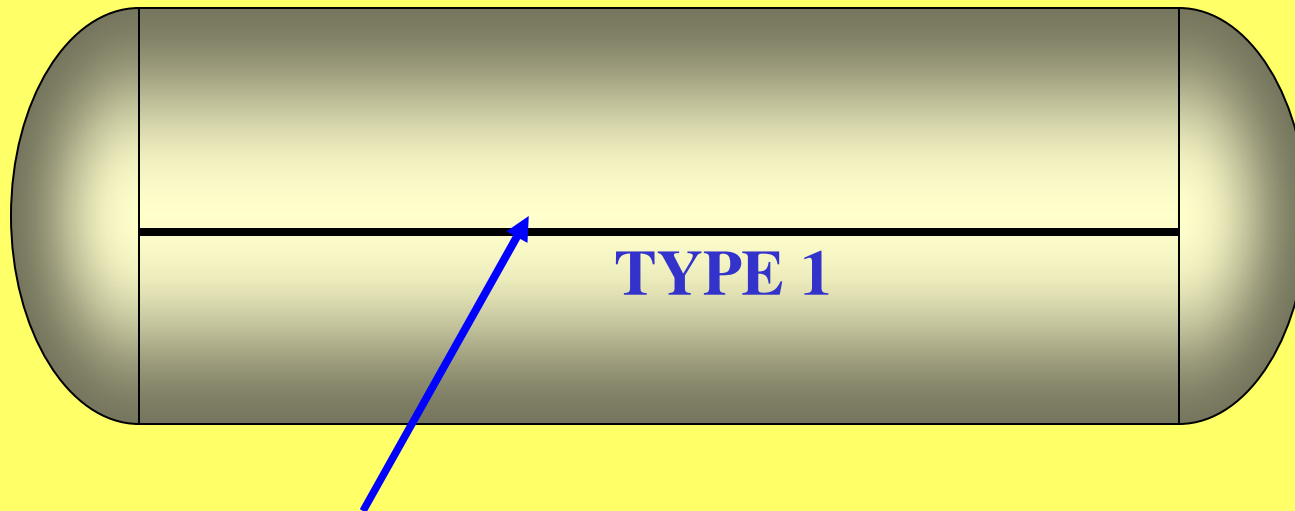
LET US HAVE A TYPE 2 JOINT

SUBJECT TO SPOT RADIOGRAPHY

WHAT IS THE JOINT EFFICIENCY E ?

$$E = 0,80$$

LET US LOOK AT FULL RADIOGRAPHY



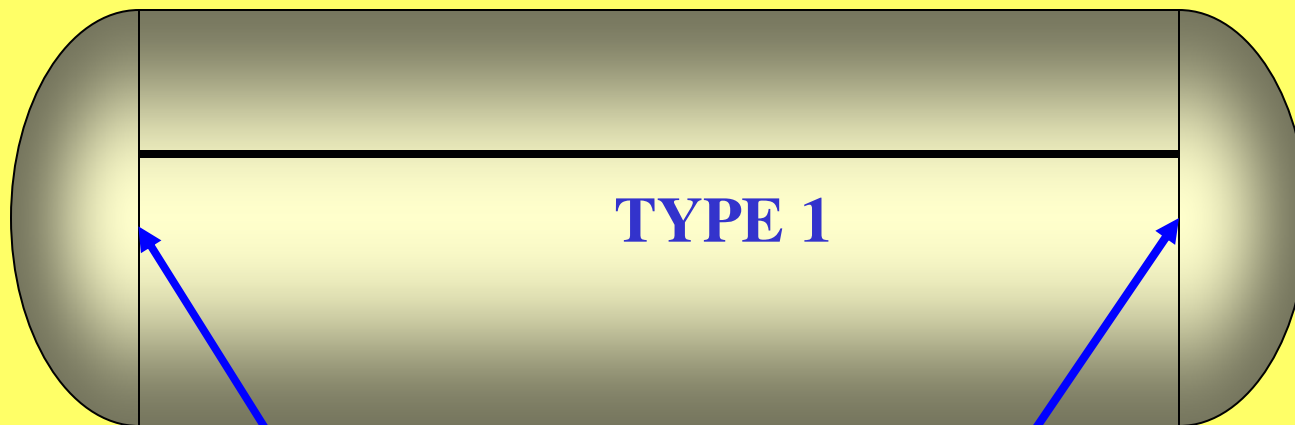
SUPPOSE THIS JOINT IS SUBJECT TO FULL RADIOGRAPHY

Type	Joint Category	Degree of Radiography		
		(a) Full	(b) Spot	(c) None
1	A,B,C, & D	1.00	0.85	0.70

IS JOINT EFFICIENCY $E = 1.00$?

WE DO NOT KNOW AT THIS STAGE - WHY ?

LET US LOOK AT FULL RADIOGRAPHY



**TO GET CREDIT FOR FULL RADIOGRAPHY OF A
CATEGORY **A** WELD:**

UW-11(A)(5)(B) SAYS:

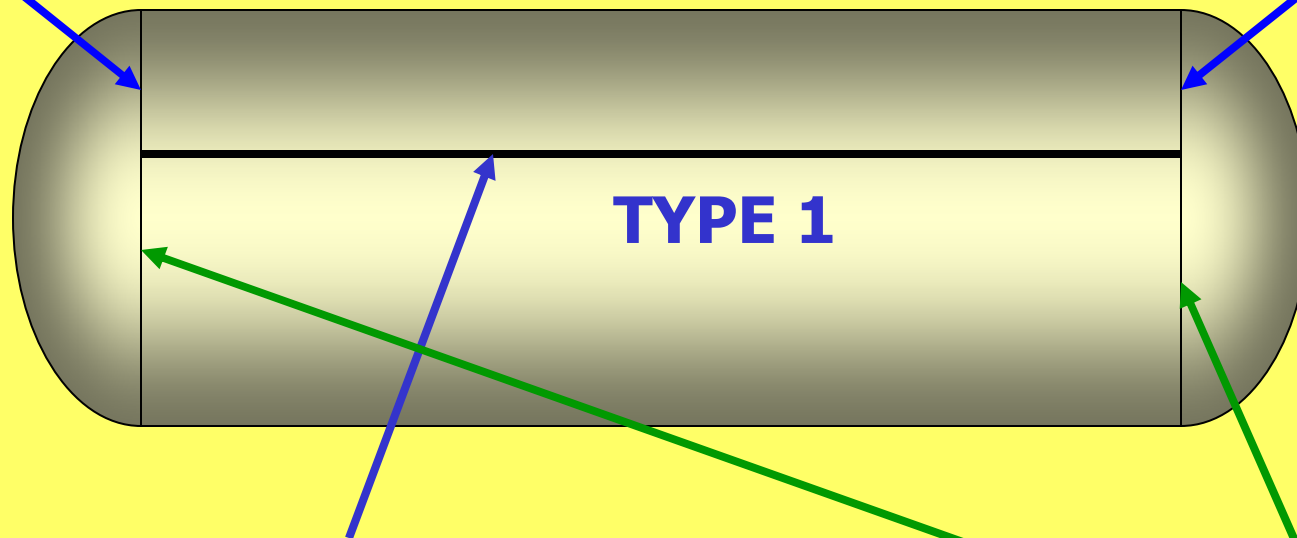
***"...CATEGORY B OR C BUTT WELDS SHALL AS A
MINIMUM , MEET THE REQUIREMENTS FOR SPOT
RADIOGRAPHY....."***

CATEGORY B WELDS MUST BE AT LEAST SPOT

CONSIDER THIS RADIOGRAPHY SETUP

NO XRAY

SPOT



DO WE GET CREDIT FOR FULL RADIOGRAPHY OF THIS JOINT ?

UW-11(A)(5)(B) SAYS:

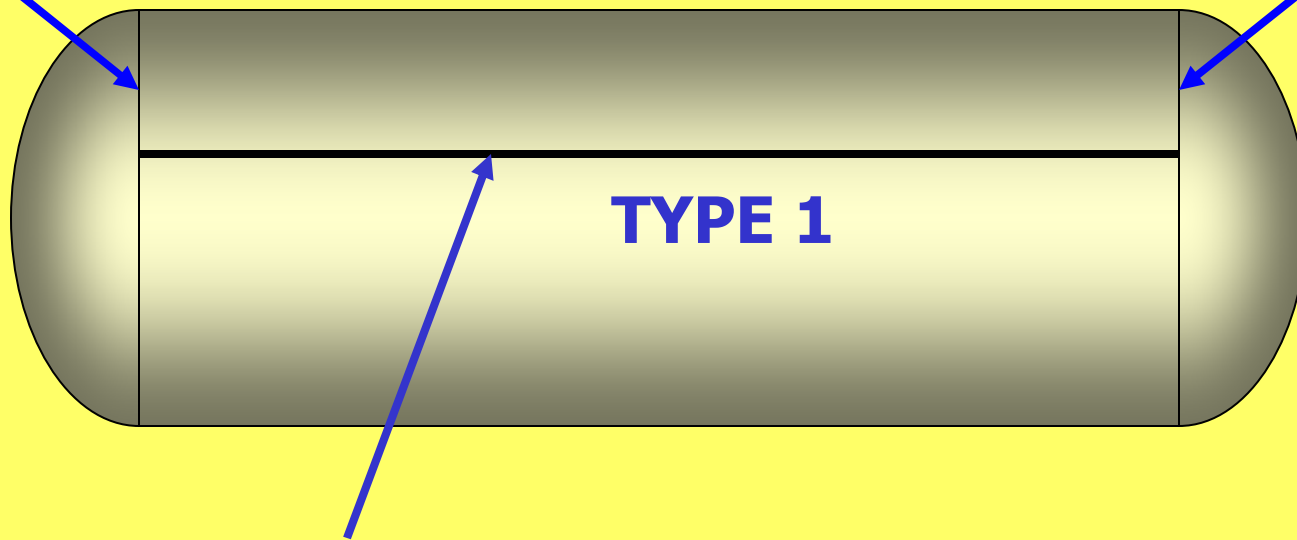
MEANS BOTH WELDS

"...CATEGORY B OR C BUTT WELDS... SHALL AS A MINIMUM, MEET THE REQUIREMENTS FOR SPOT RADIOGRAPHY....."

LET US LOOK AT FULL RADIOGRAPHY

NO XRAY

SPOT



TYPE 1

DO WE GET CREDIT FOR FULL RADIOGRAPHY OF THIS JOINT ?

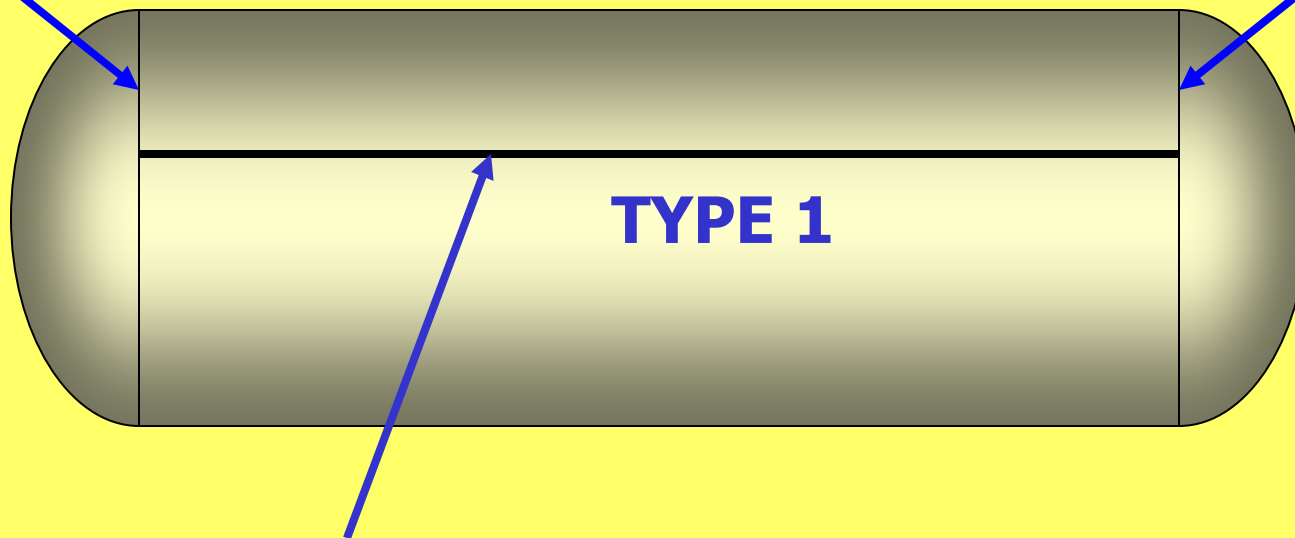
THEREFORE, WE ONLY GET CREDIT FOR SPOT RADIOGRAPHY

THEREFORE.....

LET US LOOK AT FULL RADIOGRAPHY

NO XRAY

SPOT

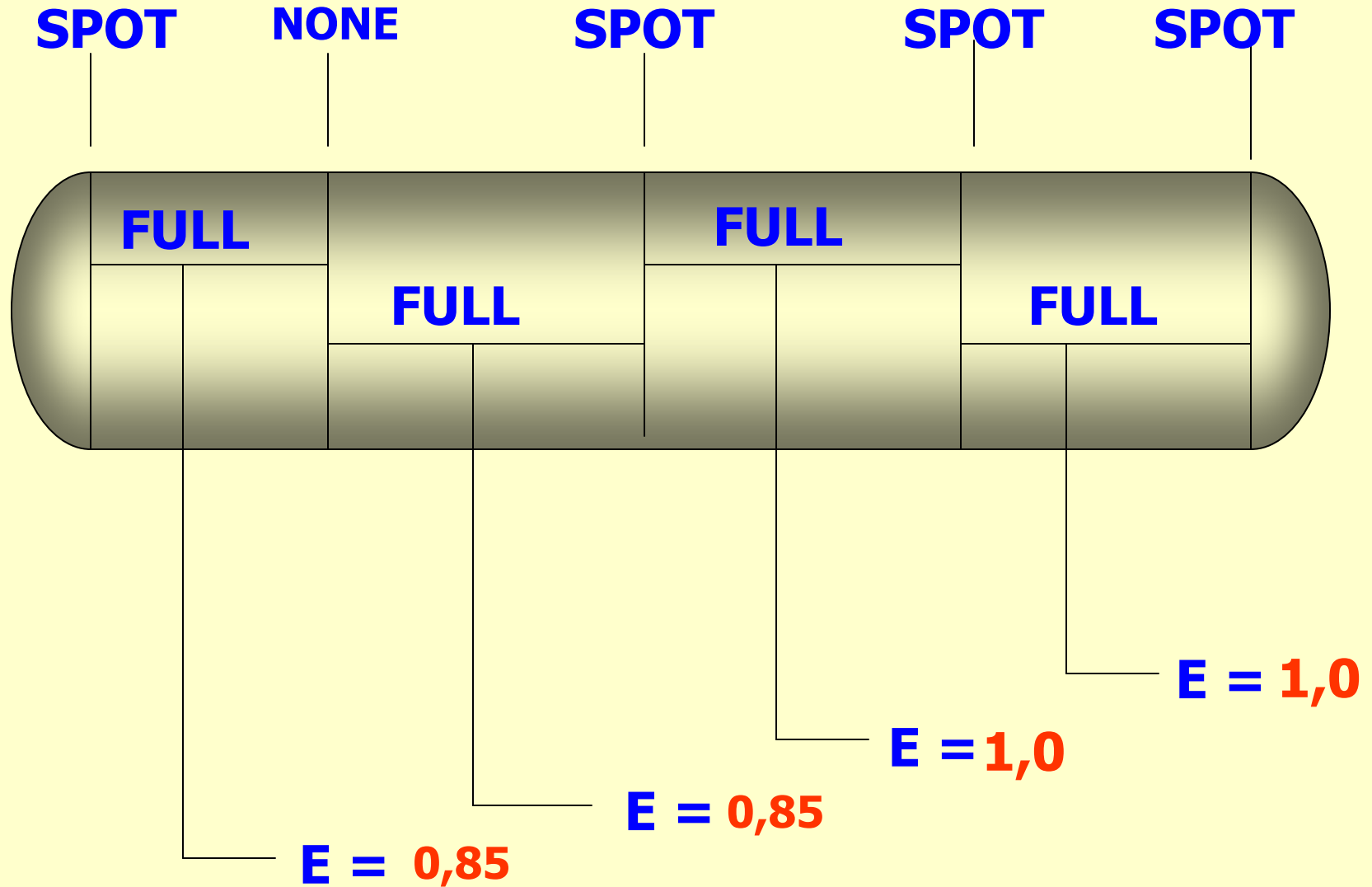


DO WE GET CREDIT FOR FULL RADIOGRAPHY OF THIS JOINT ?

NO, WE ONLY GET CREDIT FOR SPOT RADIOGRAPHY

Type	Joint Category	Degree of Radiography		
		(a) Full	(b) Spot	(c) None
1	A, B, C, & D	1.00	0.85	0.70

NOW CONSIDER THIS ARRANGEMENT

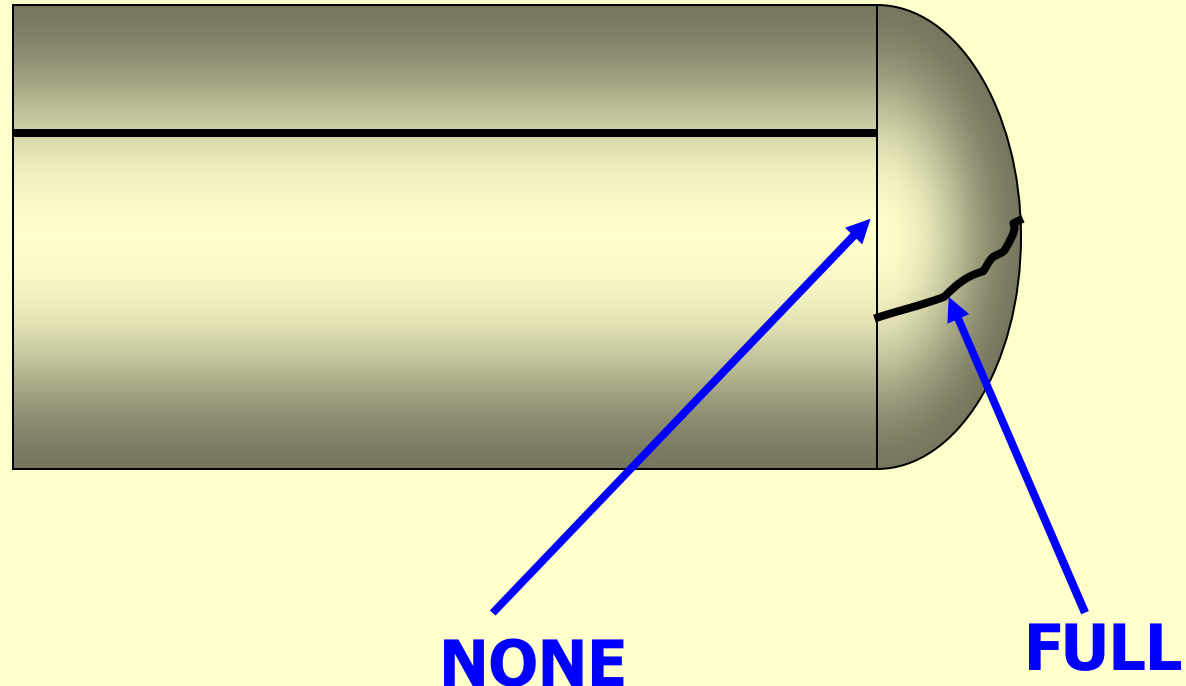


REMEMBER UW-11(a)(5)(b)

TO GET CREDIT FOR E = 1,00 FOR CATEGORY A WELDS

**MAKE SURE ALL CATEGORY B WELDS EITHER SIDE
OF THE CATEGORY A WELD ARE SPOT
RADIOGRAPHE**

CONSIDER THE WELD IN THIS HEAD



UW-11(a)(5)(b) IS NOT SATISFIED FOR THE HEAD WHICH HAS A CATEGORY A WELD

THUS FOR THE HEAD WELD: $E = 0,85$

CONSIDER A SEAMLESS COMPONENT



**THE SHELL AND HEADS ARE SEAMLESS - WHAT IS
THE JOINT EFFICIENCY FOR THE SHELL ?**

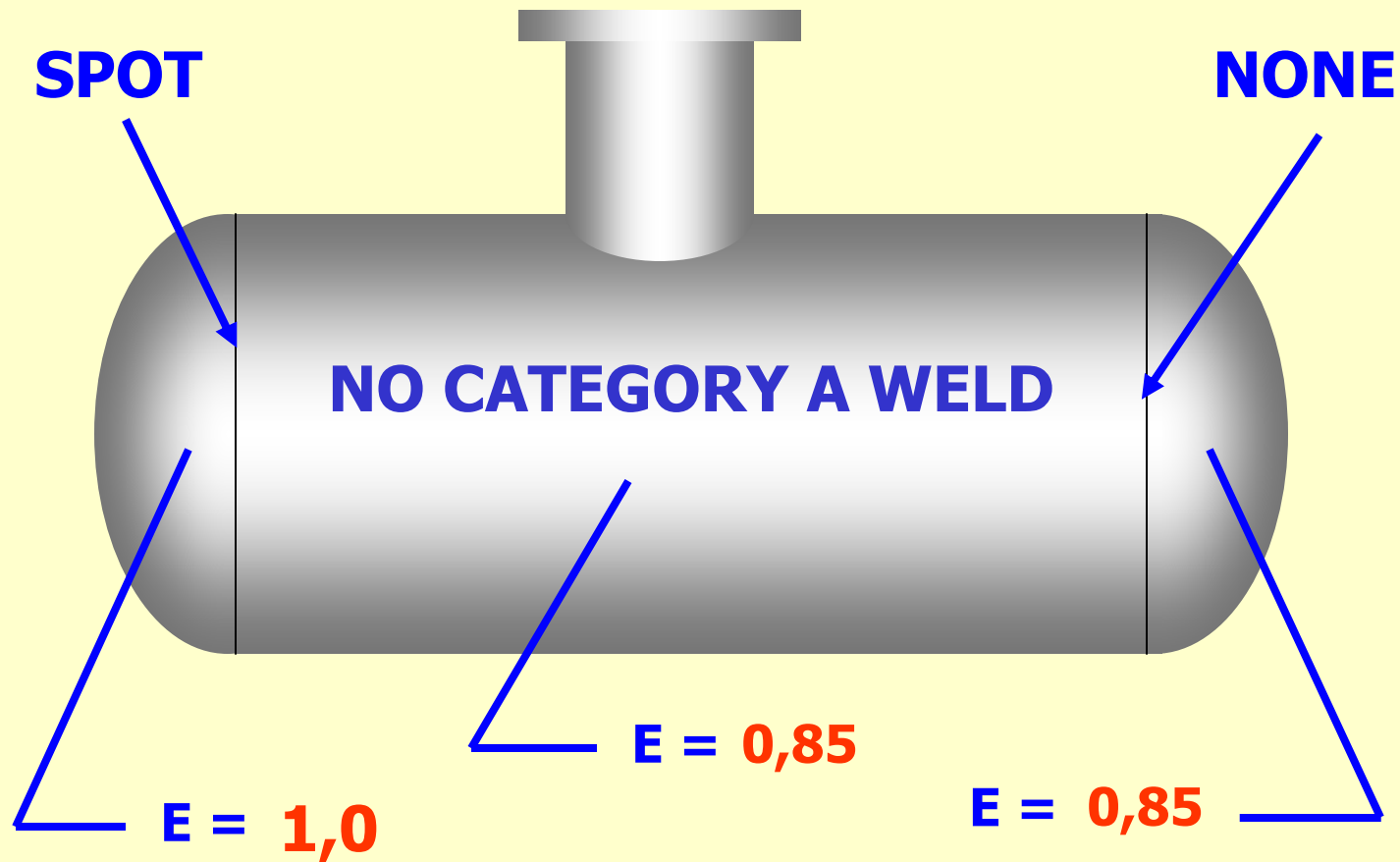
CONSIDER A SEAMLESS COMPONENT



UW-12(d) SAYS:

"SEAMLESS VESSEL SECTIONS OR HEADS SHALL BE CONSIDERED EQUIVALENT TO WELDED PARTS IN WHICH ALL CATEGORY A WELDS ARE TYPE 1.....WHEN THE SPOT RADIOGRAPHY OF UW-11(a)(5)(b) REQUIREMENTS ARE MET....."

CONSIDER A SEAMLESS COMPONENT



CONSIDER A SEAMLESS COMPONENT



YOU WILL MEET MANY SEAMLESS COMPONENTS

SMALL SEAMLESS PRESSED OR SPUN HEADS

CYLINDRICAL SHELLS FROM SEAMLESS PIPE

WHEN RADIOGRAPHY IS MANDATORY

IF A VESSEL IS TO CONTAIN A LETHAL SUBSTANCE:

UW-2 SAYS:

"... ALL BUTT WELDED JOINTS SHALL BE FULLY RADIOGRAPHE, EXCEPT UNDER PROVISION OS UW-2(a)(2) AND UW-2(a)(3) BELOW AND UW-4(a)(4)...."

THIS IS A BIT COMPLICATED, BUT BASICALLY LMEANS THAT ALL THE MAIN CATEGORY **A AND **B** WELDS MUST BE FULLY RADIOGRAPHED.**

BUT CATEGORY **B AND **C** WELDS IN NOZZLE AND COMMUNICATING CHAMBERS THAT ARE NOT LARGER THAN 10 INCH NOMINAL PIPE SIZE AND DO NOT EXCEED 1-1/8" THICK ARE EXEMPT**

CONCLUSIONS

$$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}} \quad \left(S = \frac{F}{A} \right)$$

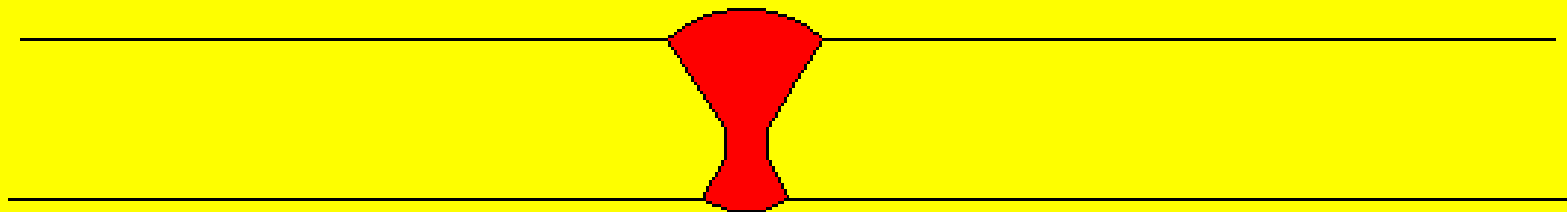
$$\text{FORCE} = \text{STRESS} \times \text{AREA}$$

$$\text{FORCE} = \text{PRESSURE} \times \text{AREA}$$

JOINT EFFICIENCY 'E' DETERMINED BY

- 1 WELD TYPE**
- 2 DEGREE OF RADIOGRAPHY**

CONCLUSIONS



$$E = \frac{\text{STRENGTH OF THE WELD}}{\text{STRENGTH OF PARENT METAL}}$$

**DEGREE OF CONFIDENCE IN WELD
QUALITY**