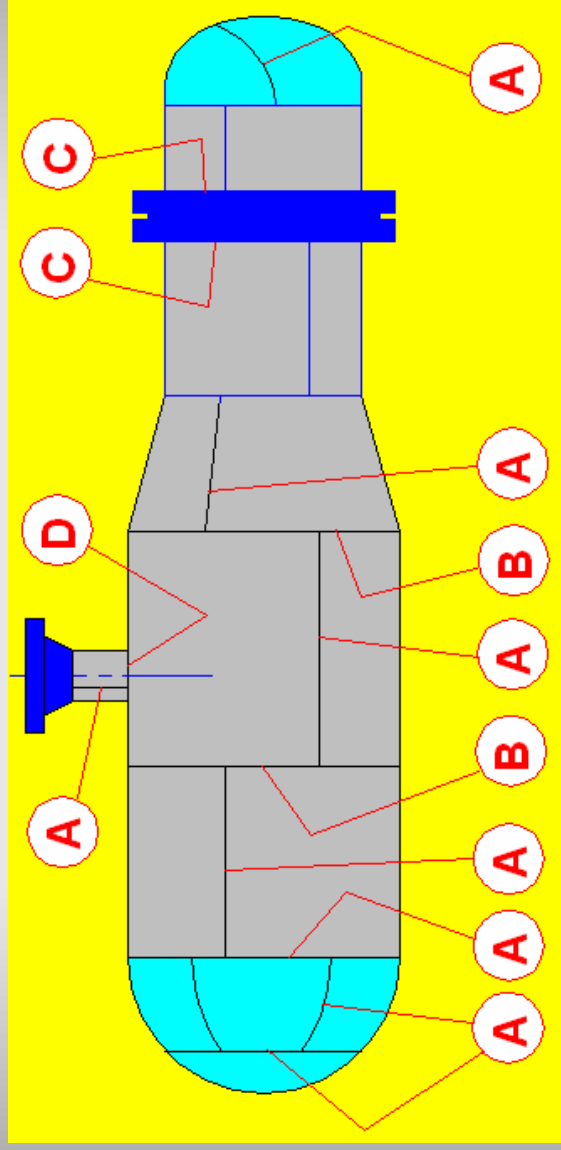


The meaning of Joint Efficiency



ASME UW-3 and UW-12

Weld Category

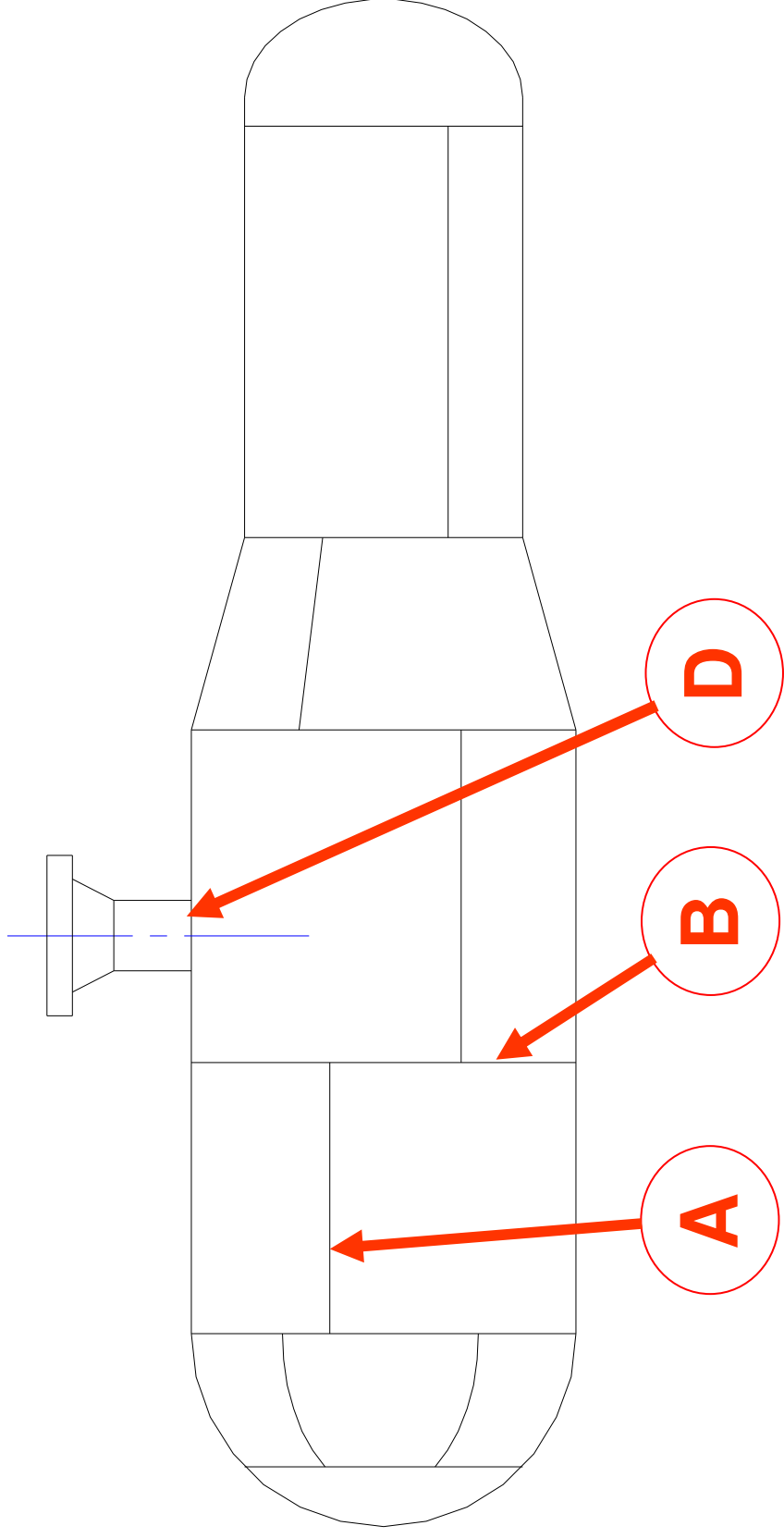
Weld Type

Joint Efficiency

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

Pressure Envelope

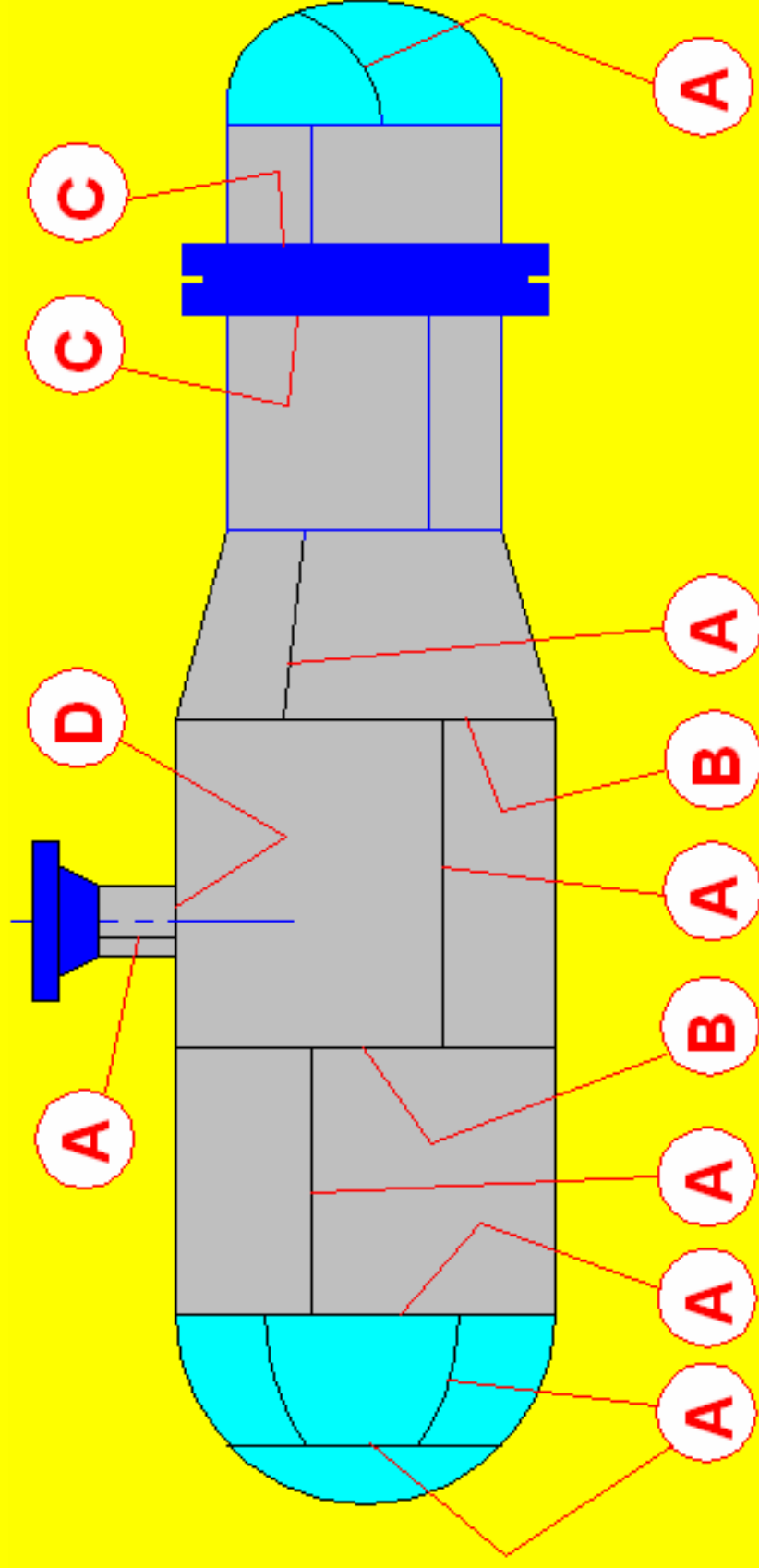
However Parts Must be Welded Together



Location of any Weld is its *Category*

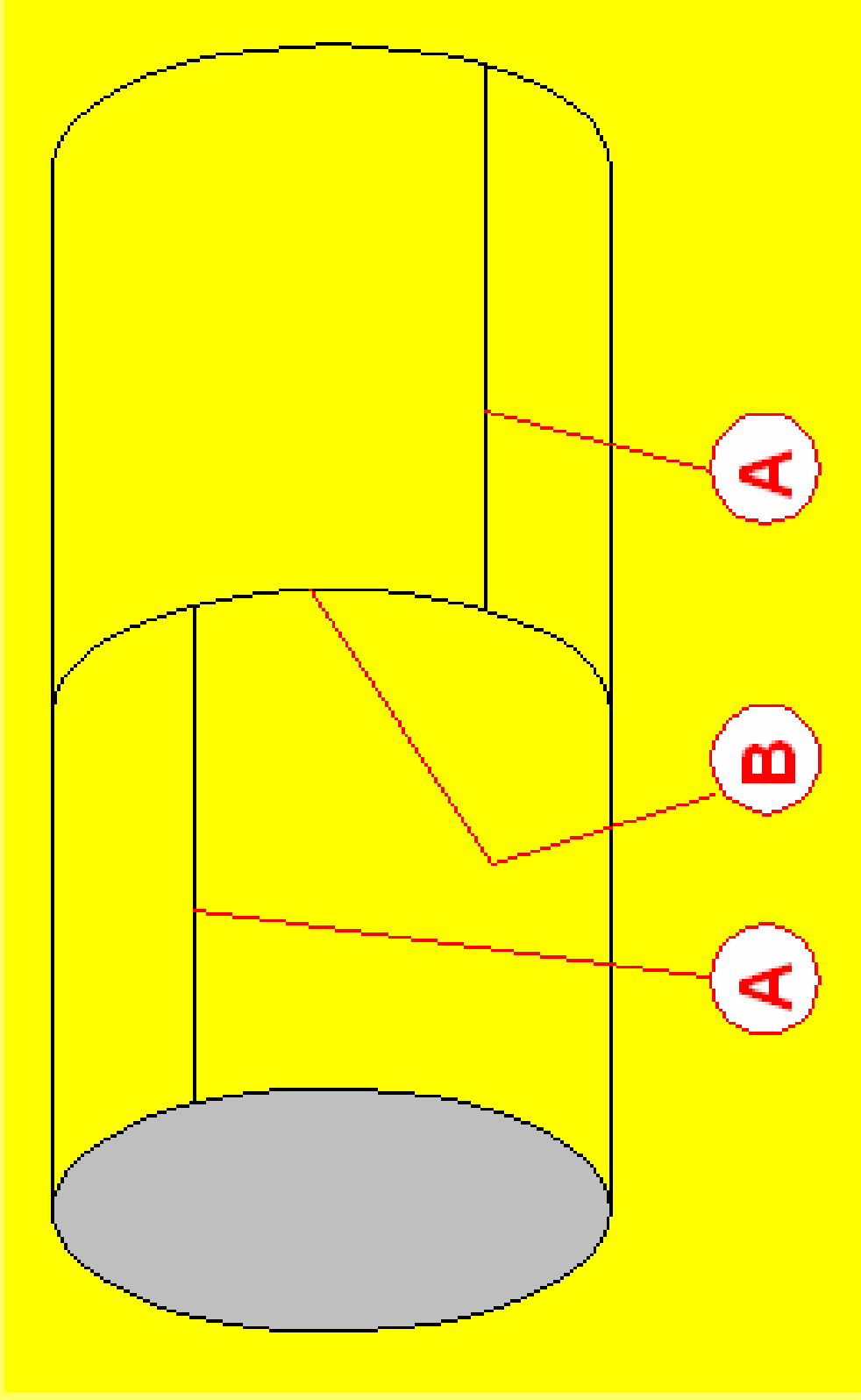
Copyright = 100% Profit

Weld Categories

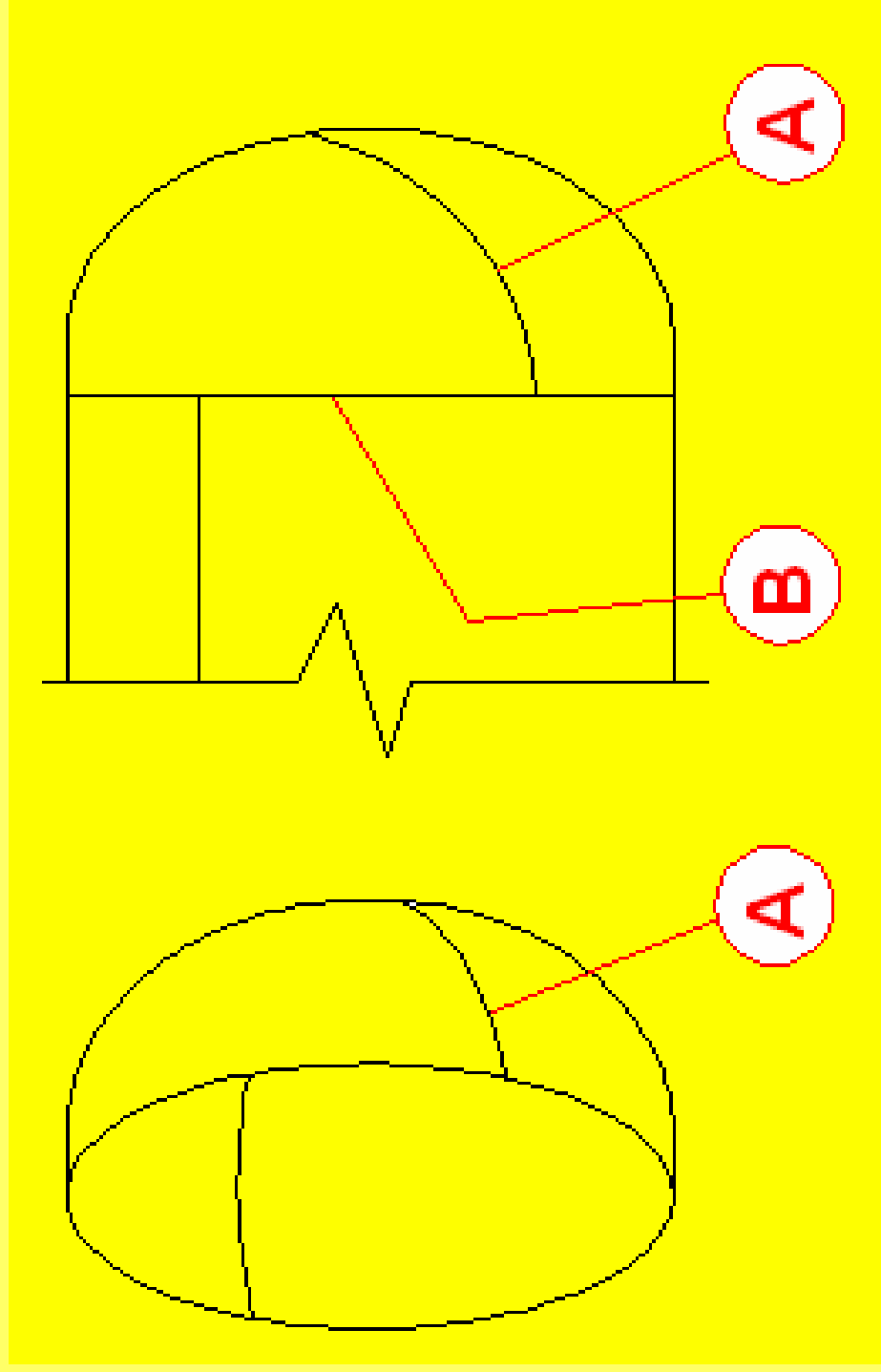


Category = Location

Categories in a Cylindrical Shell

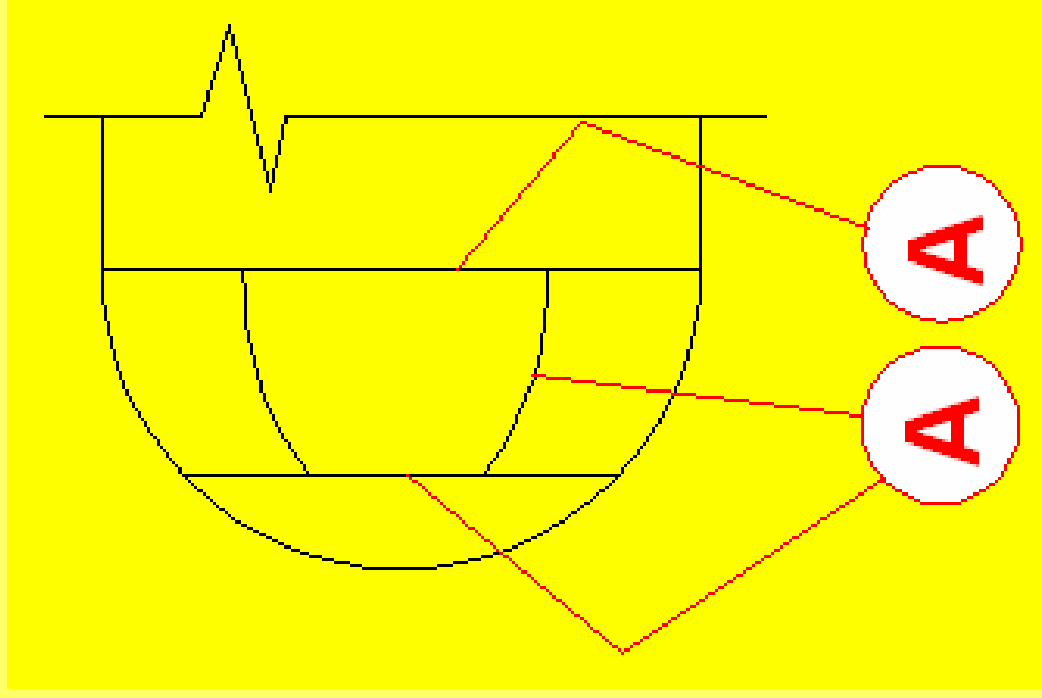


Categories in a Head



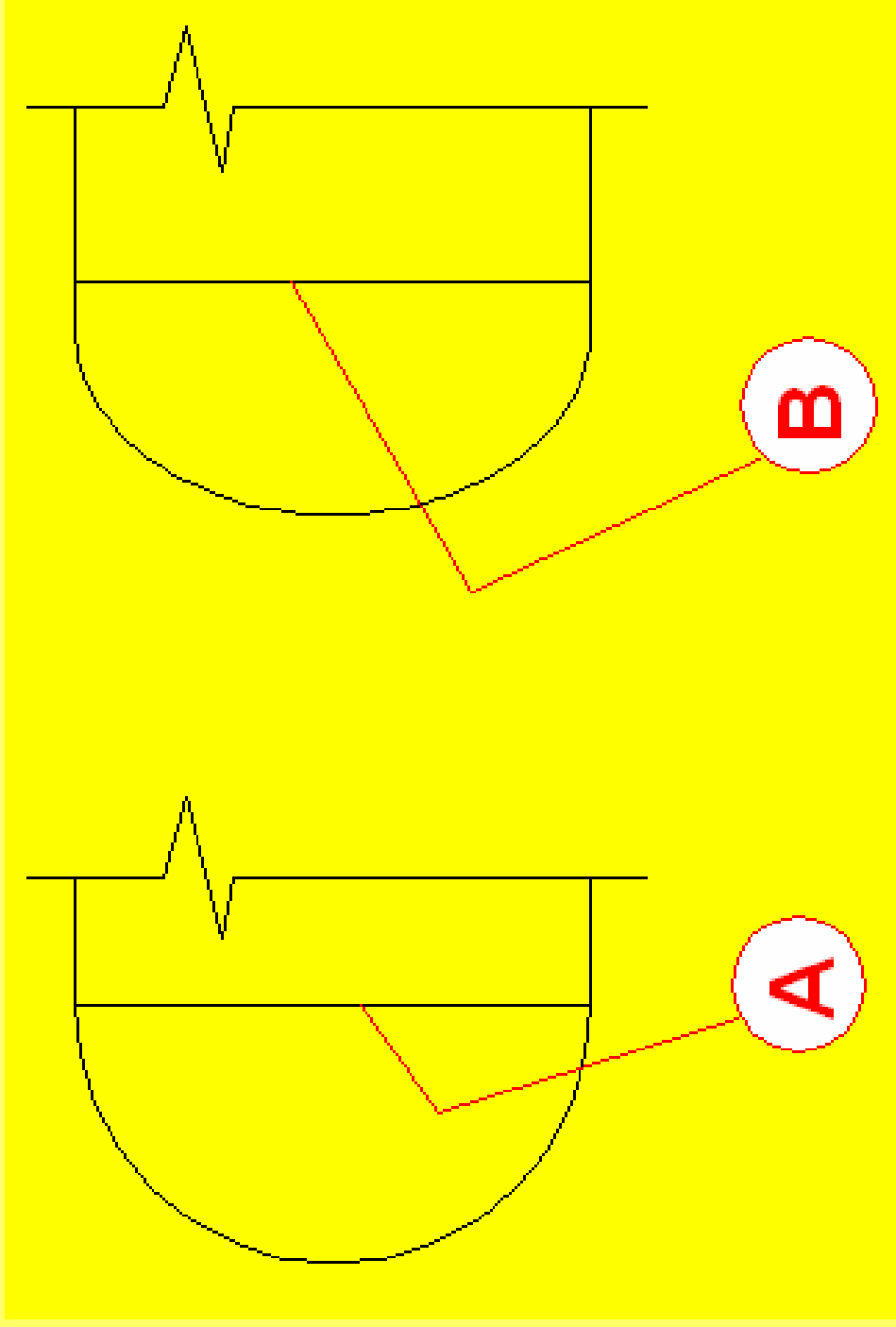
Any Weld Within a Head is Category A

Categories in a Head



Any Weld Within a Head is Category A

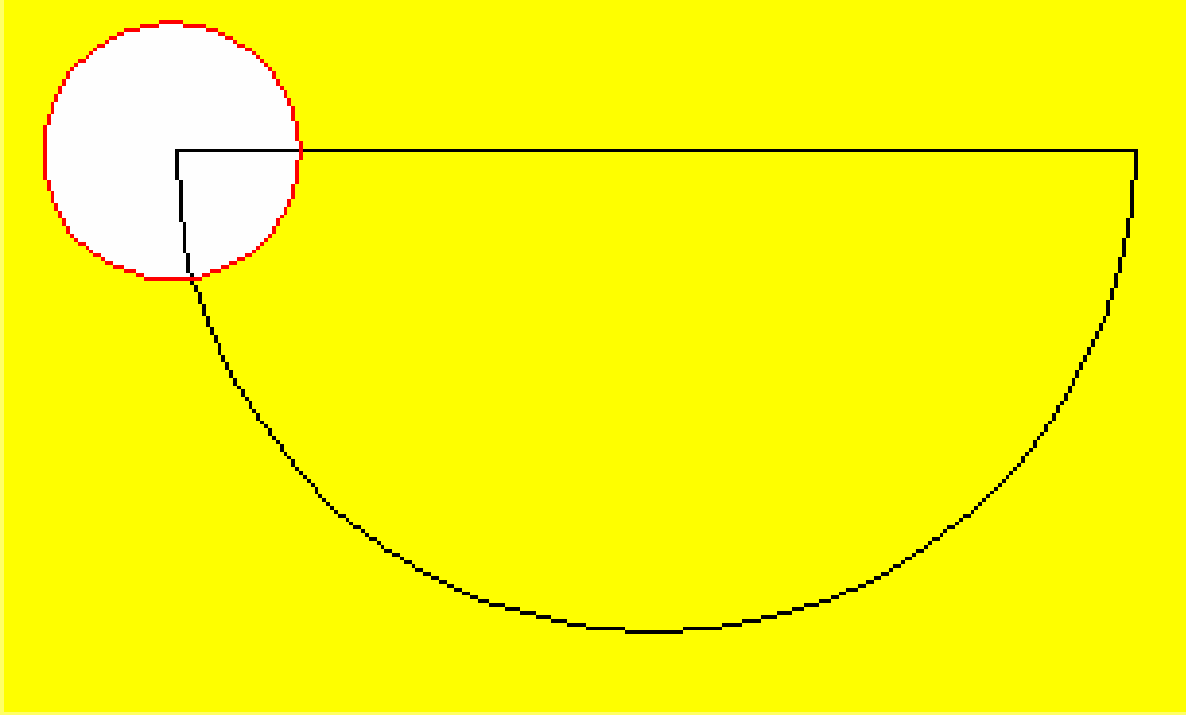
Difference Between Hemisphere Head and Ellipse / Torispherical Head



Hemisphere

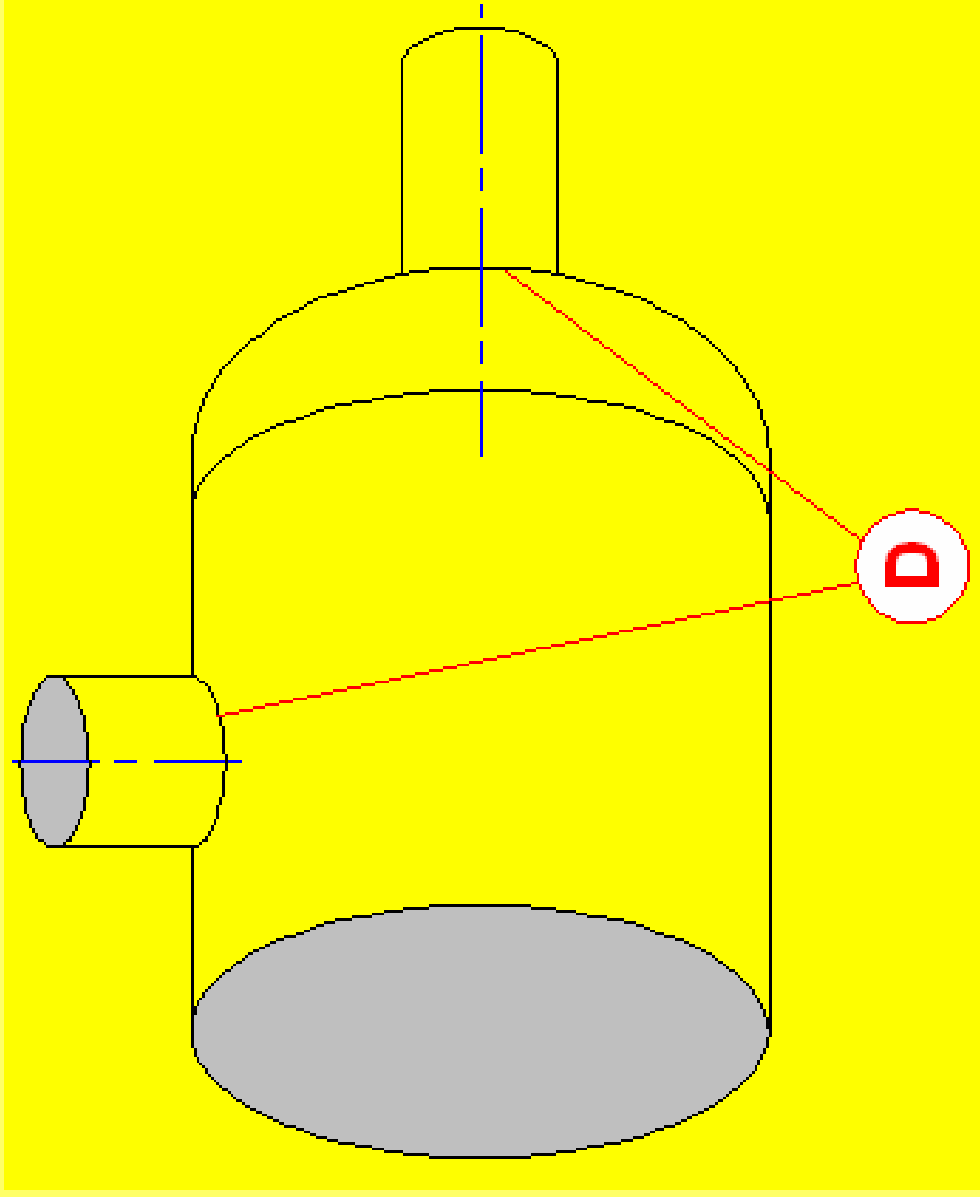
Ellipse / Torisphere

Hemisphere - Special Requirements



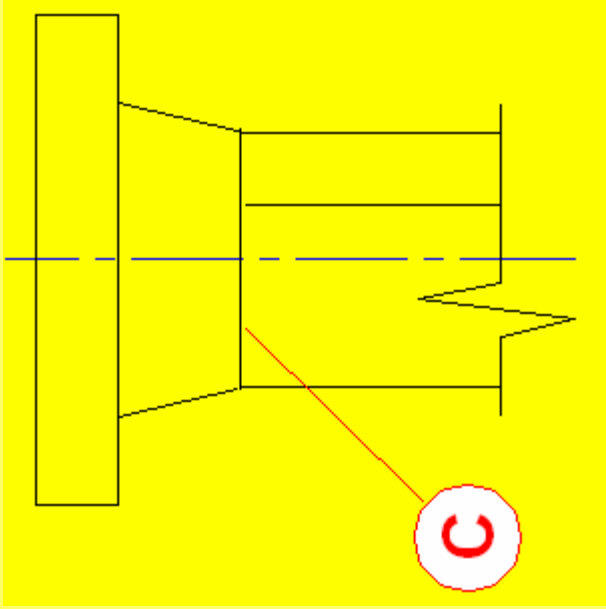
**It is not Permitted to
Have a Straight
Flange on a
Hemispherical Head**

Nozzle Installed in a Chamber

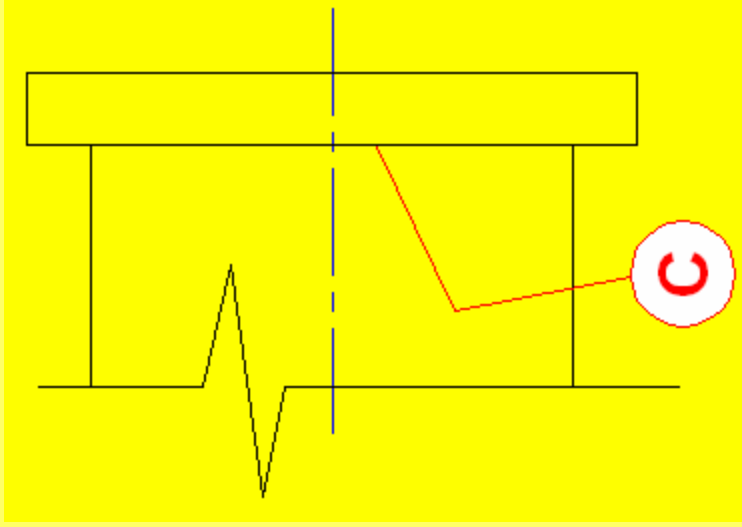


This is a Category **D** Weld

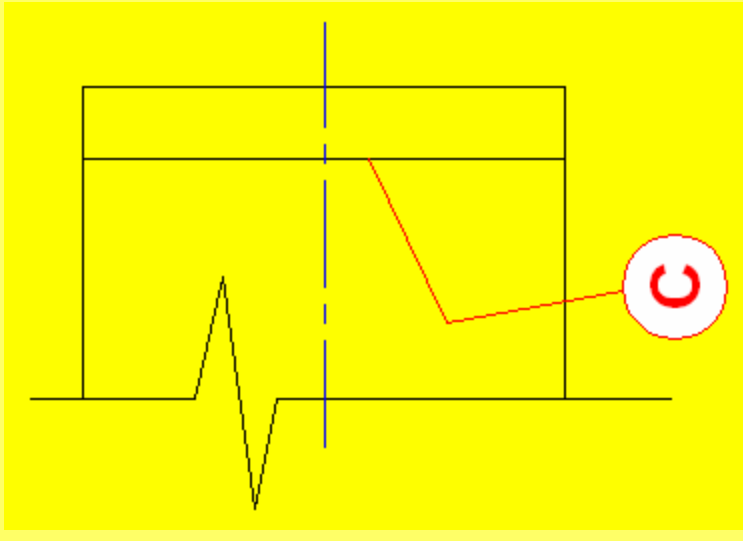
Category **C** Weld



**Flange
Weld**



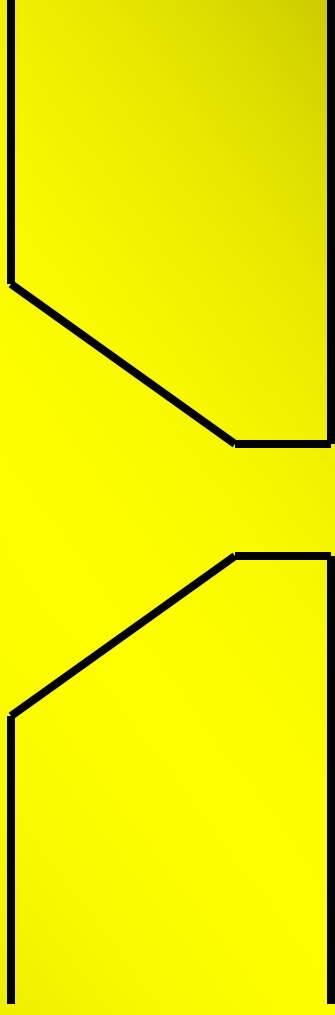
**Tubesheet
Weld**



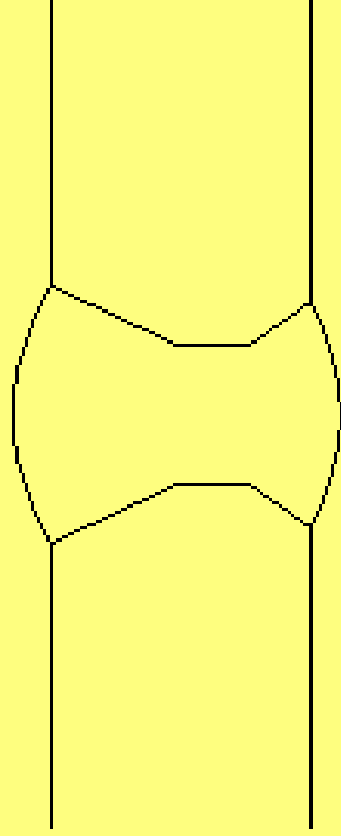
**Flat Head
Weld**

Weld Type = Joint Geometry

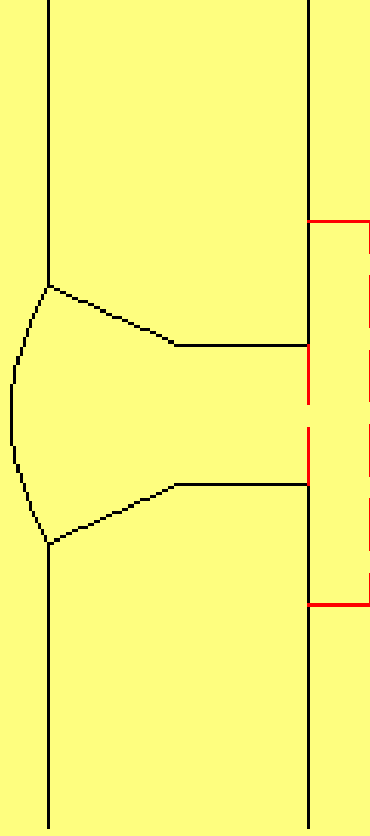
**Is the Method of Welding and
Marking the Joint**



Type 1

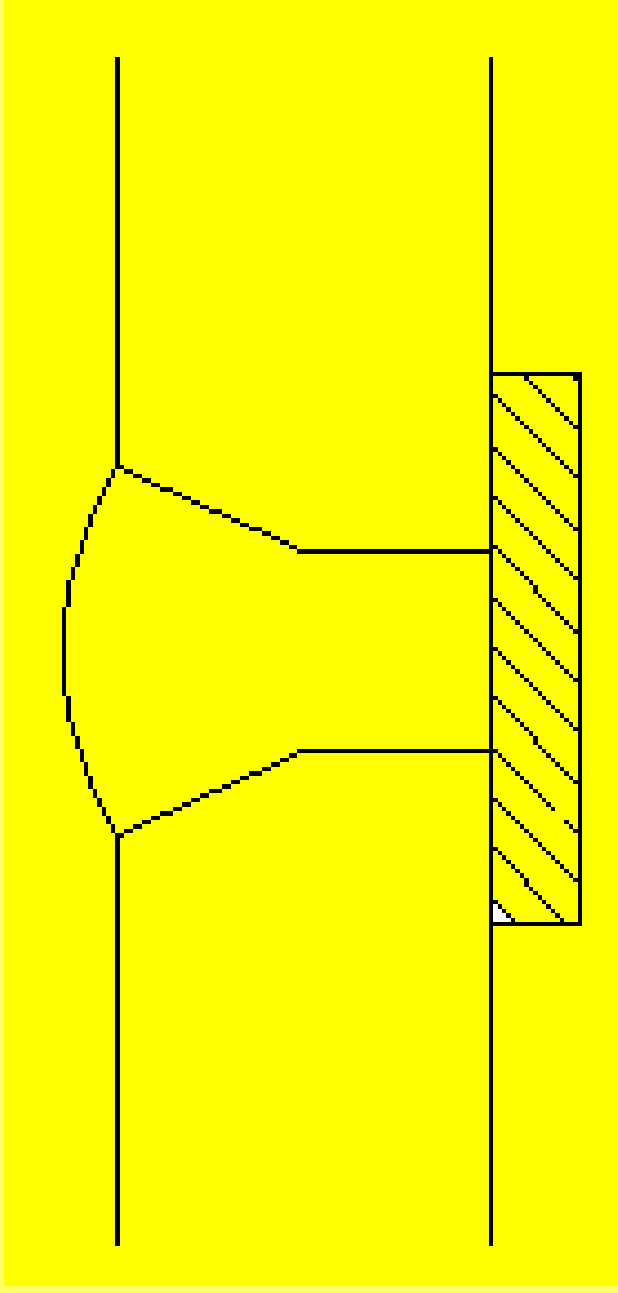


**Welded From Both
Sides**



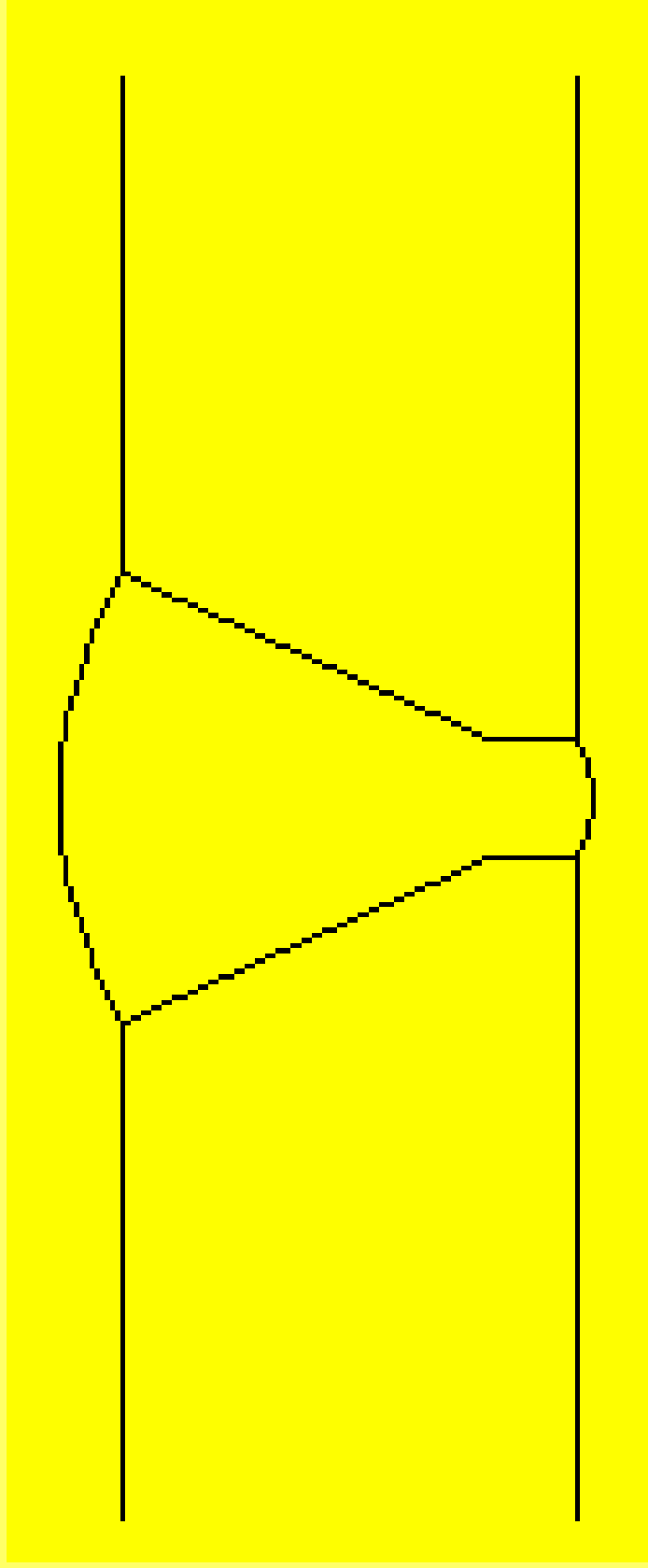
**Welded From One Side
With Removable
Backing**

Type 2



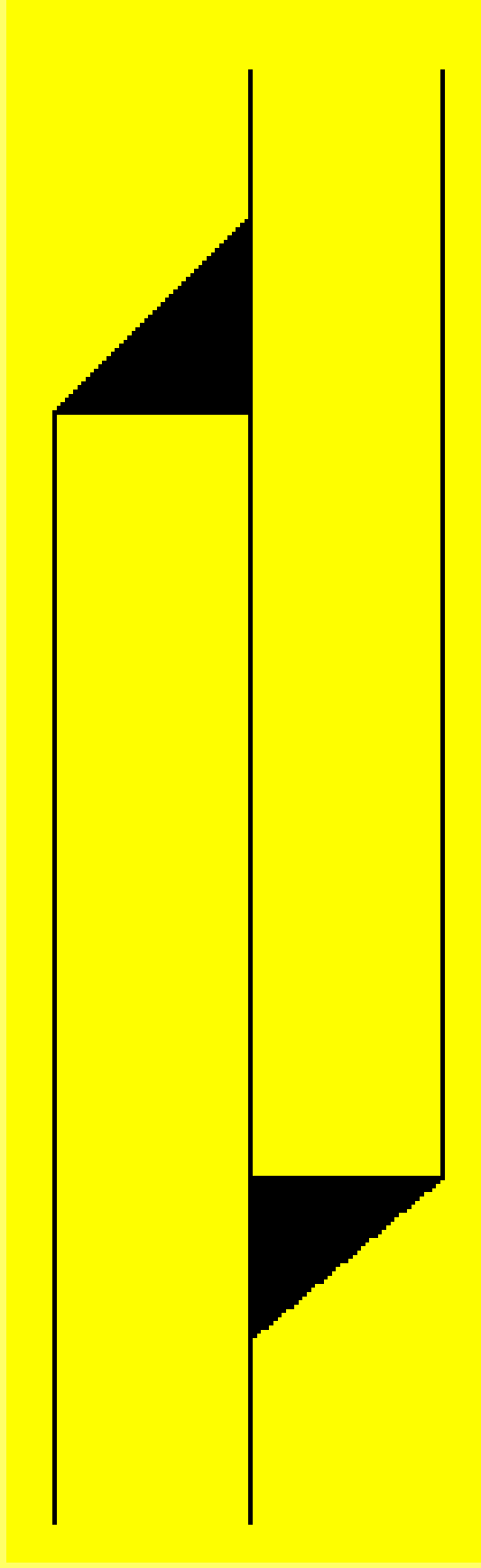
Backing That Remains in Place

Type 3



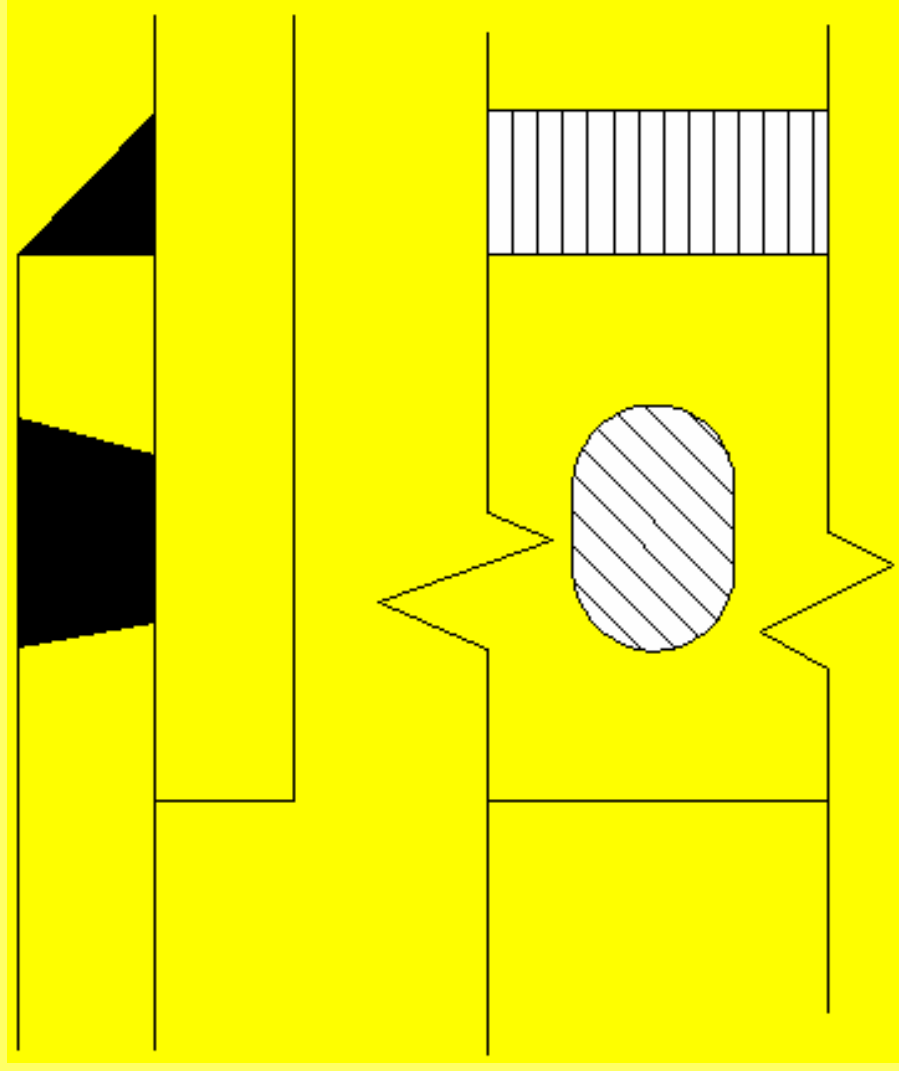
Welded From One Side Only

Type 4



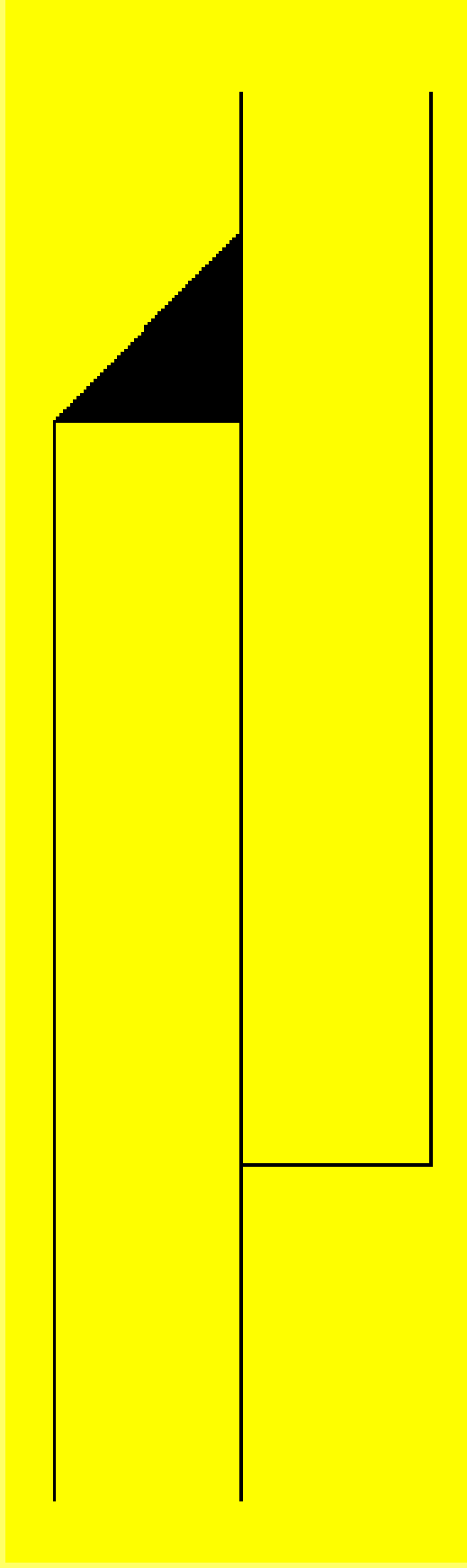
Double Fillet Welded

Type 5



Single Fillet With Plug Welds

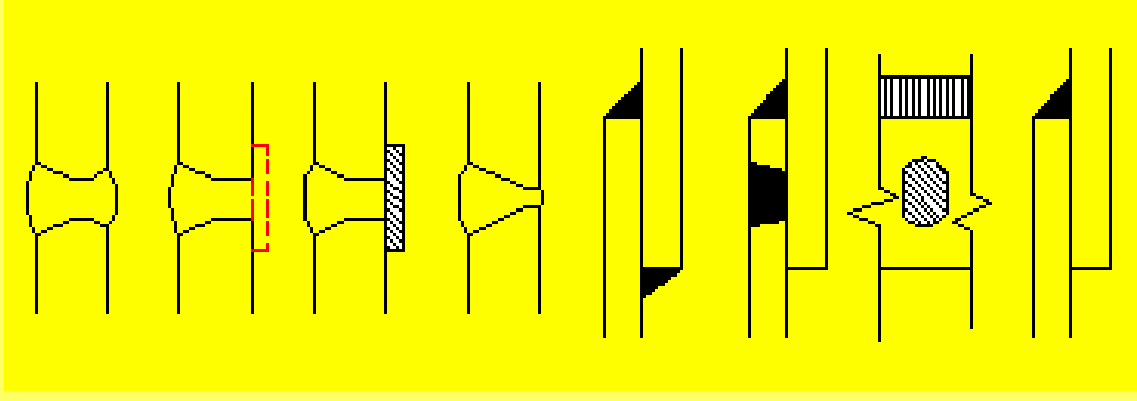
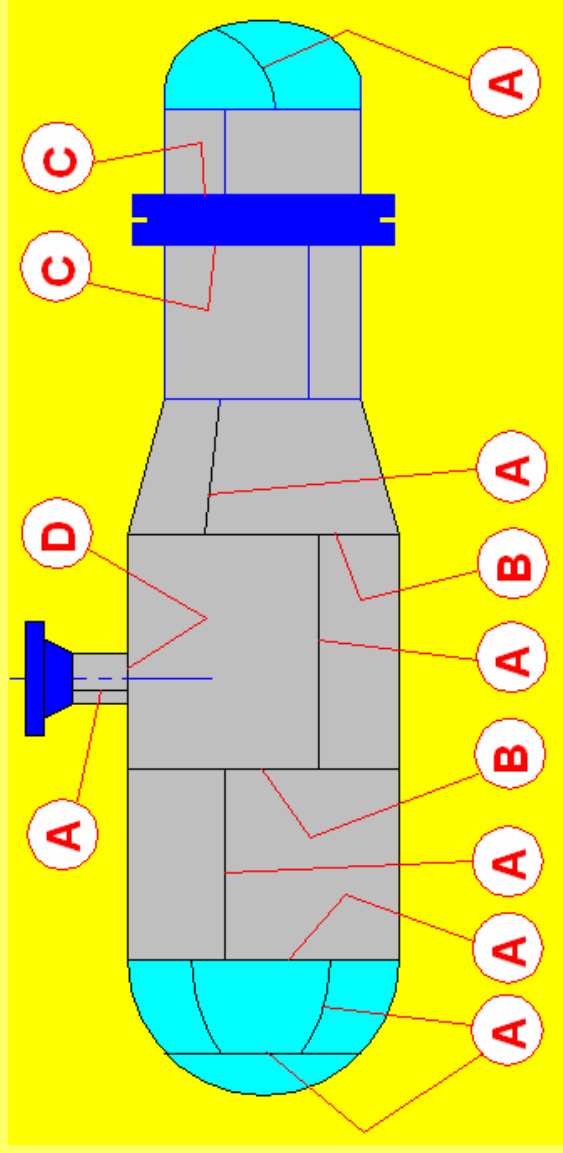
Type 6



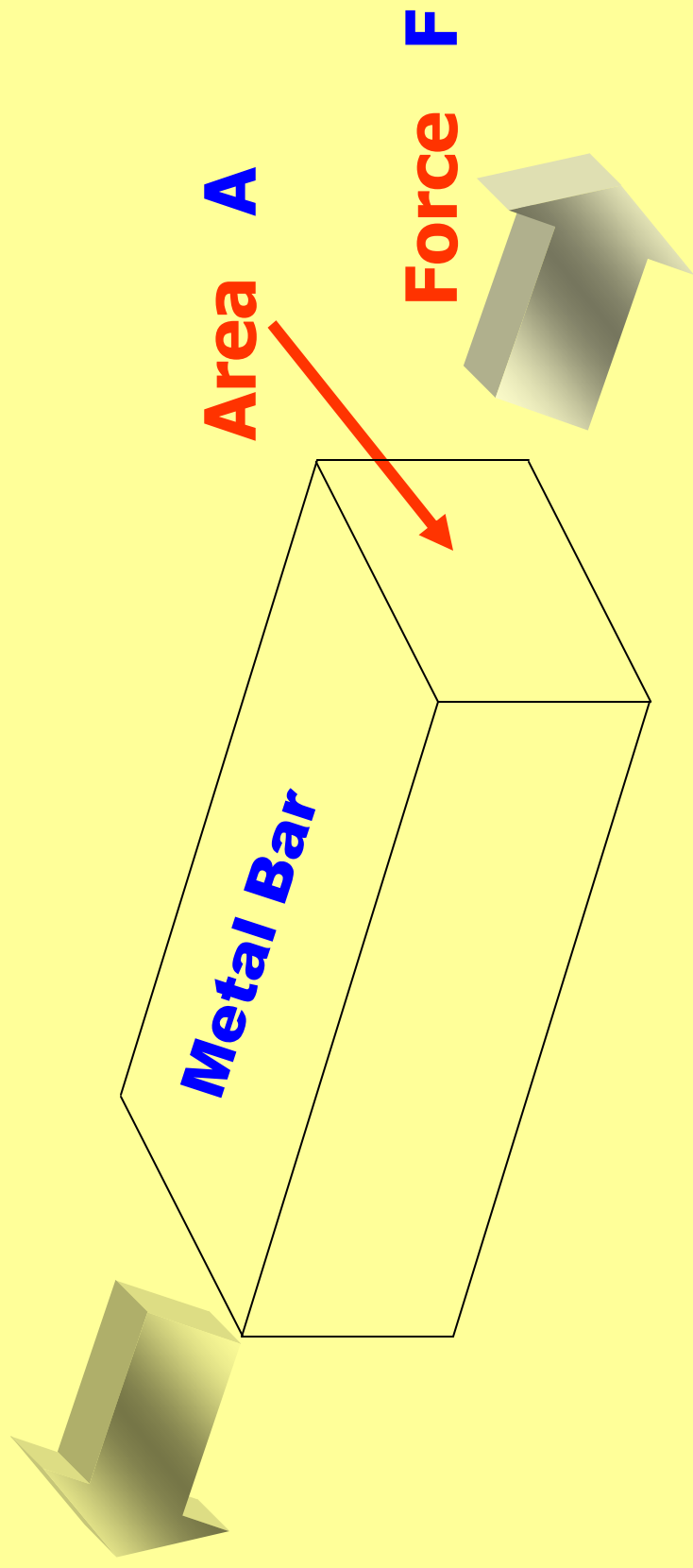
Single Fillet Weld

Type = Geometry

Category = Location



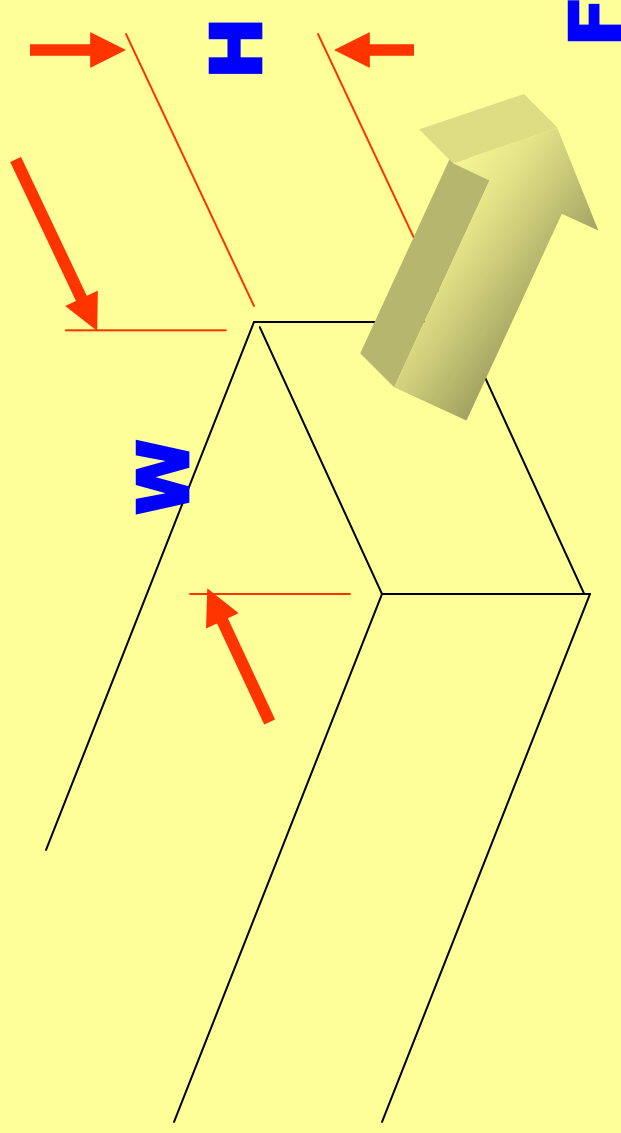
Definition of Stress: **S**



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

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

Simple Stress Calculation



$$W = 15 \text{ mm}$$

$$H = 10 \text{ mm}$$

$$F = 6\,000 \text{ N}$$

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

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

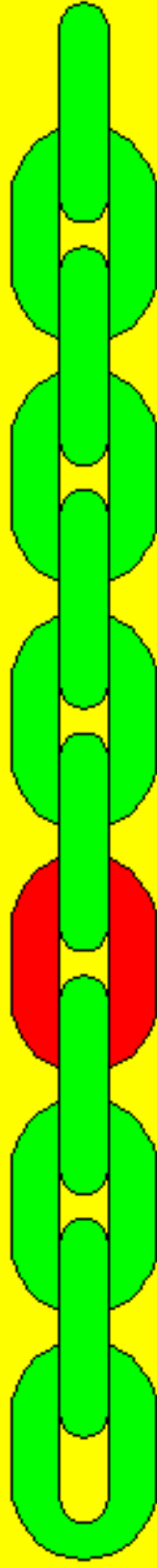
$$\text{FORCE} = \text{STRESS} \times \text{AREA}$$

AND

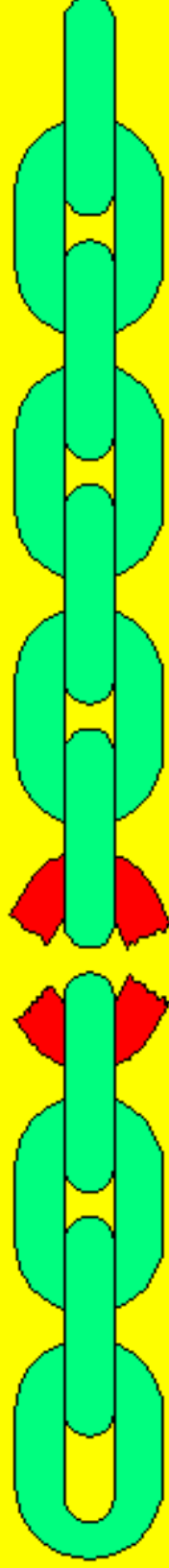
$$\text{FORCE} = \text{PRESSURE} \times \text{AREA}$$

DEFINITION OF JOINT EFFICIENCY **E**

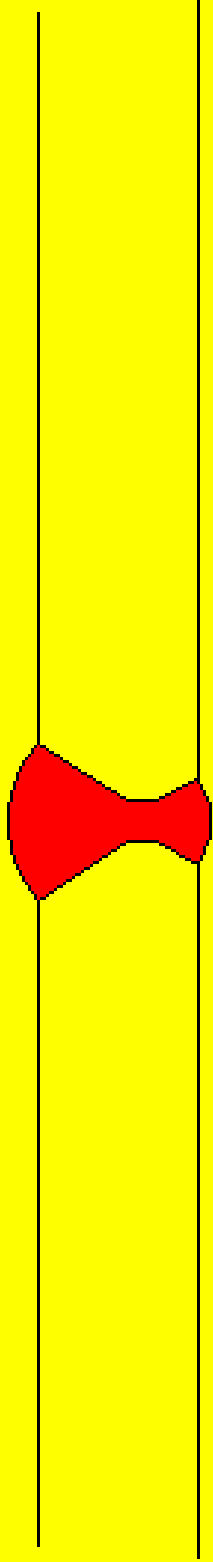
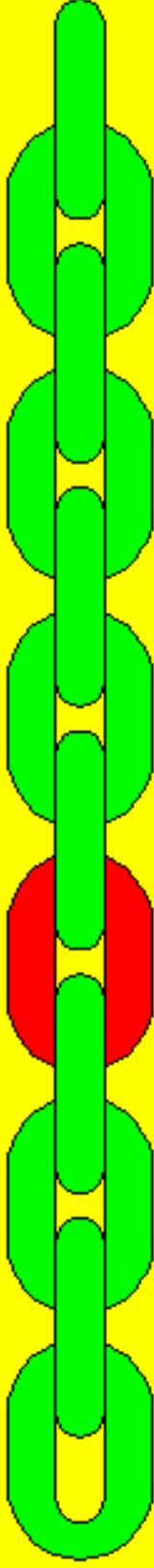
A CHAIN IS AS STRONG AS ITS WEAKEST LINK !



BREAKS



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	Radiographic Examination		
				Degree of Penetration	(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)	None except in (a) below Turner butt joints with offset, see Fig. 3.1, sketch	A, B, & D A, B, & C	0.90 0.90	0.80 0.80	0.65 0.65
(3)	Single-welded butt joint with backing strip other than those included in (1)	None except in (a) below Turner butt joints with offset, see Fig. 3.1, sketch	A, B, & C	NA	NA	0.60
(4)	Single-welded butt joint with backing strip other than those included in (1)	None except in (a) below Turner butt joints with offset, see Fig. 3.1, sketch	A	NA	NA	0.55
(5)	Single-welded butt joint with backing strip other than those included in (1)	None except in (a) below Turner butt joints with offset, see Fig. 3.1, sketch	B & C ⁶	NA	NA	0.55
(6)	Single-welded butt joint with backing strip other than those included in (1)	None except in (a) below Turner butt joints with offset, see Fig. 3.1, sketch	B	NA	NA	0.50
(7)	Single-welded butt joint with backing strip other than those included in (1)	None except in (a) below Turner butt joints with offset, see Fig. 3.1, sketch	C	NA	NA	0.50

(a) Circumferential joints⁴ 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.

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 joints not over 24 in. nominal thickness, see Fig. UW-13(b) and plate offset, see UW-13(b)	A, B, C, & D A, B, & C	0.90 0.90	0.80 0.70	0.65 0.65
(3)	Single-welded fillet lap joint with 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) 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
(5)	Single full fillet lap joints with plug welds conforming to UW-17					

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	(a) Full	Degree of Radiography (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.....				

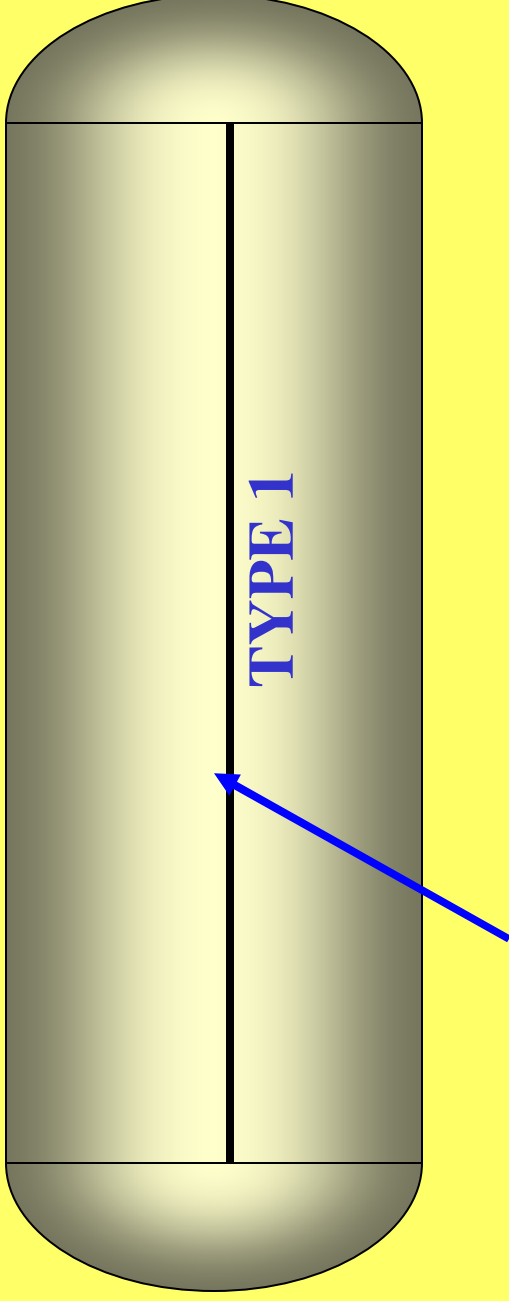
LET US HAVE A TYPE 2 JOINT

SUBJECT TO SPOT RADIOGRAPHY

WHAT IS THE JOINT EFFICIENCY E ?

$$E = 0.80$$

LET US LOOK AT FULL RADIOGRAPHY



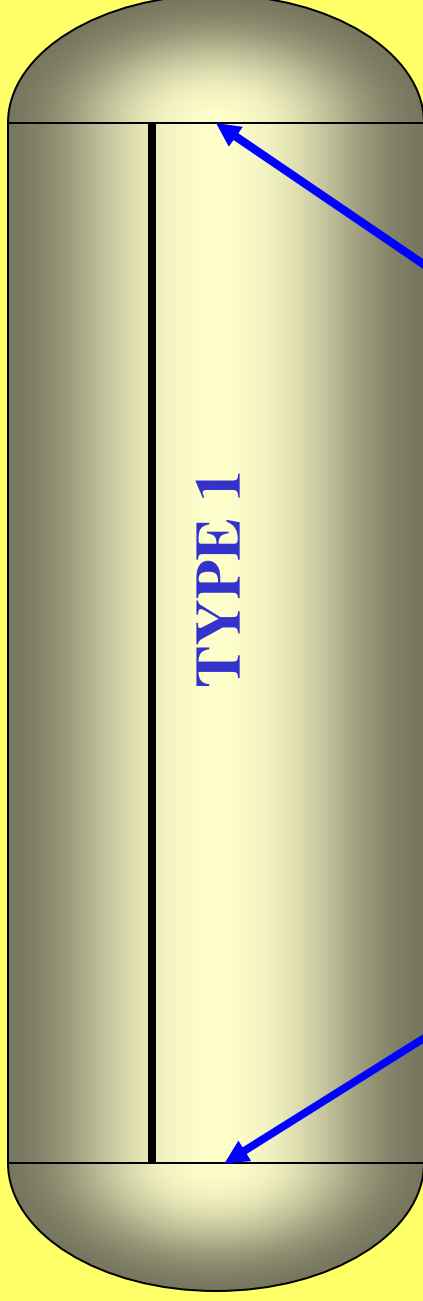
SUPPOSE THIS JOINT IS SUBJECT TO FULL RADIOGRAPHY

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:**

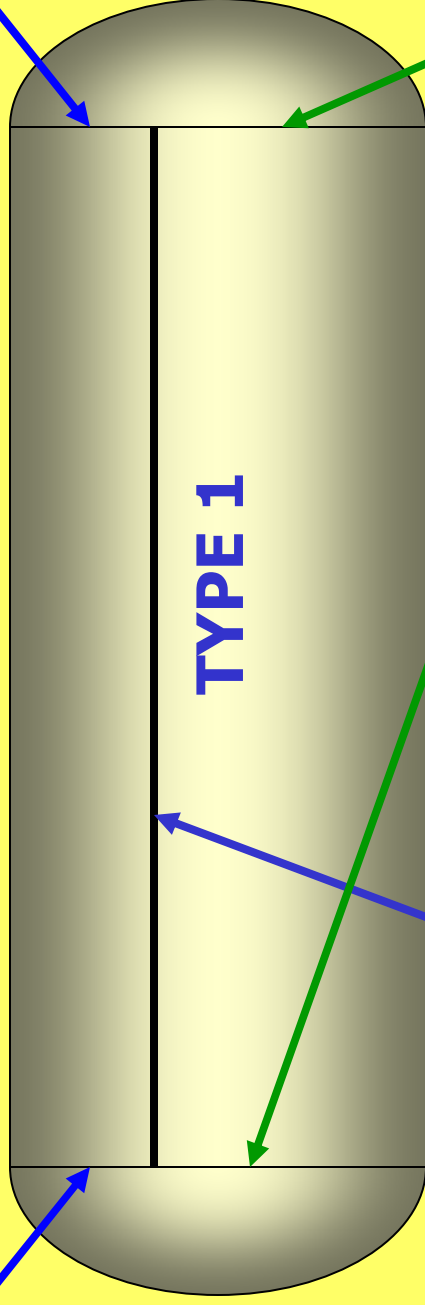
UW-11(A)(5)(B) SAYS:

***"...CATEGORY B OR CBUTT 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 ?

MEANS BOTH WELDS

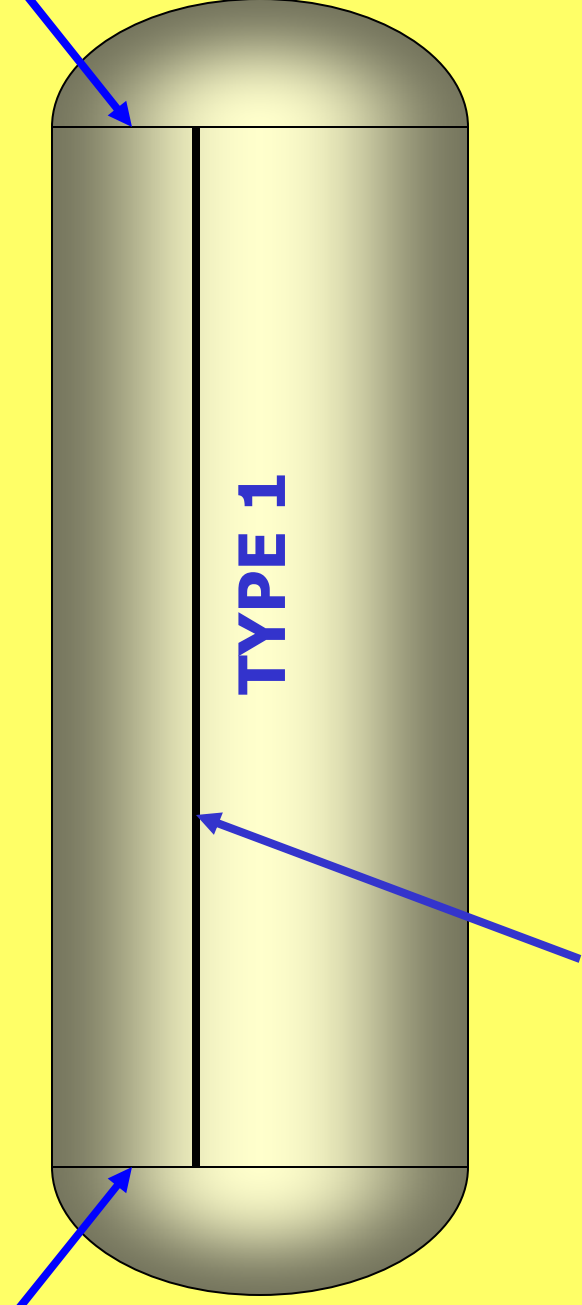
UW-11(A)(5)(B) SAYS:

"...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

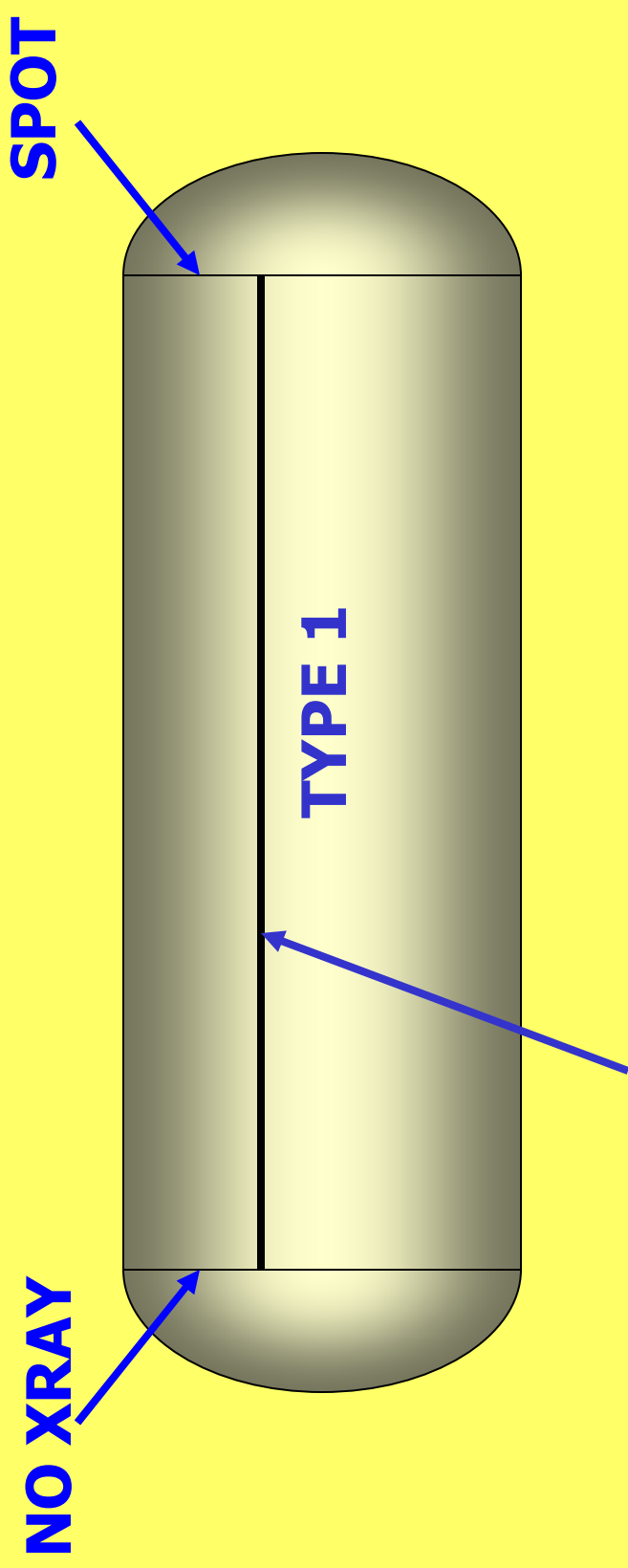


**DO WE GET CREDIT FOR FULL RADIOGRAPHY OF THIS
JOINT ?**

**THEREFORE, WE ONLY GET CREDIT FOR SPOT
RADIOGRAPHY**

THEREFORE.....

LET US LOOK AT FULL RADIOGRAPHY

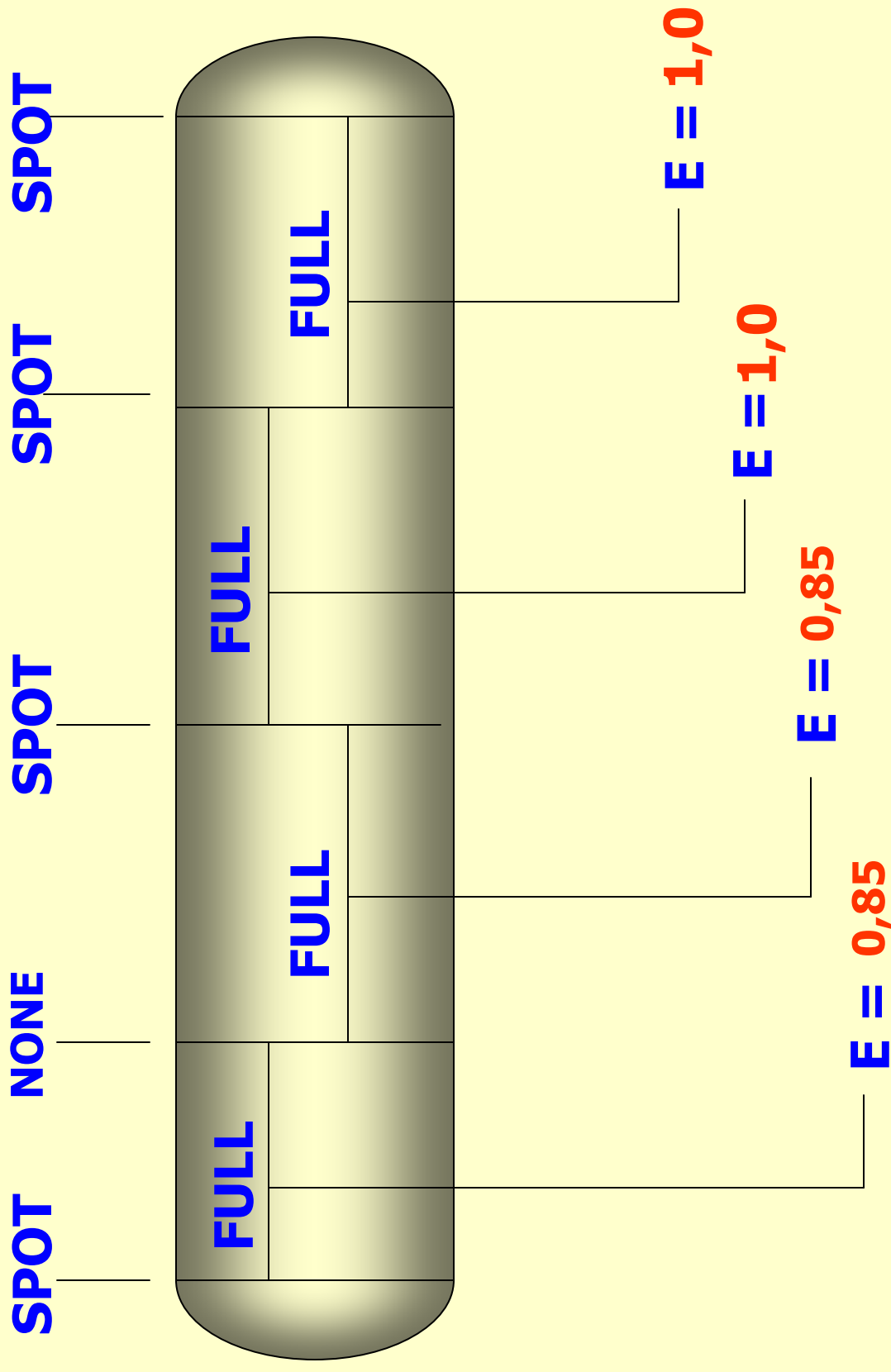


DO WE GET CREDIT FOR FULL RADIOGRAPHY OF THIS
JOINT ?

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

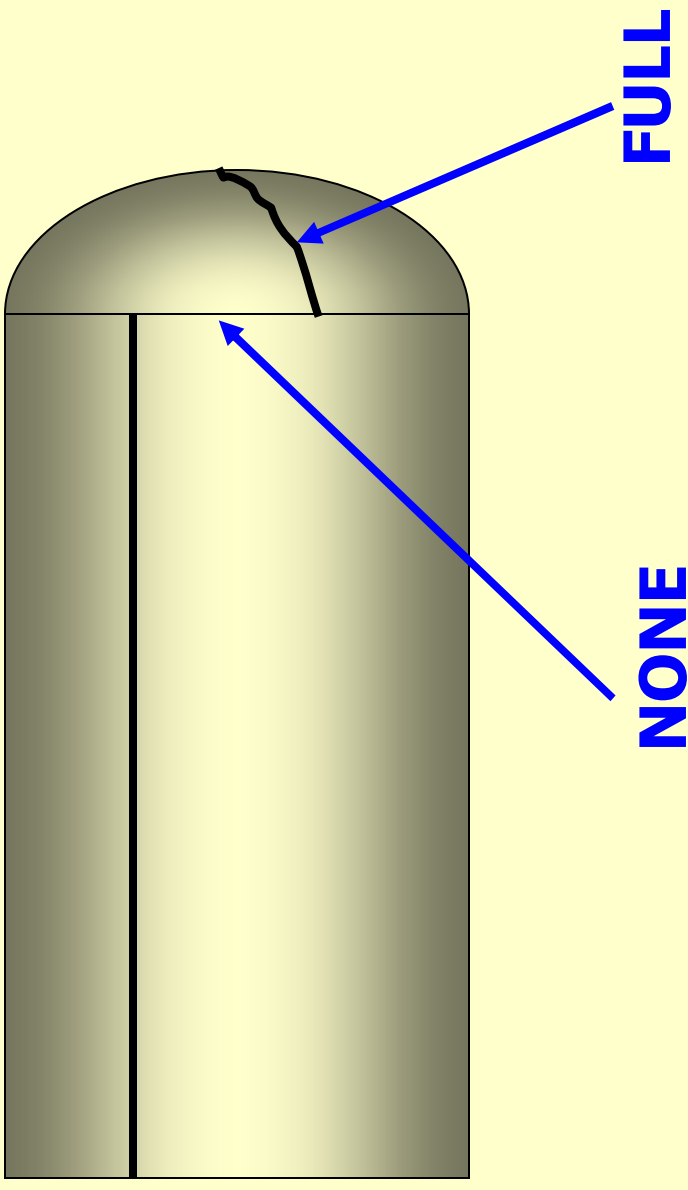


REMEMBER UW-11(a)(5)(b)

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

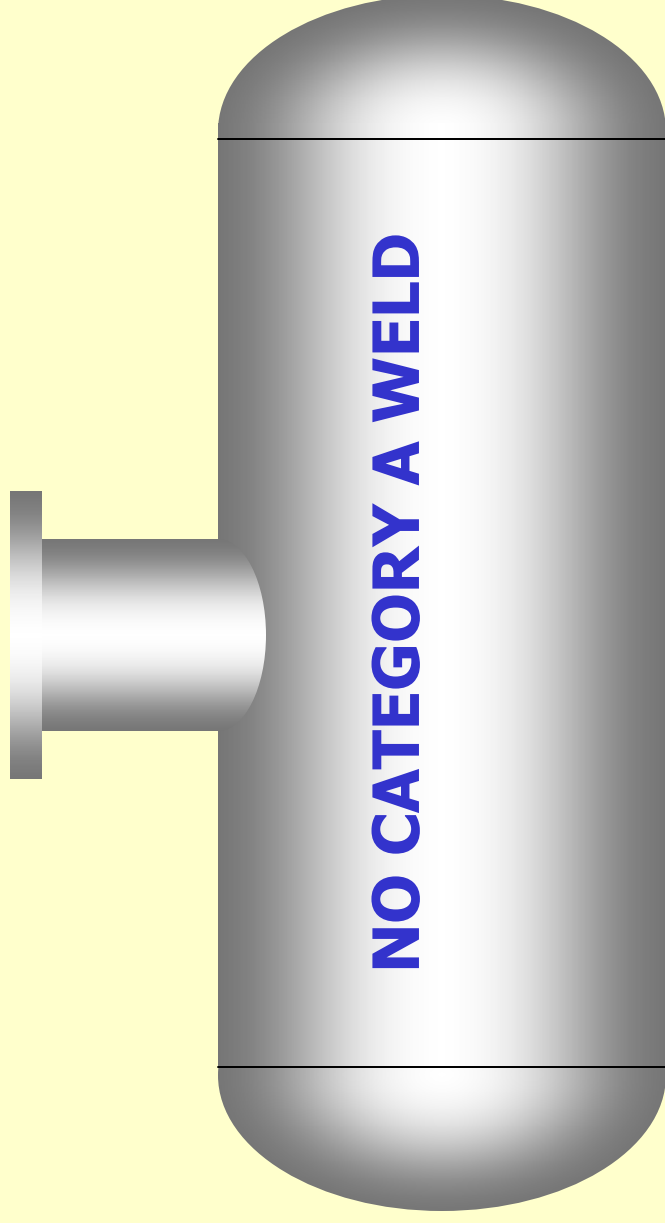
THUS FOR THE HEAD WELD: $E = 0,85$

CONSIDER A SEAMLESS COMPONENT



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

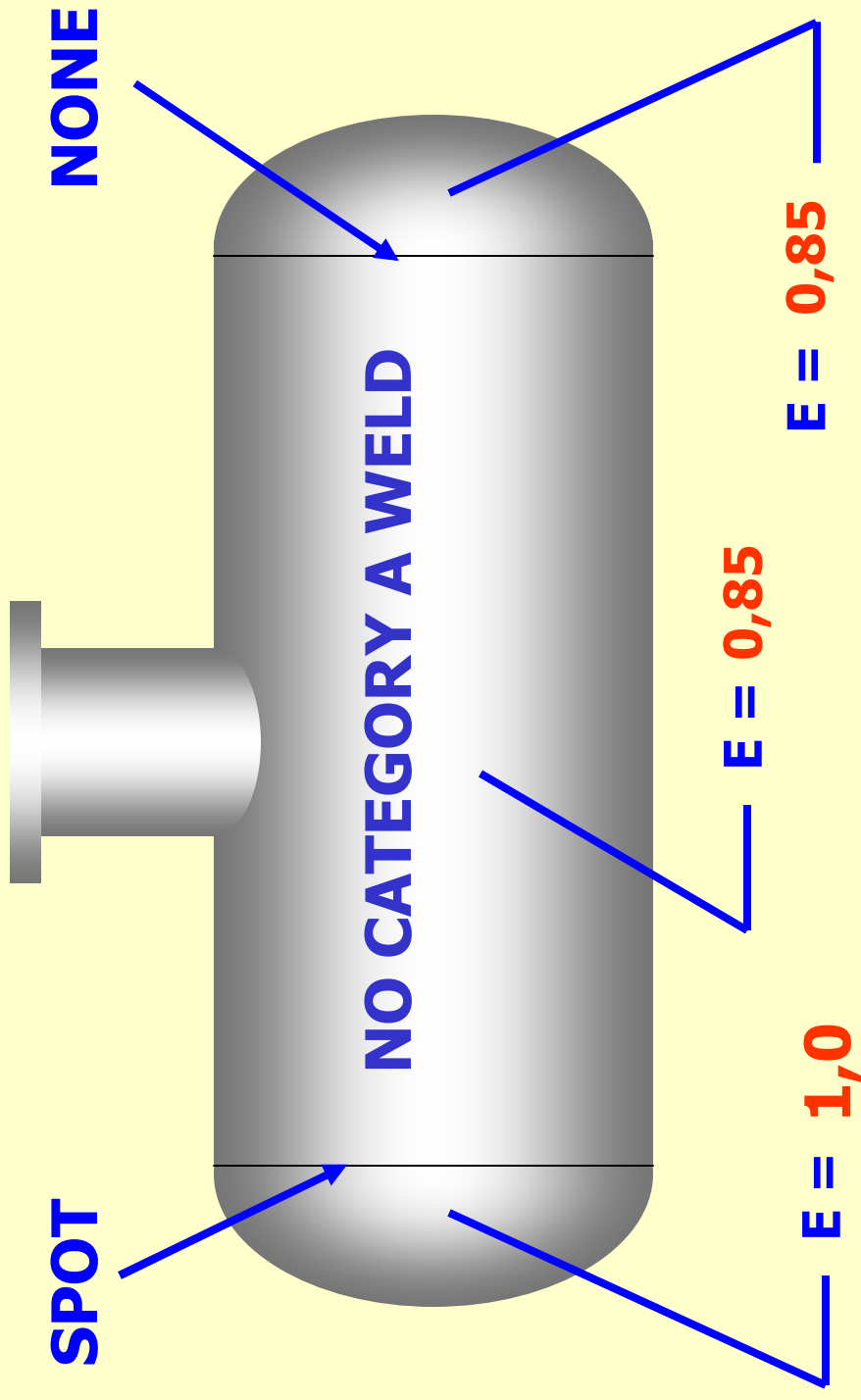
CONSIDER A SEAMLESS COMPONENT



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

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

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

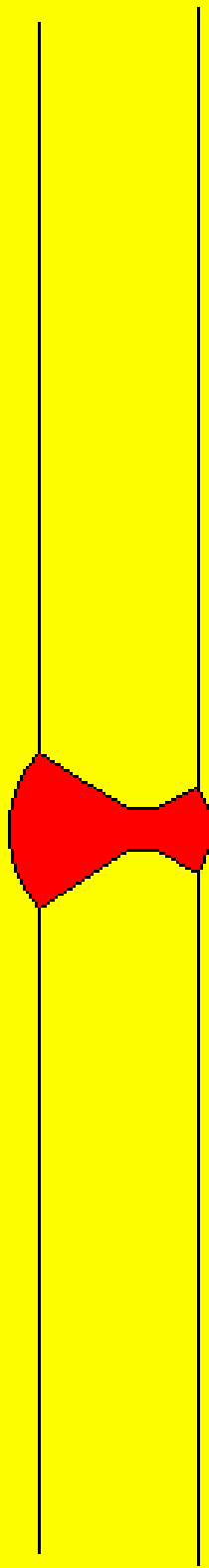
$$\text{FORCE} = \text{PRESSURE} \times \text{AREA}$$

JOINT EFFICIENCY 'E' DETERMINED BY

1 WELD TYPE

2 DEGREE OF RADIOGRAPHY

CONCLUSIONS



STRENGTH OF THE WELD

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

**DEGREE OF CONFIDENCE IN WELD
QUALITY**

END OF THIS PRESENTATION

