
Inspection Techniques

L&T - HED HZW - PRODUCTS

- **Pressure Vessels**
 - **Reactors**
 - **Towers**
 - **Columns**
 - **Heat Exchangers**
 - **Shell & Tube**
 - **Spiral**
 - **Plate**
 - **Submarines**
-

L&T - HED – POWAI & HZW - CUSTOMERS

- **Fertilizer Industries**
 - **Chemical Industries**
 - **Petrochemical Industries**
 - **Steel Plant Industries**
 - **Indian Navy**
 - **Nuclear Power Corporation**
 - **Indian Space Research Organization**
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DESIGN & CONSTRUCTION CODE

- **ASME**
 - **Sec VIII Div I, II, III**
 - **Sec III**
 - **Sec I**
- **TEMA**
- **IBR**
- **PD (BS) 5500**
- **AD Merkblatt**

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**CUSTOMER
SPECIFICATION**

MATERIAL FOR CONSTRUCTION

- CS
- LAS
 - C. Mn, C. Mo, Cr. Mo, Cr. Mo. V, Ni. Cr.Mo, Ni Steel
- Stainless Steel.
 - Austenitic, Ferritic, Martensitic, Duplex, Super Duplex
- NF Metals & Alloys
 - Al, Cu, Brass, Bronze, Monel, Cupronickel, Inconel, Titanium

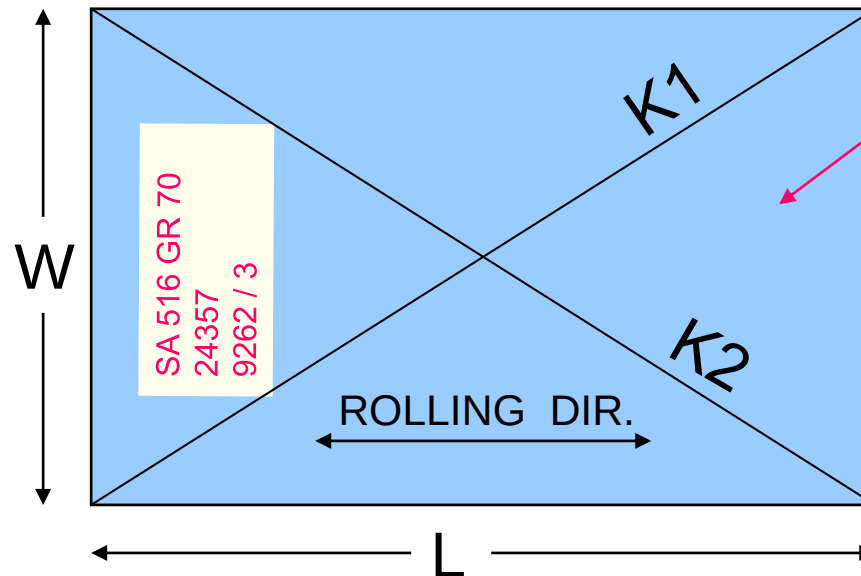
MATERIAL PRODUCT FORM

- Plate
- Forging
- Pipe
- Tube
- Casting

RAW MATERIAL IDENTIFICATION

- Material Quality, Thick. & Size -- Drawing
- Verify HT No., Plate No. & Isp. ID -- Material & TC
- Verify Properties Reported in TC – ASME Sec.II. Part A / B + ARM + Simulation HT
- Verify NDT (UT) Requirement
- Look For Pitting, Surface Damage / Defect on Both Sides

PROCEDURE FOR MARKING, CUTTING AND CHECKING OF SHELL PLATE



SHELL PLATE

No Hard Punching on

1) FM Below 6 mm thick

2) NFM Below 12 mm thick

TOLERANCE

- L & W - ± 1 mm / M, Max. ± 3 mm.
- $K1 - K2 = \pm 1$ mm / M, Max. ± 5 mm
- IDENTIFICATION MARKING $\perp$ TO ROLLING DIRECTION.
- L - NOMINAL CIRCUMFERENCE = MEAN DIA. $\times \pi$

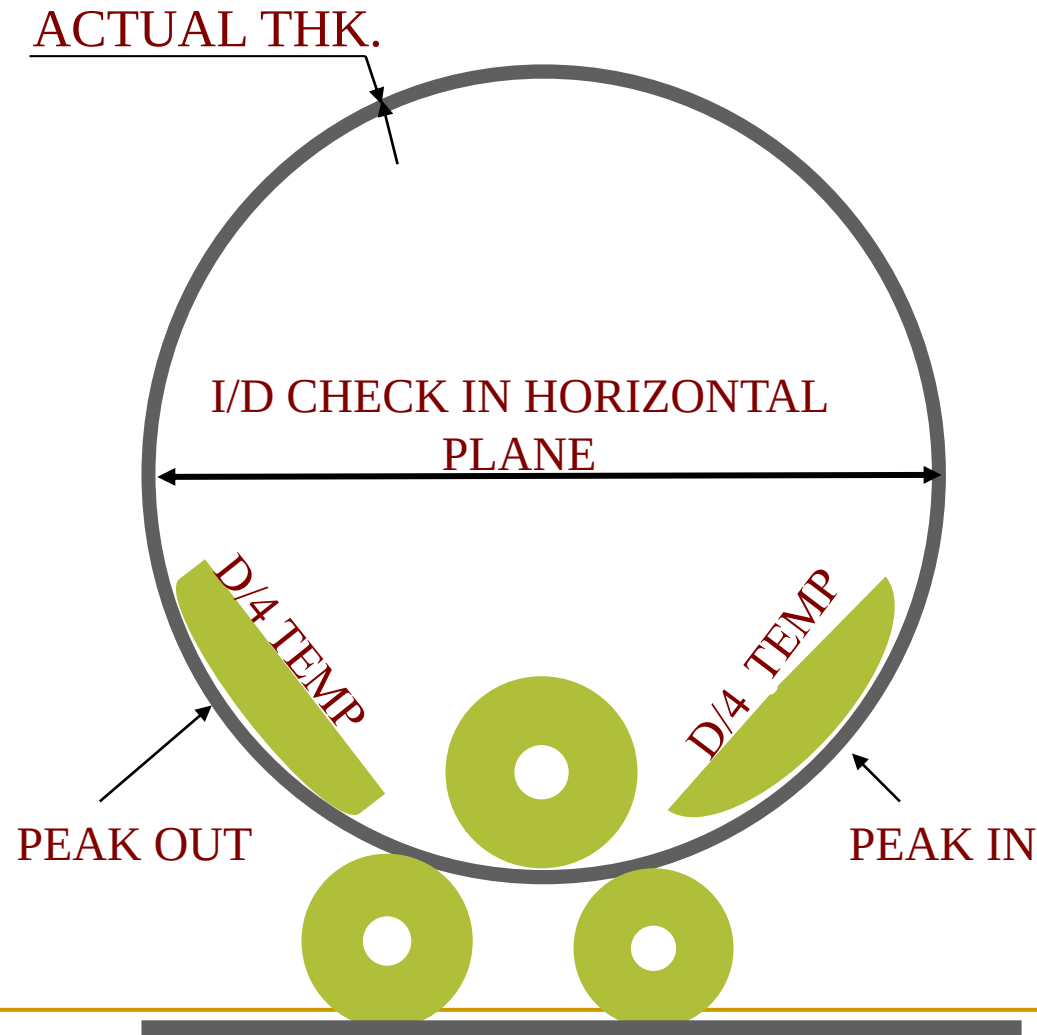
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LOADING OF PLATES FOR ROLLING

- Gas Cut Edges Free From Serrations
 - All Corners Along the Edge Rounded Off
 - Plate Loaded on M/c With ID Up side.
 - Identification Marking On Bottom Side
 - Rollers Across The Plate Length
 - Edge Breaking Allowance Provided For Plates Above 75 mm Thick.
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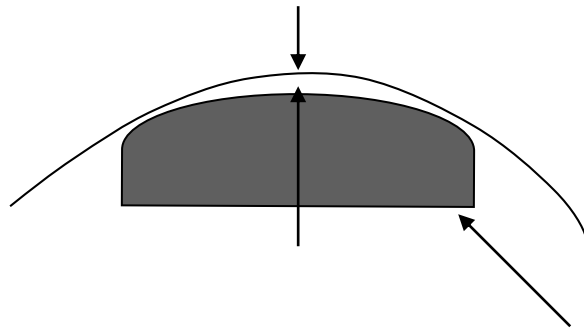
CHECKING SHELL PROFILE, OVALITY AND CIRCUMFERENCE

OVALITY = ID max - ID min = 0.5 % (1%) of Nominal ID



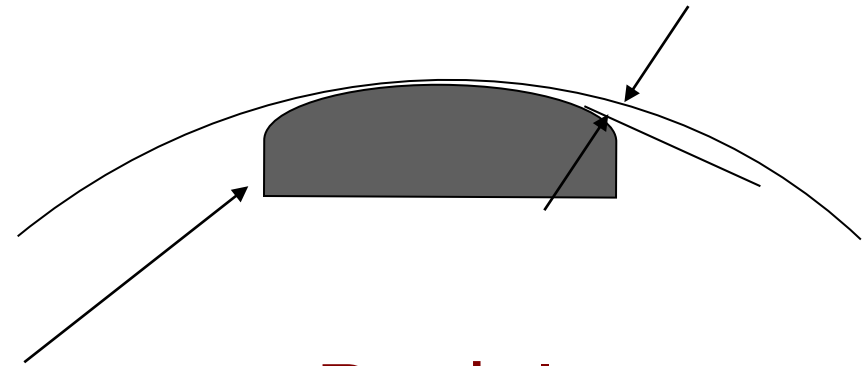
ID	Allowed gap Peak in / out
≤ 152	0.8 MM
≤ 305	1.2 MM
≤ 457	1.6 MM
≤ 610	2.4 MM
≤ 914	3.2 MM
≤ 1219	4.0 MM
≤ 1524	4.8 MM
≤ 1905	5.6 MM
≤ 2133	6.4 MM
≤ 2438	6.4 MM
≤ 2743	7.1 MM
≤ 3048	7.9 MM
>3048	0.2% OF ID

PROFILE CHECK BY TEMPLATE

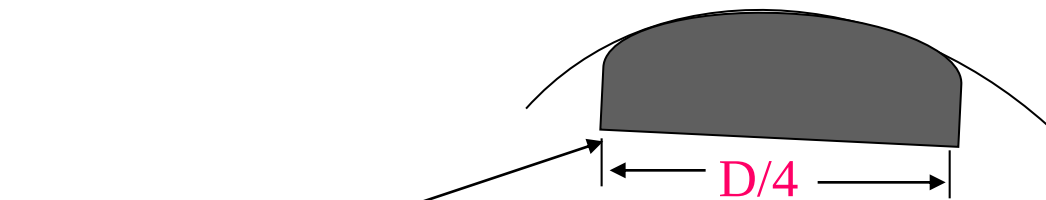


Peak Out

D/4 Template



Peak In



D/4 Template

Matching Profile

LONG SEAM SET UP & INSPECTION

Check & Confirm the following

1. Identification of part- inspector's stamp and punching details.
 2. Punching the seam No along the seam at every 1000 mm apart (highlighting the same with paints) with minimum one per seam.
 3. Cleanliness of W.E.P & adjoining area of 25 mm wide on either side.
 4. All tacks are free from crack.
 5. WEP – Groove angle / profile, Root face, Root opening as per drawing
 6. Weld edges and shell surface free from arc strikes, spatters, gas cutting serration, pitting & dents.
 7. Offset, is within the limit
 8. Run in & run out coupon on both ends, with matching WEP.
 9. Welders' stamp for tacks on groove for set up.
 10. PTC as an extension to the seam, if applicable.
 11. Profile and ovality within limits
 12. Circumference at both ends and centre measured - found within limit & recorded
-

MAXIMUM OFF SET IN BUTT WELD

Joint Thickness . 't'	Long Seam	Circ. Seam
13 mm & Below	$1/4^{\text{th}} t$	$1/4^{\text{th}} t$
Over 13 mm to 19 mm	3.2 mm	$1/4^{\text{th}} t$
Over 19 mm to 38 mm	3.2 mm	4.8 mm
Over 38 mm to 51 mm	3.2 mm	$1/8^{\text{th}} t$
Over 51 mm	$1/16^{\text{th}} t$. Max. 10 mm	$1/8^{\text{th}} t$. Max. 19mm

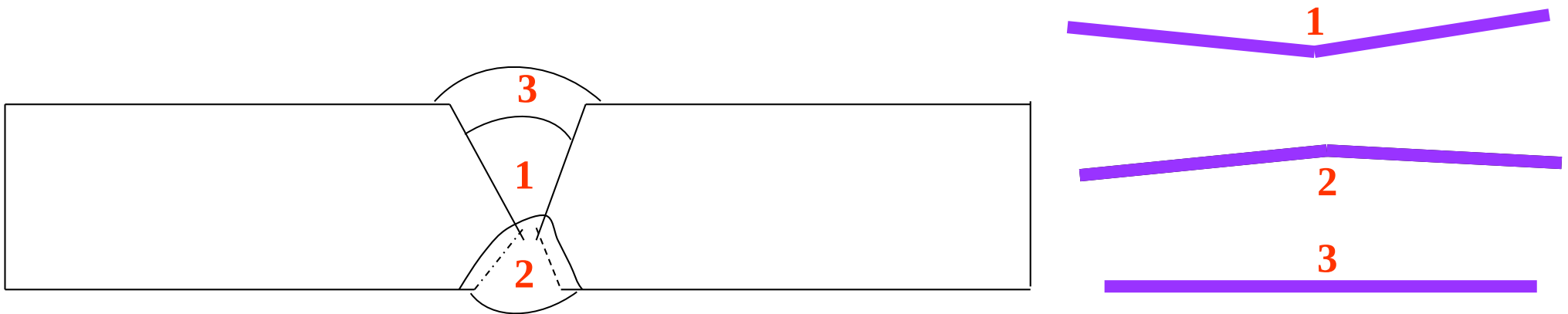
Aim For Half Of The Permissible Off Set At Set Up Stage

LONG SEAM WELDING & INSPECTION

1. Get the seam inspected and cleared from inspection
 2. Make burner arrangements, if preheating is required
 3. Weld the seam as per weld plan.
 4. Welding parameters (Process, Consumables, Preheat, Post heat, Inter pass temperature) in accordance with weld plan.
 5. Adopt sequence welding (I/S – O/S) to control Peak in or Peak out.
 6. Chip back to sound metal and clear PT or MT.
 7. Maintain Weld reinforcement within the limit.
 8. Weld seam free from visible surface defects.
 9. Check the profile and ovality
 10. Re-roll the shell if the shape is out
 11. Clear NDT of seam as per test plan.
 12. Process the PTC for mechanical testing.
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LONG SEAM WELDING & INSPECTION

Sequential Welding to Control Peak in / Peak out



REINFORCEMENT LIMIT ON BUTT WELDS- UW 35

Material Thickness	Max. Reinforcement	
	Long Seam	Circ. Seam
Below 2.4 mm	0.8 mm	2.4 mm
2.4 to 4.8 mm incl	1.6 mm	3.2 mm
Over 4.8 to 13 mm incl	2.4 mm	4.0 mm
Over 13 to 25 mm incl	2.4 mm	4.8 mm
Over 25 to 51 mm incl	3.2 mm	5.0 mm
Over 51 to 76 mm	4.0 mm	6.0mm
Over 76 to 127 mm	6.0 mm	6.0 mm
Over 127 mm	8.0 mm	8.0 mm

PRODUCTION TEST COUPON - PTC

1. What is Production Test Coupon (PTC)?

A sample weld produced along with the production welds on main / most critically stressed weld joint of the vessel. All welding variables on the coupon shall be same as that of production weld. Welded PTC will represent in all respect the properties of production weld

2. What is the Purpose of PTC?

PTC Facilitates destructive testing of true representation of production welds for ascertaining physical properties

PRODUCTION TEST COUPON - PTC

1. **PTC Requirement (When?, Where? & How many?)**
 - Customer Specification – Design Code – Design Temperature
 2. **Extend of testing & Acceptability of test results**
 - Customer Specification - Design Code - Base metal Properties
 3. PTC to be welded along with first long seam
 4. PTC shall undergo all PWHT envisaged on Production welds prior to testing
 5. PTC shall be radiographed to eliminate possible defects from test specimens
 6. PTC shall be processed / tested immediately after its welding
 7. PTC results shall decide acceptability of production welds
 8. Failure of PTC calls for rejection / repair / rework of production welds
 9. PTC, therefore, demands special attention and care in handling & testing
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MATERIAL TEST COUPON - MTC

1. What is Material Test Coupon (MTC)?

A sample of actual raw material used in manufacturing main or critical vessel component.

2. What is the Purpose of MTC?

Raw material used for vessel components undergoes various heat treat during manufacturing and final PWHT. Each of these heat treatment alters mechanical properties of material.

MTC Facilitates simulation heat treatment & destructive testing of actual material representing vessel components for their mechanical properties as the final heat treated condition.

PRODUCTION TEST COUPON - PTC

1. When MTC is Required ?

- Whenever vessel component undergoes any heat treatment and
- Customer Specification or Code of construction calls for MTC.

2. Extend of Testing Requirement

- Customer Specification or Design Code

3. Acceptability of Test Results

- Minimum values specified in the material specification.

4. MTC shall undergo all heat treatment including final PWHT prior to testing.

- MTC shall be subjected to a simulation heat treatment in advance by vessel manufacturer and tested prior to releasing the material for production.
- Alternatively, vessel manufacturer can obtain the raw material from Mill duly an MTC tested with predetermined simulation heat treatment in advance. Vessel manufacturer shall provide total time and heating cycle to the Mill along with the purchase order.

INSPECTION OF ROLLED / CYLINDRICAL SECTIONS

Shape	Checking Method
Profile	Template
Ovality (Out Of Roundness)	Diameter Measurement
Circularity	Swing Arm Method
Straightness	Stretching Twine

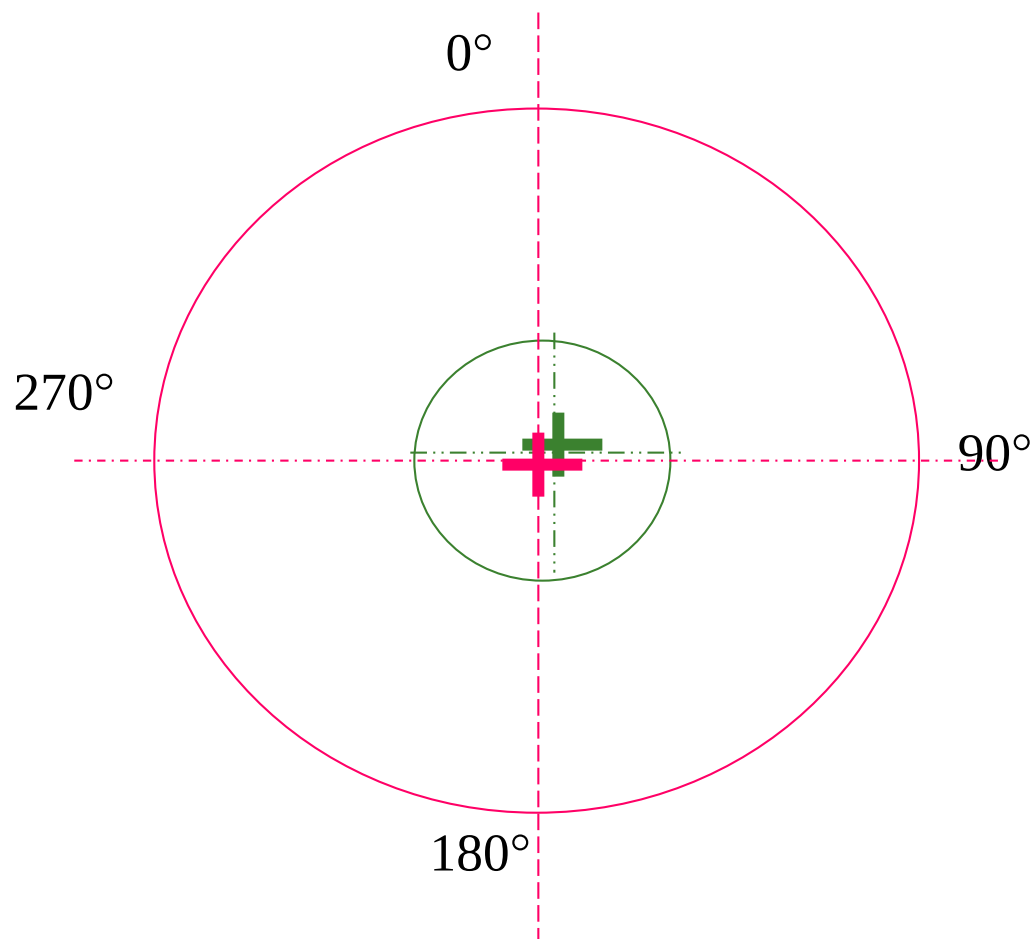
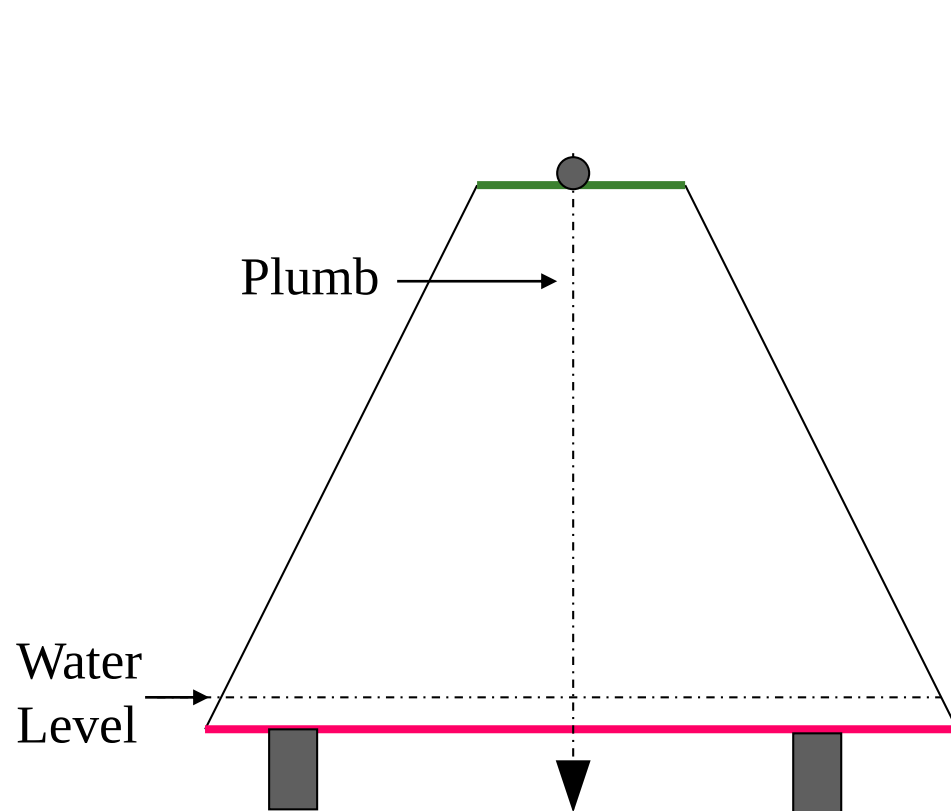
INSPECTION OF ROLLED / FORMED CONICAL SECTIONS

Shape	Checking Method
Profile At Open Ends	Template
Ovality (Out of Roundness)	Diameter Measurement
Circularity	Swing Arm Method
Concentricity	Leveling & Plumbing

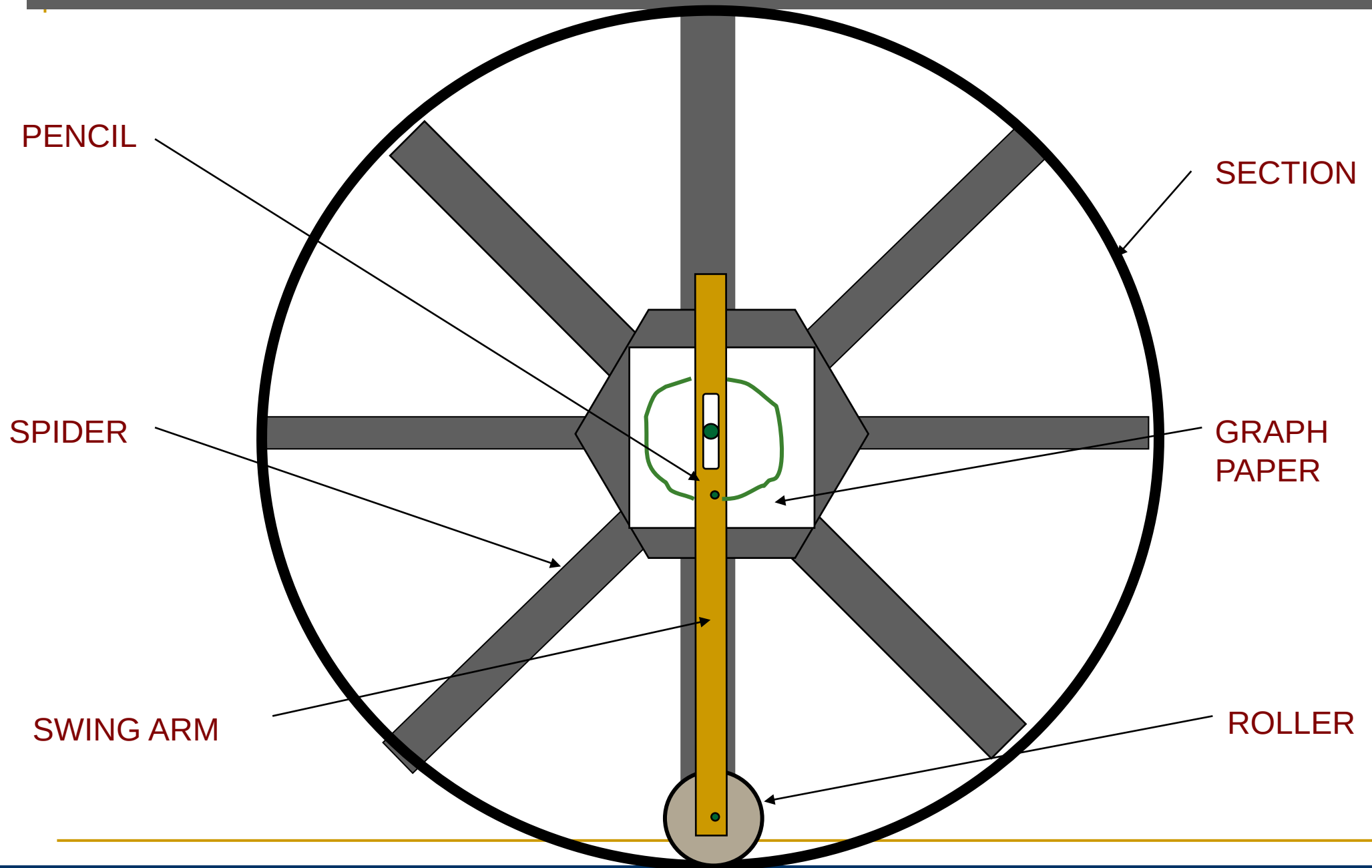
PROFILE VERIFICATION OF SHELL SECTIONS UNDER EXTERNAL PRESSURE

- Ovality Check – $0.5 \varnothing$ (1 % $\varnothing$ Code Requirement)
 - Template Check – UG 80 (b)
 - Chord Length of Template = 2 Times the Arc Length Obtained From UG 29.2 (Based on OD, Thickness & Length)
 - Vessel Length as Given in UG 28 & 28.1
 - Gap Permissible With the Template to be Obtained from UG 80.1
 - Hemispherical D/Es & Spherical Portion of Other D/Es, Template Check using $L/D = 0.5$
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CONCENTRICITY CHECK OF CONES



CIRCULARITY CHECKING- SWING ARM METHOD



DERIVATION OF OUT OF CIRCULARITY

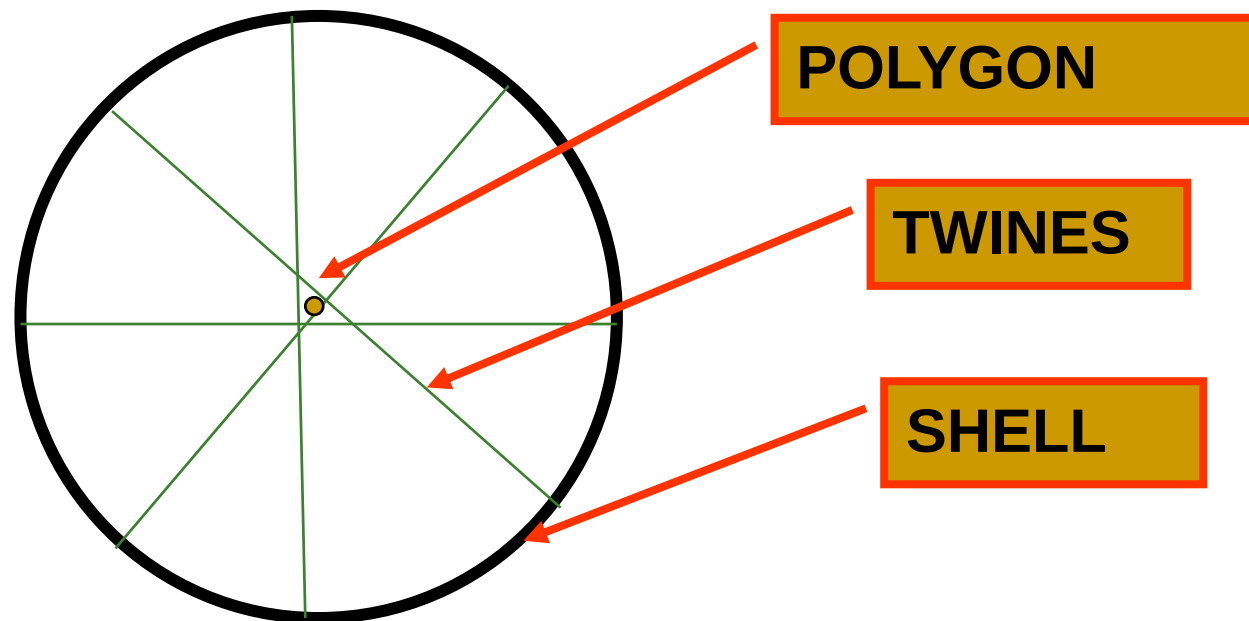
1. Measure the Area Encircled by the Curve From Graph
2. Calculate the Mean Diameter From The Area.

$$D = \sqrt{4A / \pi}$$

3. Mark Three Circles On A Transparent Paper
 - Circle With Mean Diameter D Derived
 - Circle With Mean Dia. $D - (\text{Tolerance in } \% D)$
 - Circle With Mean Dia. $D + (\text{Tolerance in } \% D)$
4. **SUPERIMPOSE THE CIRCLES IN TRANSPARENT PAPER ON CURVE OBTAINED ON GRAPH & DEMONSTRATE THAT THE CURVE IS WITHIN THE OUTER & INNER CIRCLES.**

CIRCULARITY CHECK BY TAPE OR TELESCOPIC GAUGE

1. FIND THE GEOMETRIC CENTRE OF THE SHELL SECTION.
CROSS 4 DIA TWINES. MARK THE CENTRE OF POLYGON



2. MEASURE THE RADIUS AT 48 LOCATIONS (R1 TO R48)
3. CALCULATE THEORITICAL RADIUS FROM Circumference

CIRCULARITY CHECK BY TAPE OR TELESCOPIC GAUGE

4 FIND THE MAXIMUM & MINIMUM RADIUS

5 CHECK THEY ARE WITHIN PERMISSIBLE PERCENTAGE VARIATION

CIRC. SEAM SET UP & INSPECTION

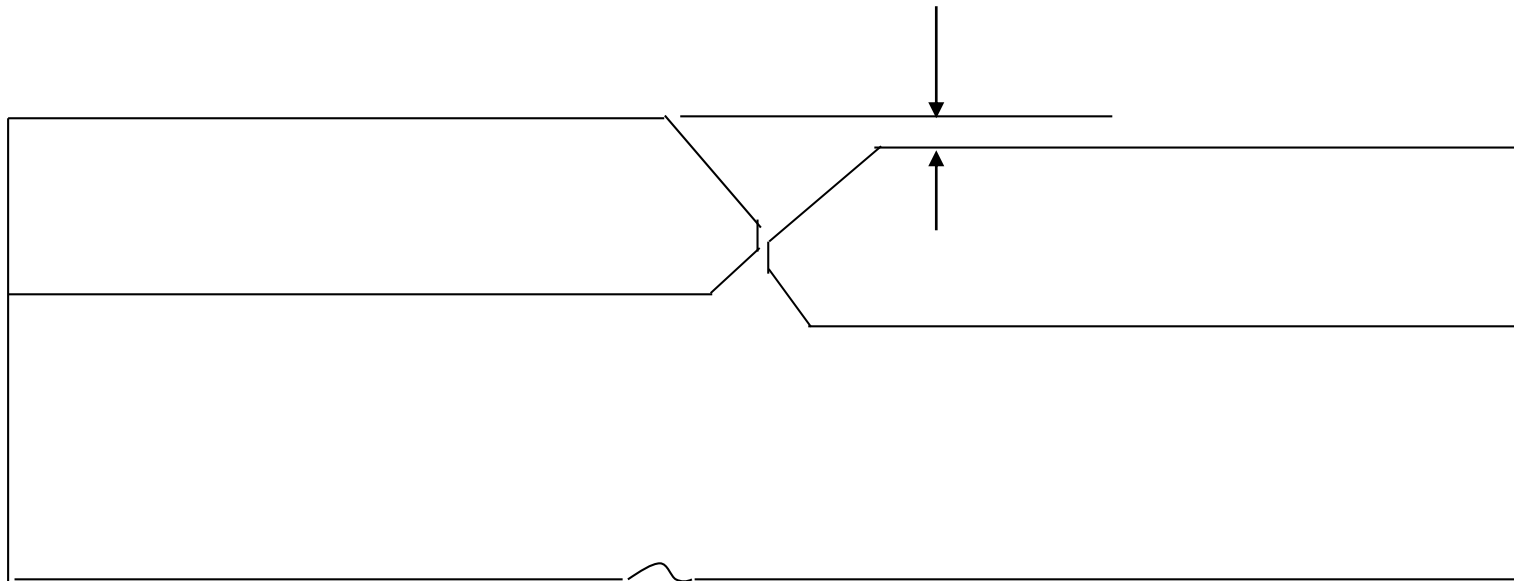
1. Ensure Following on Individual Shell Sections

- 1.1 Profile verification
- 1.2 Ovality Check
- 1.3 NDT of Long Seams
- 1.4 PTC Test results, if any
- 1.5 Orientation Marking & Verification
- 1.6 Weld edge preparation & PT / MT
- 1.7 Circumference difference of Butting ends
- 1.8 Theoretical Off Set on account of Circumference difference

CIRC. SEAM SET UP & INSPECTION

Theoretical Off Set

Difference in Circumference $\div 2 \pi$



Set Up With the Off Set

CIRC. SEAM SET UP & INSPECTION

1. Align Two pairs of tank rotators – One of them Drive unit
2. Keep each shell section on tank rotators facing butting face together
3. Match orientations by rotating one shell section
4. Bring the sections closer to the required root gap by turn buckle / wedges
5. Lock 4 orientations keeping theoretical off set with wedges and tacks
6. Tack all 4 quadrants at every 300 mm apart keeping theoretical off set
7. Remove all external & internal cleats, dress and PT check

CIRC. SEAM SET UP & INSPECTION

- 1. Check Off Set on full circumference.**
- 2. Check Surface Alignment at 4 orientations**
- 3. Verify WEP, Root face & Root opening**
- 4. Provide PTC, if required**

INSPECTION OF DISHED ENDS

TYPE OF DISHED ENDS

- **Hemispherical**
- **Ellipsoidal**
- **Torispherical**

INSPECTION OF DISHED ENDS

TYPE OF CONSTRUCTION

- **Pressed From Single Blank**
 - Without Any Weld Seam
 - With One Long Seam
 - With More Than One Long Seam
- **Crown & Petal Construction**
 - Single Tier
 - Multi Tier

INSPECTION OF DISHED ENDS

FORMING TEMPERATURE

- **Cold Formed At Room Temperature**
- **Hot Formed At NR Temperature**
- **Cold Formed With Intermediate NR**
- **Cold Formed with Intermediate SR**

INSPECTION OF DISHED ENDS

FORMING METHOD

- **Single Pressing Using A pair of Male / Female Punch & Die**
- **Progressive Forming By Repeated Point Pressing**
- **Progressive Forming For Crown Profile By point pressing & Knuckle Radius By Spinning**

INSPECTION OF DISHED ENDS

IDENTIFICATION MARKING

- **Project No.**
- **Mtl. Specification**
- **Heat No. & Plate No.**

LOCATION OF MARKING

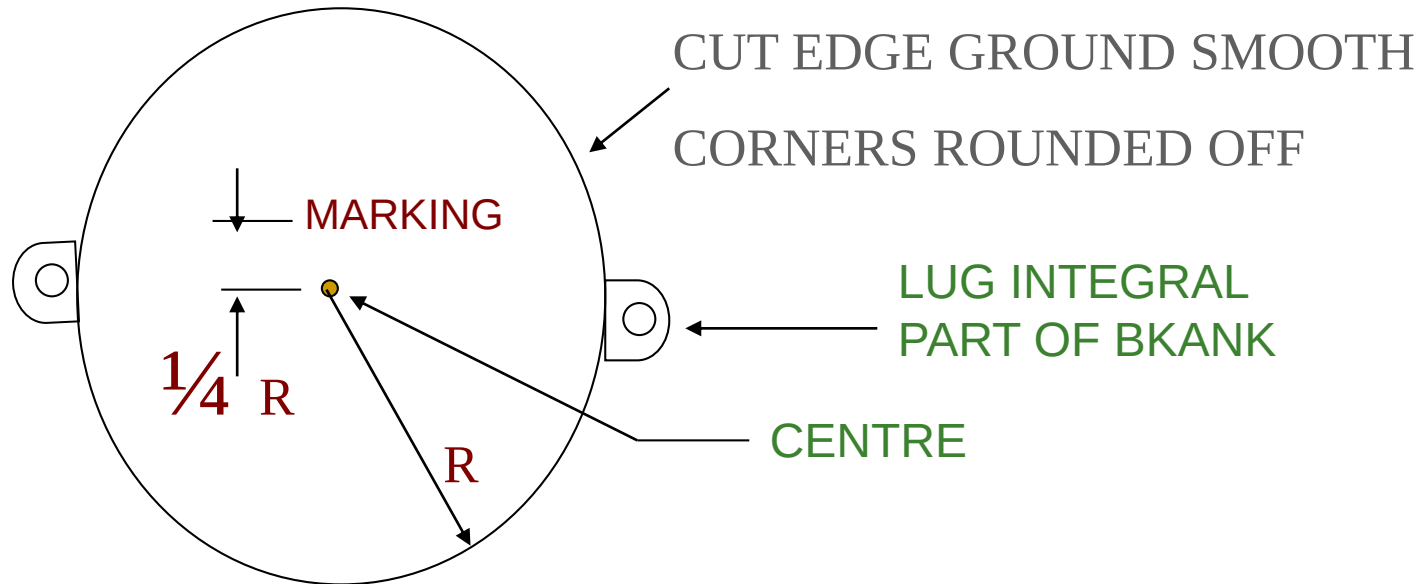
- **Appx. $\frac{1}{4}$ th Radius of Single Disc Blank & Crown Disc**
- **Appx. At the Centre Of Blanks For Petals**

INSPECTION OF DISHED ENDS

LIFTING LUGS ON BLANKS & PETALS

- Provide Integral Lugs on Blanks & Petals For Handling.

D/E BLANK



INSPECTION OF FORMED DISHED ENDS

Applicable For Single Piece & Crown + Petal Construction

- 1 Circumference At Trimming line (Acceptance as per Tolerance Chart)
- 2 Knuckle Profile With 2D Full Size Template (No Gap At Center – End Gap max. 2mm)
- 3 Height From Tan line (+ Half of $1\frac{1}{4} \% D/E \text{ } \emptyset$, – Half Of $5/8 \% D/E \text{ } \emptyset$)
- 4 Thickness At Crown, Knuckle & Edge (Above Minimum Specified In Drg.
- 5 Ovality On Open End ($\frac{1}{4}$ Of 1% Of $D/E \text{ } \emptyset$)

INSPECTION OF FORMED DISHED ENDS

Applicable For Single Piece & Crown + Petal Construction

- 6 Check - Profile, Tan Line & Trimming Line With Full Size 2D Template. (Template radius – Open End, Crown & Knuckle - Less be 20 mm.) Template Shall Have Markings Of Tan Line, Trimming Line & Crown Centre. Deviation Permitted – Half of $1\frac{1}{4}\%$ D/E Ø in Plus & Half Of $5/8\%$ D/E Ø in Minus; No Abrupt Change In Profile. (Template To Be Verified On Lay Out)**
- 7 Water Level 3 Points at 120° Apart On Trimming Line & Check Crown Center By A Plumb. (Deviation 5 mm per Meter Length Of D/E Ø Max. 20mm.(Not Applicable To Hemispherical D/E)**

INSPECTION OF FORMED DISHED ENDS

Applicable For Single Piece & Crown + Petal Construction

- 8 Check – Straight Face (Tan Line To Trimming Line)
With A Straight Edge of 1 Foot Scale. Minimum As
Specified In Drawing. (Not Applicable To Hemispherical
D/E)**
- 9 All Press Marks On Out Side & Inside Shall Be Smoothly
Ground / Merged.**
- 10 PT Check Out Side Surface – No Linier Indication
Permitted**

INSPECTION OF FORMED DISHED ENDS

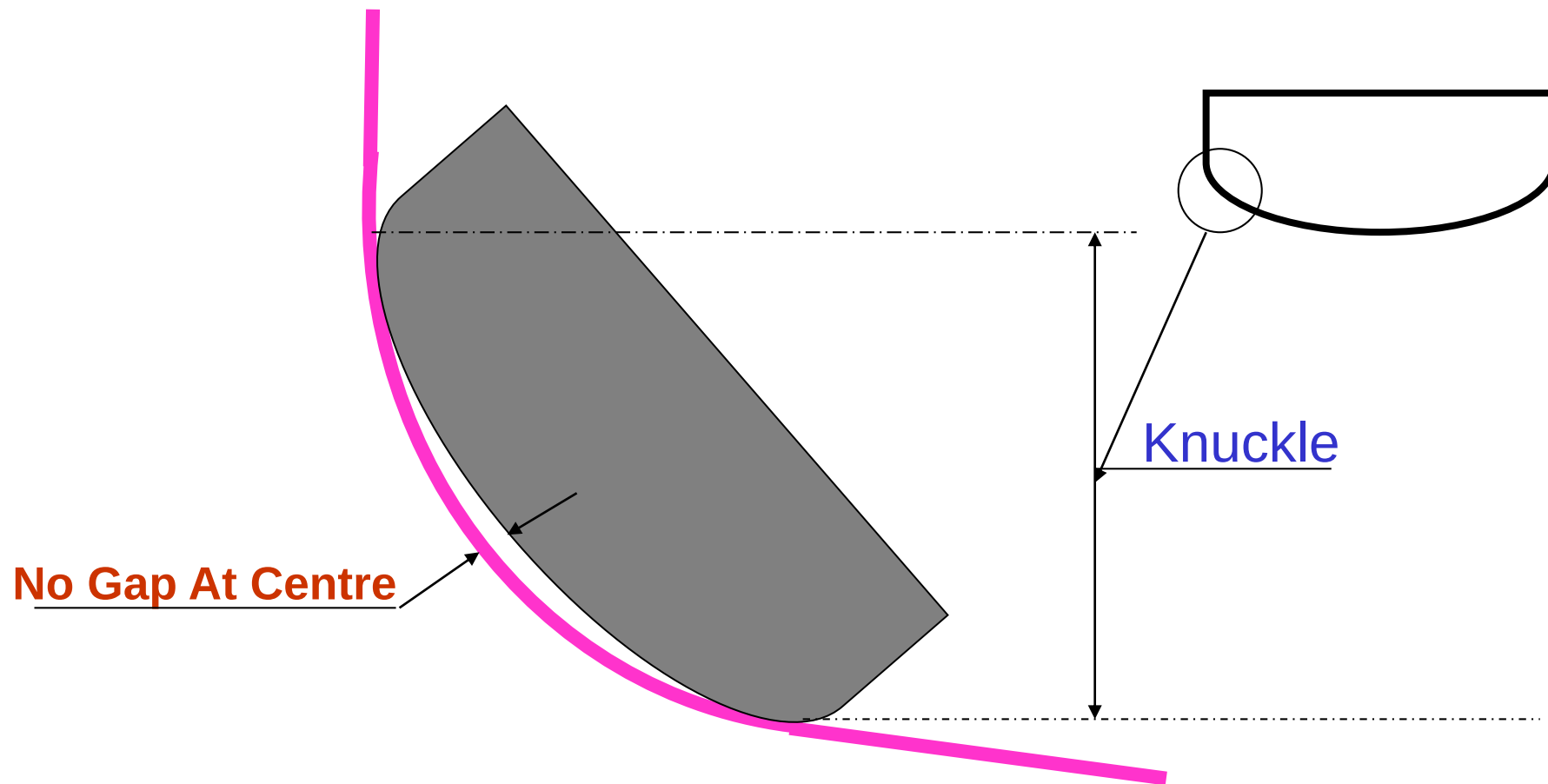
Applicable For Single Piece & Crown + Petal Construction

11 If Hot Formed, Check For MTC With Simulation Heat Treatment. (Not Applicable To Cold Formed D/E)

12 Blanks With Weld Joints Shall Be PT Checked & Radiographed Before & After Forming.

INSPECTION OF FORMED DISHED ENDS

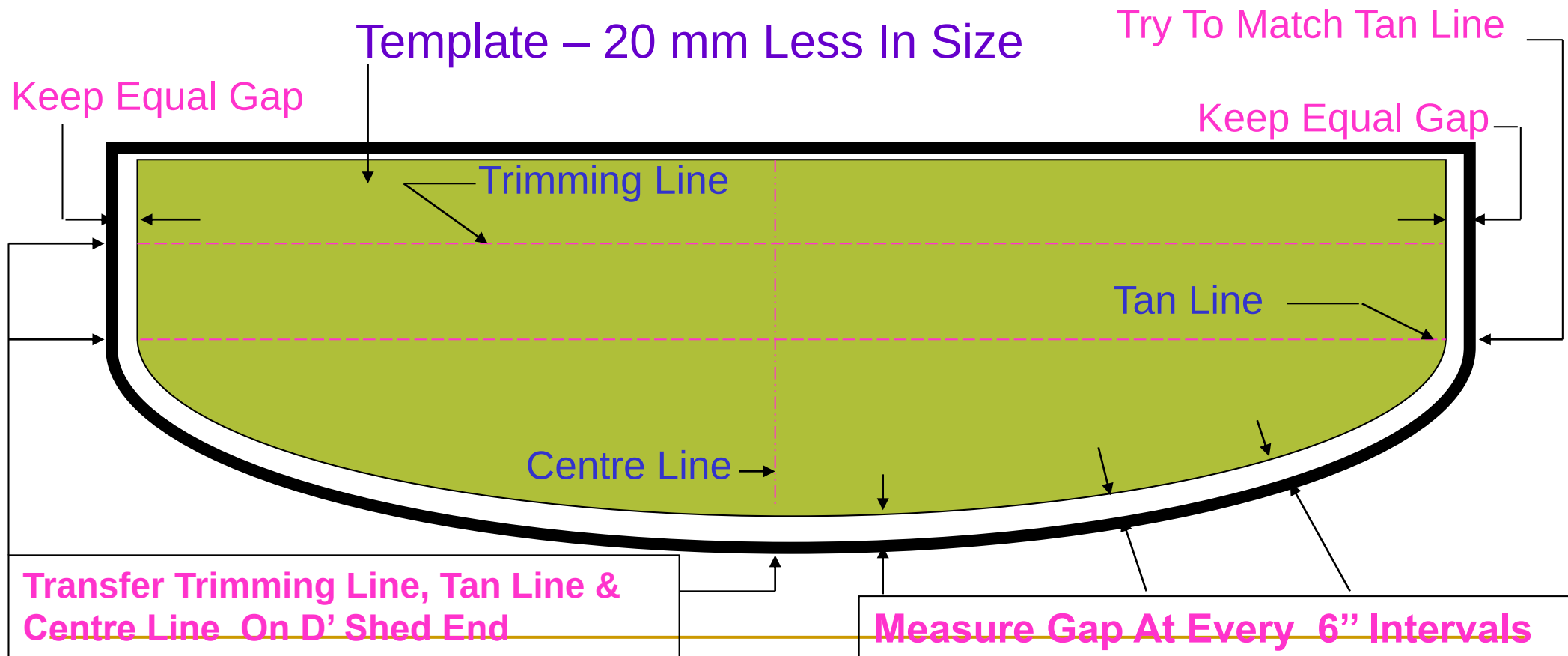
Profile Check At Knuckle Portion



INSPECTION OF FORMED DISHED ENDS

2D Full Size Template Check. Profile-Tan Line-Trimming Line

Repeat Marking & Checking Along the Full Circumference at Every 300 mm apart.



INSPECTION OF FORMED DISHED ENDS

Applicable For Only Crown + Petal Construction

- 1. Each Formed Petal Segment Shall Be Checked By A 3D Template From Inside. Profile Of Template Ribs To Be Verified. Maximum Gap Permissible At Any Location At The Rate Of 3mm / Mtr. Length Of Petal With Maximum Of 6mm.**
- 2. Crown Segment Shall Be Checked By 2D Template. Gap Permissible 3mm / Mtr. Blank Dia.**

INSPECTION OF FORMED DISHED ENDS

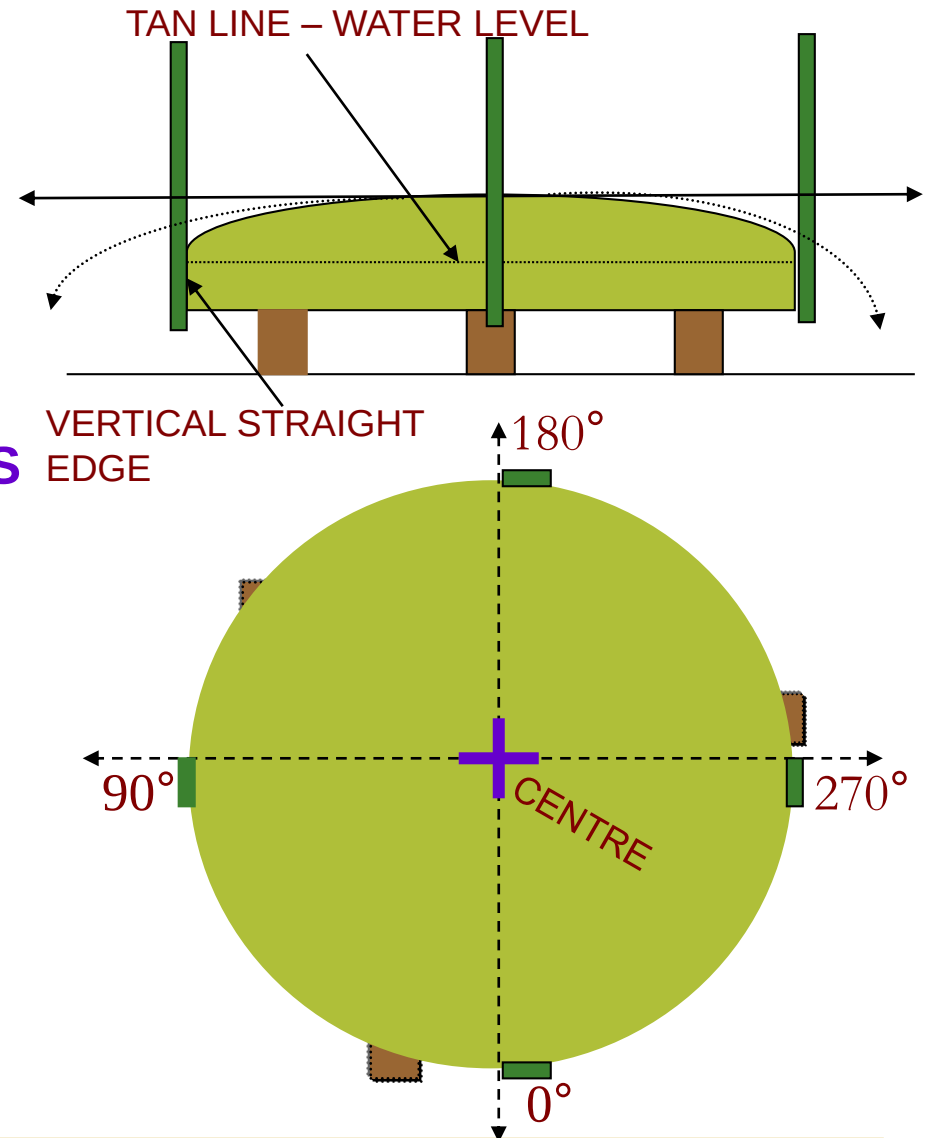
Applicable For Only Crown + Petal Construction

3. Checks After Assembly

- Off Set – Half Of Permissible As Per Code.
- Root Gap – (– 1mm , + 2mm)
- Root Face – ($\pm$ 1mm)
- Serrations If Any On W E P, To Be Ground Smooth
- No Temporary Tacks On Groove
- No Defects On Tacks With External Cleats
- Petals To Be Numbered With D/E No.
- Match Marks On Adjacent Petals

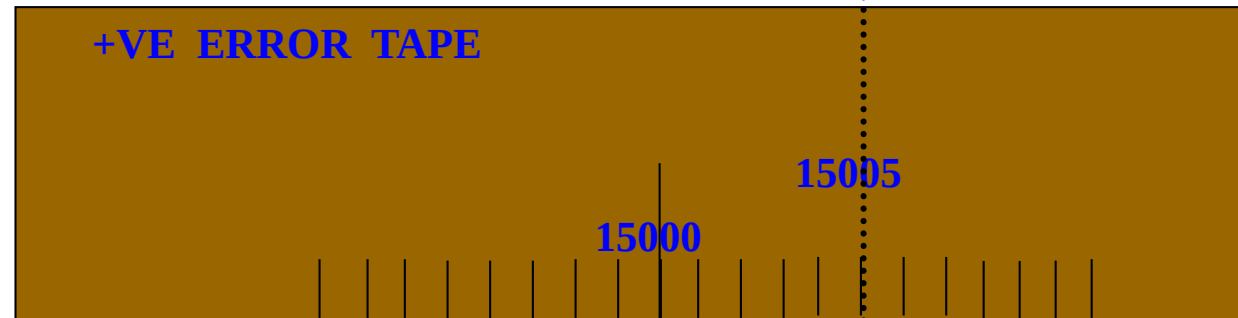
MARKING OF CENTRE LINES ON DISHED ENDS

- 1) KEEP D/E ON THREE SUPPORTS
- 2) WATER LEVEL TAN LINE OR TRIMMING LINE
- 3) MEASURE CIRCUMFERENCE AND DEVIDE IN TO 4 EQUAL PARTS
- 4) MARK 0° , 90° , 180° & 270° ORIENTATIONS
- 5) CLAMP VERTICAL STRAIGHT EDGES AT ALL ORIENTATIONS. VERTICALITY TO BE VERIFIED WITH SPIRIT LEVEL
- 6) STRETCH TWO TWINES DIMETRICALLY OPPOSITE ALONG THE STRAIGHT EDGES AND BRING DOWN TO MARKED ORIENTATIONS
- 7) MARKS THE LOCATION OF TWINE (CENTRE LINES) ON THE D/E SURFACE

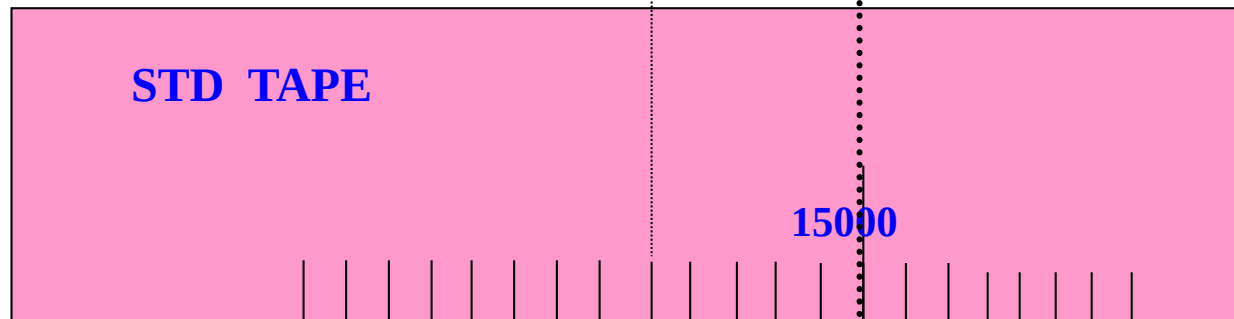


CALIBRATION OF MEASURING TAPE

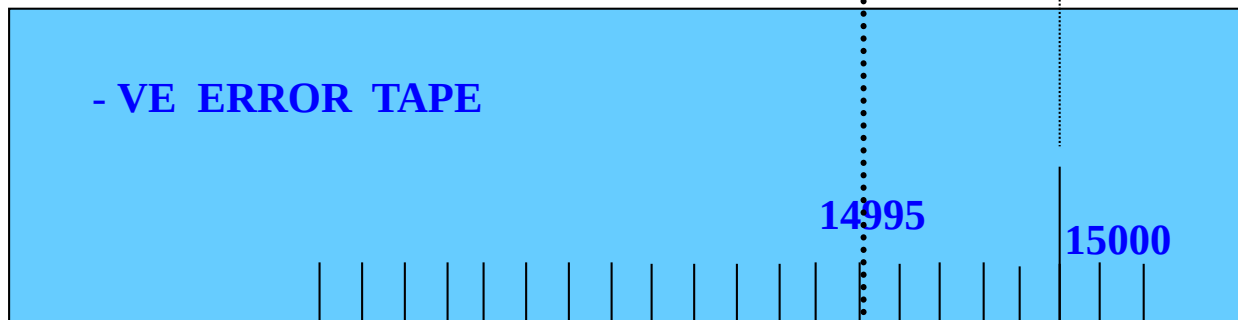
ERROR



← **WITH USER**

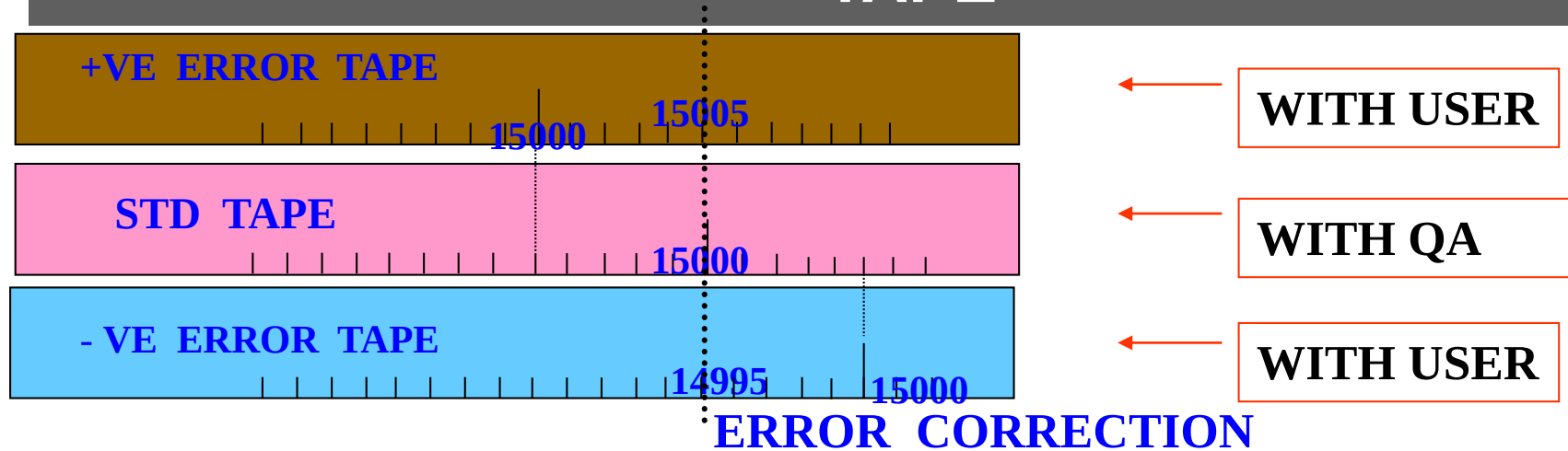


← **WITH QA**



← **WITH USER**

APPLICATION OF ERROR ON CALIBRATED TAPE



TYPE OF ERROR	OPERATION	
	MARKING (ADD ERROR)	MEASURING (SUBTRACT ERROR)
+ VE	$X + (+Y)$	$X -- (+Y)$
-- VE	$X + (--Y)$	$X -- (--Y)$

NOTE :1. USE CALIBRATED TAPES ONLY

2. DO NOT USE TAPE HAVING ERROR MORE THEN ± 1 mm FOR

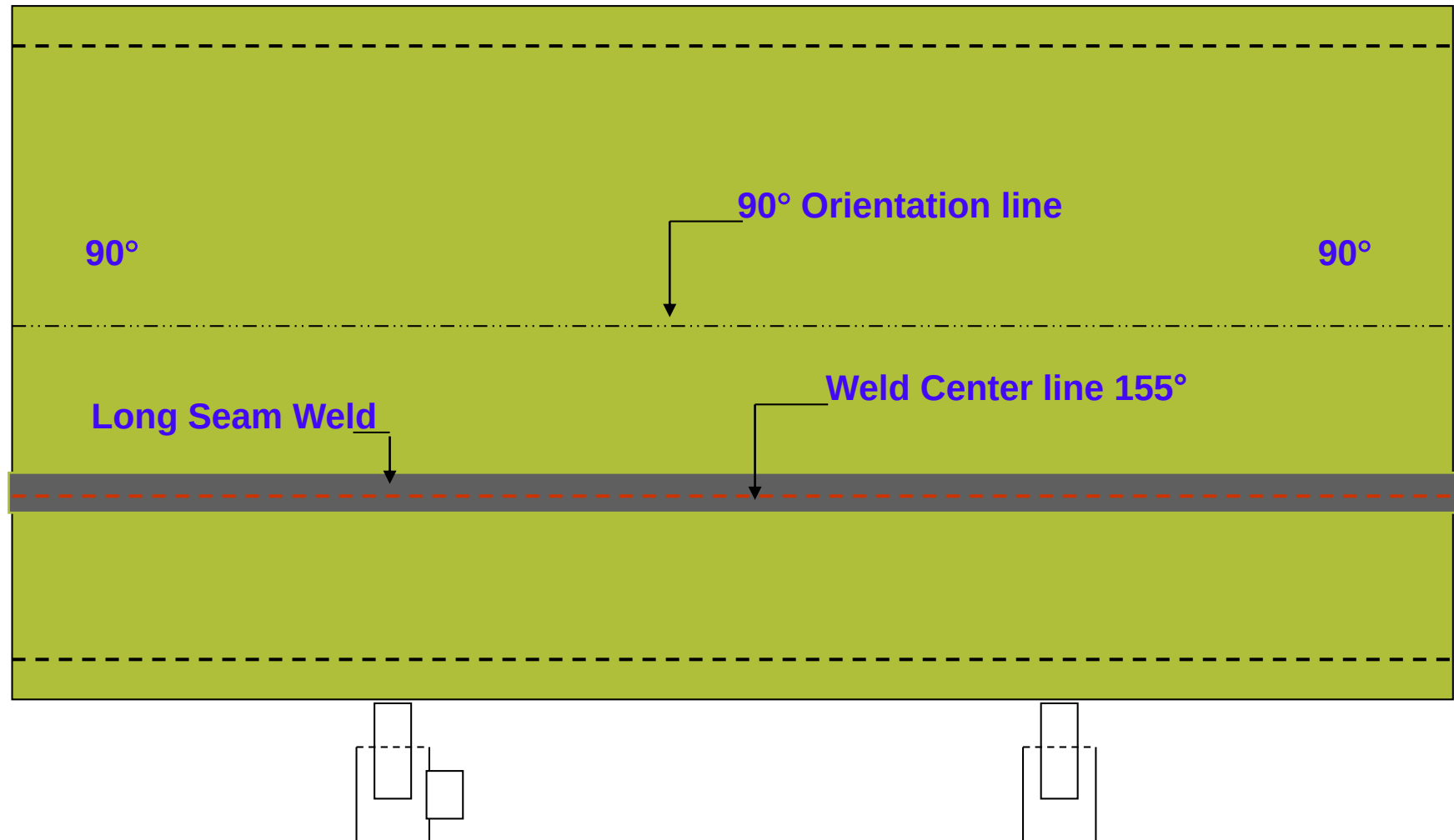
CRITICAL JOBS.

ORIENTATION MARKING ON CYLINDRICAL SHELLS

1. ROLLED SHELLS WITH ONE OR MORE LONG SEAMS
2. FORGED SHELLS WITHOUT ANY WELD SEAM

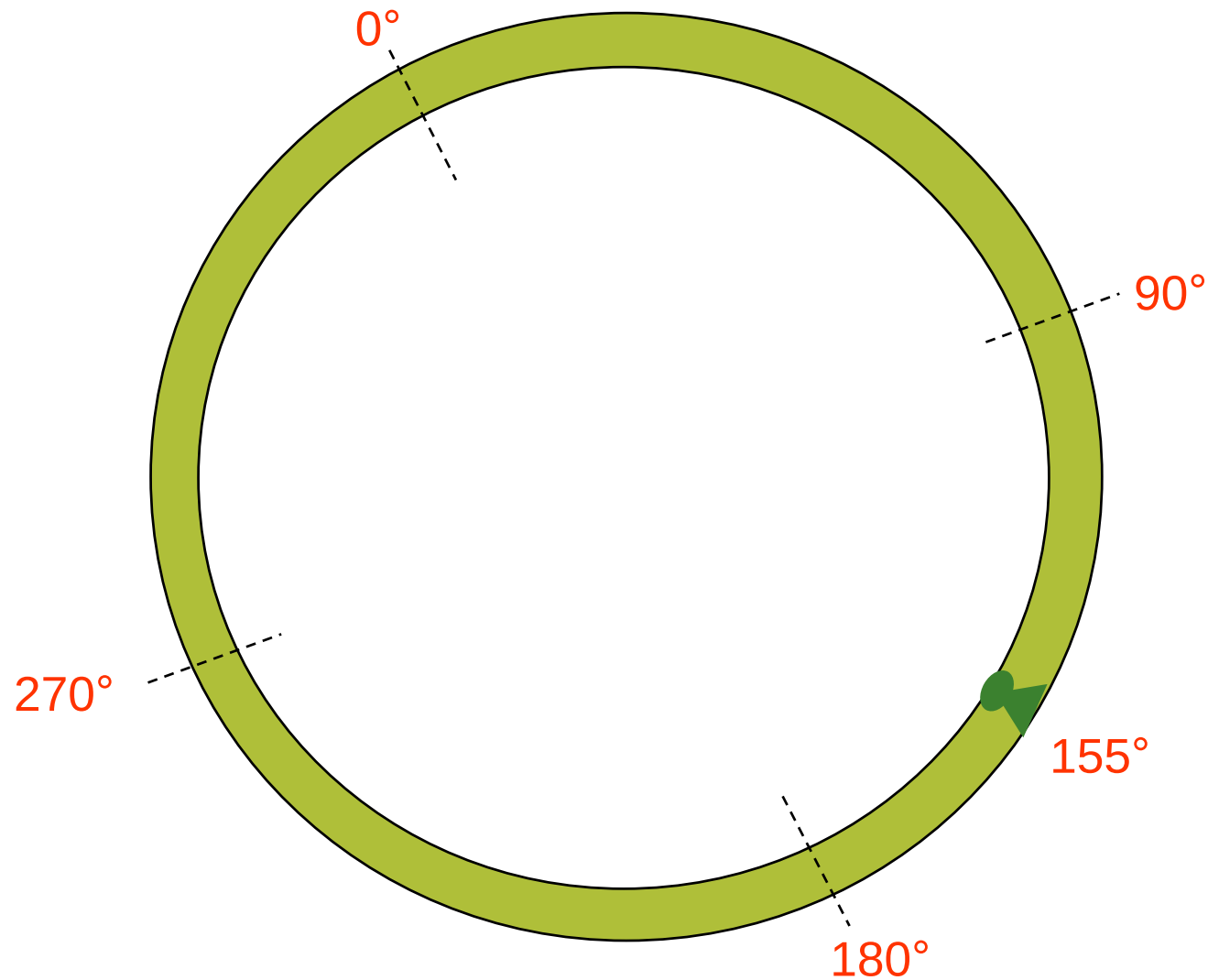
ORIENTATION MARKING ON ROLLED SHELLS

Shell With Weld Seam

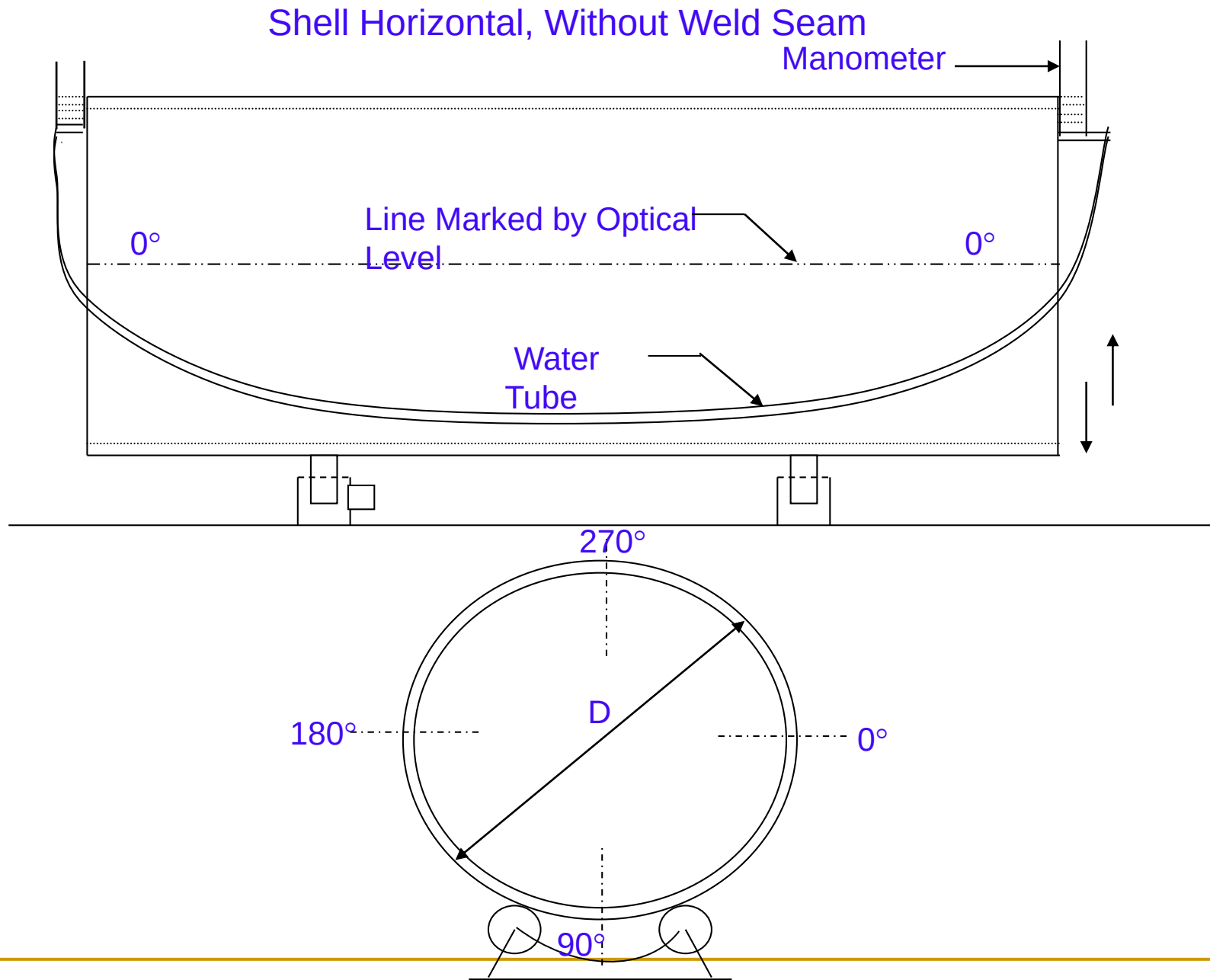


ORIENTATION MARKING ON ROLLED SHELLS

Shell With Long Seam

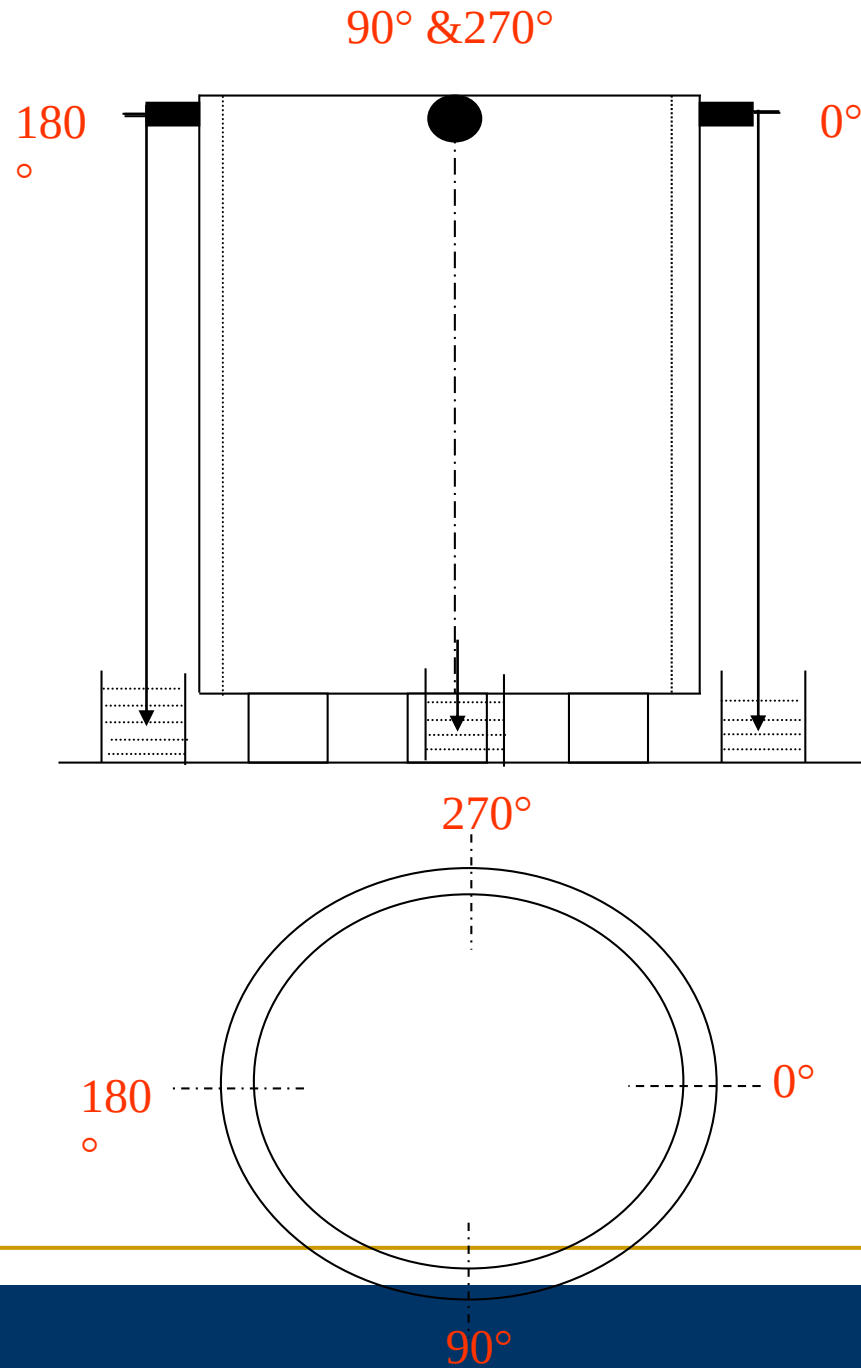


ORIENTATION MARKING ON FORGED SHELLS



ORIENTATION MARKING ON FORGED SHELLS

Shell Vertical Without Seam

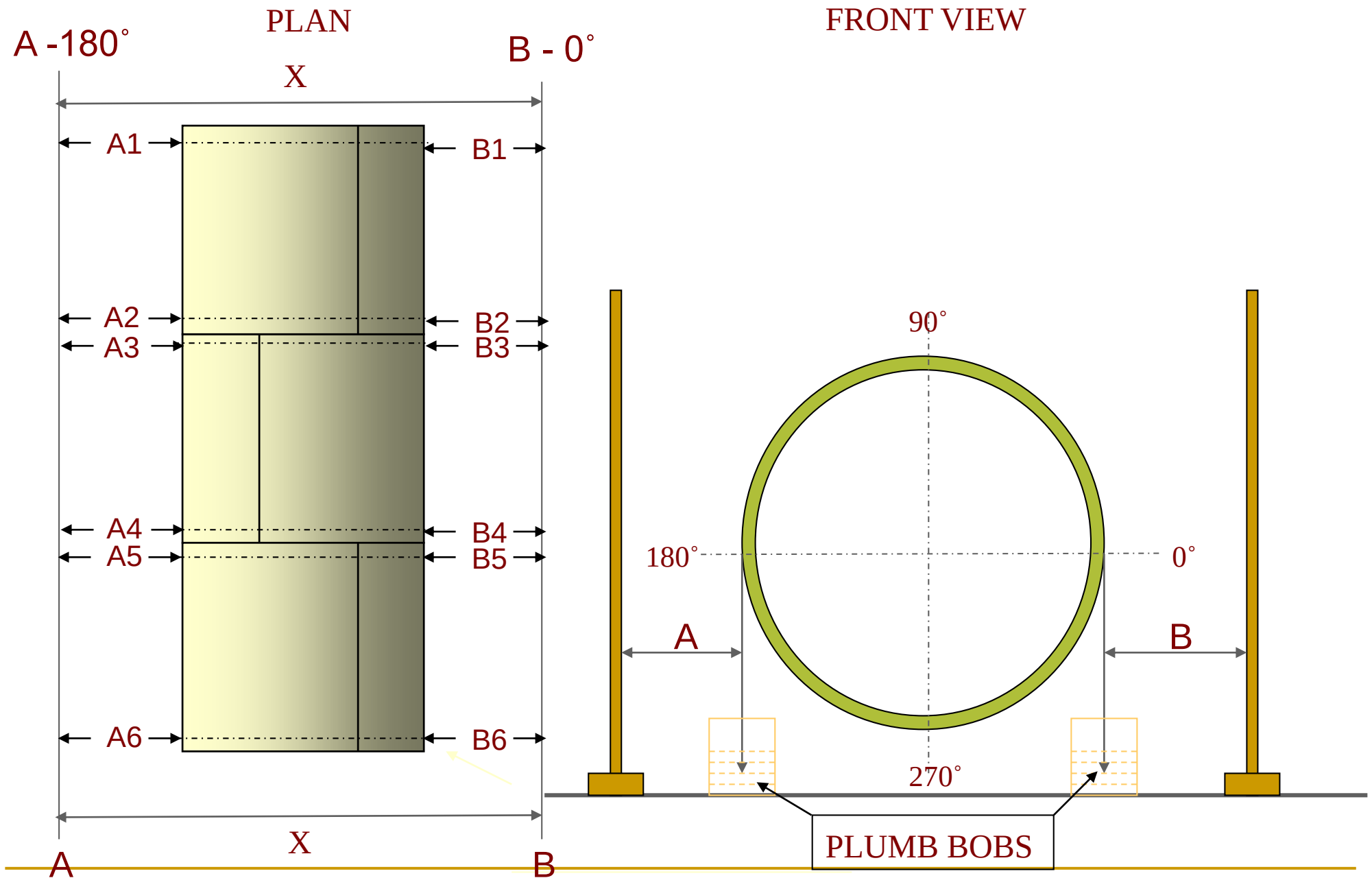


ALIGNMENT CHECK

1. AXIS ALIGNMENT

2. SURFACE ALIGNMENT

AXIS ALIGNMENT CHECK



AXIS ALIGNMENT CHECK

MEASURE PERPENDICULAR DISTANCE BETWEEN PLUMB LINE AND HORIZONTAL TWINE & TABULATE READINGS AS SHOWN BELOW.

Orientation 0° - 180°				
Location	Reading A	Reading B	Half of Difference in Readings	
1	A1	B1	$(A1 - B1) \times \frac{1}{2}$	= +/- - X1
2	A2	B2	$(A2 - B2) \times \frac{1}{2}$	= +/- - X2
3	A3	B3	$(A3 - B3) \times \frac{1}{2}$	= +/- - X3
4	A4	B4	$(A4 - B4) \times \frac{1}{2}$	= +/- - X4
5	A5	B5	$(A5 - B5) \times \frac{1}{2}$	= +/- - X5
6	A6	B6	$(A6 - B6) \times \frac{1}{2}$	= +/- - X6

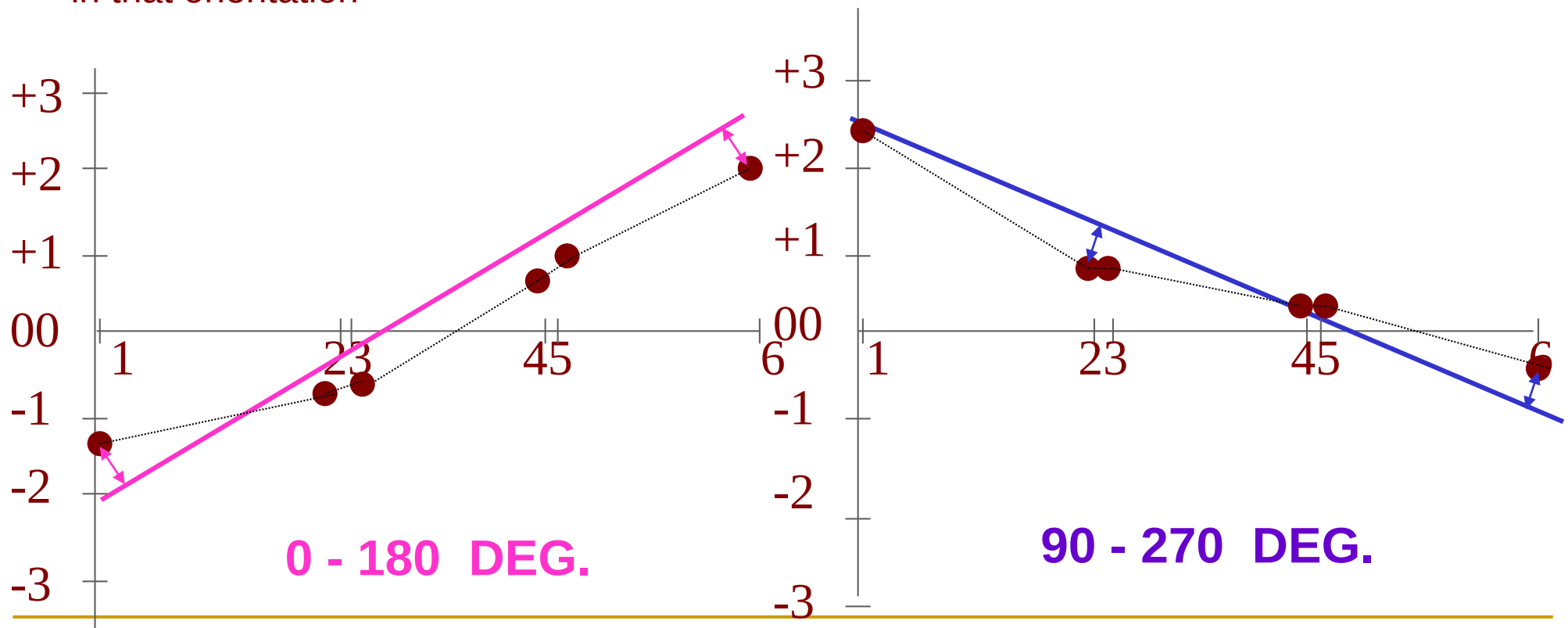
AXIS ALIGNMENT CHECK

MEASURE PERPENDICULAR DISTANCE BETWEEN PLUMB LINE AND HORIZONTAL TWINE & TABULATE READINGS AS SHOWN BELOW.

Orientation 90° - 270°				
Location	Reading A	Reading B	Half of Difference in Readings	
1	A1	B1	$(A1 - B1) \times \frac{1}{2}$	= +/- - X1
2	A2	B2	$(A2 - B2) \times \frac{1}{2}$	= +/- - X2
3	A3	B3	$(A3 - B3) \times \frac{1}{2}$	= +/- - X3
4	A4	B4	$(A4 - B4) \times \frac{1}{2}$	= +/- - X4
5	A5	B5	$(A5 - B5) \times \frac{1}{2}$	= +/- - X5
6	A6	B6	$(A6 - B6) \times \frac{1}{2}$	= +/- - X6

AXIS ALIGNMENT CHECK

- Plot the Following Points on A Graph Paper With A Suitable Scale
- Points 1,2,3,4,5 & 6 of Shell on Horizontal Axis
- Half the Difference obtained in Readings (+/- X1, X2, X3, X4, X5 & X 6) on Vertical Axis
- Mark A Best Fit Line Passing Through All The Points
- The Maximum Distance measured from the line in + or – is the maximum out of alignment in that orientation



SURFACE ALIGNMENT CHECK

- ROTATE THE SHELL ORIENTATIONS 0 – 180 HORIZONTALLY & 90-270 VERTICALLY
- PLACE A PAIR OF MAGNETS OF EQUAL HEIGHT AT BOTH ENDS OF THE SHELL AT 0° & 180°
- STRETCH TWINS BETWEEN THE TWO MAGNETS AT 0° & 180° ON BOTH SIDES
- MAINTAIN EQUAL DISTANCE AT BOTH ENDS OF THE SECTIONS BETWEEN HORIZONTAL TWINES AND SHELL SURFACE
- MEASURE PERPENDICULAR DISTANCE BETWEEN HORIZONTAL TWINES AND SHELL SURFACE AND RECORD THE READINGS.
- ROTATE THE JOB 90° AND REPEAT THE ABOVE MEASUREMENTS AT 90 & 270 ORIENTATION.
- SURFACE MISALIGNMENT = **MAXIMUM READING - MINIMUM READING.**

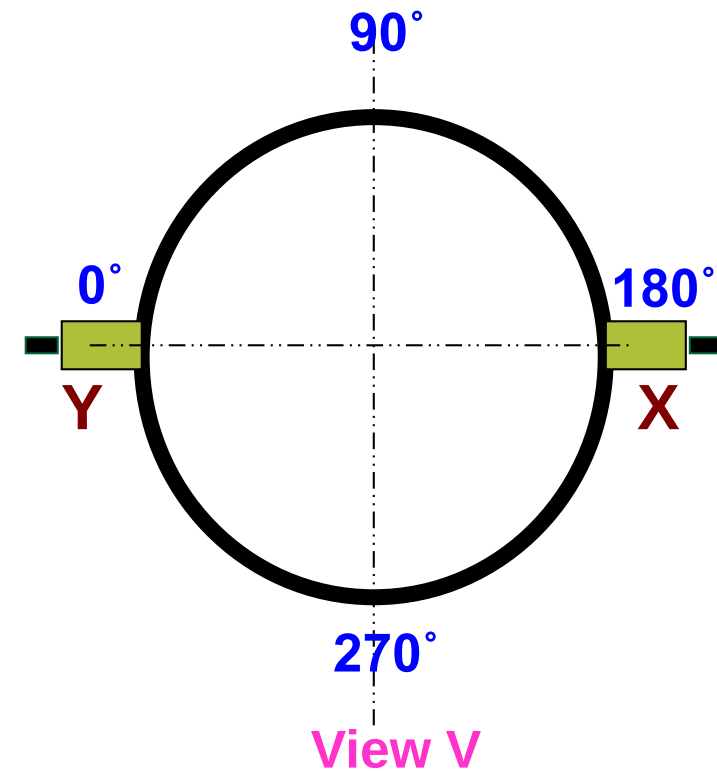
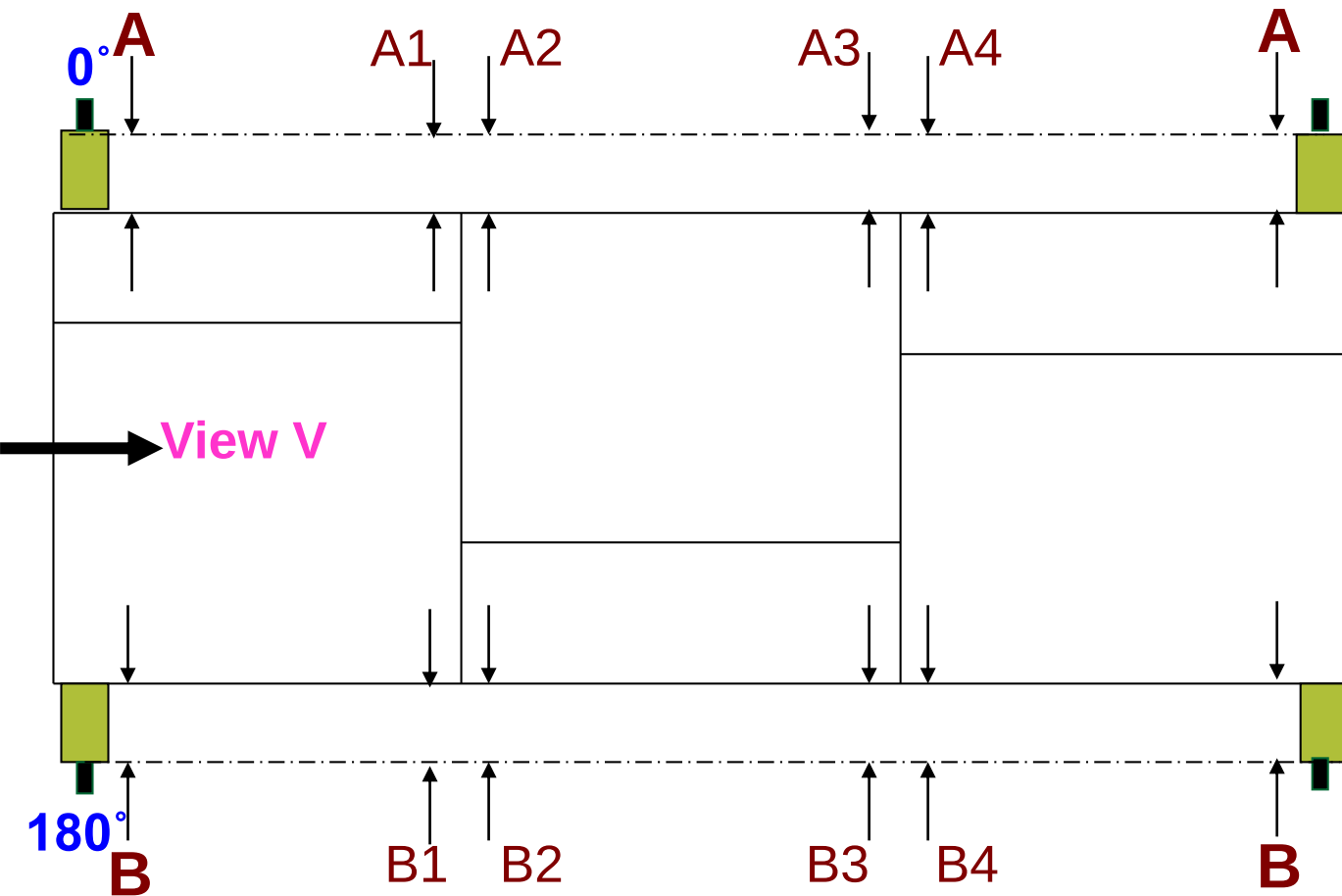
Orientation	Readings				Misalignment
0° - A	A1	A2	A3	A4	A Max – A Min
180° - B	B1	B2	B3	B4	B Max – B Min
90° - X	X1	X2	X3	X4	X Max – X Min
270° - Y	Y1	Y2	Y3	Y4	Y Max – Y Min

SURFACE ALIGNMENT CHECK

Misalignment Check At 0° & 180°

AT 0° = A Max – A Min

AT 180° = B Max – B Min

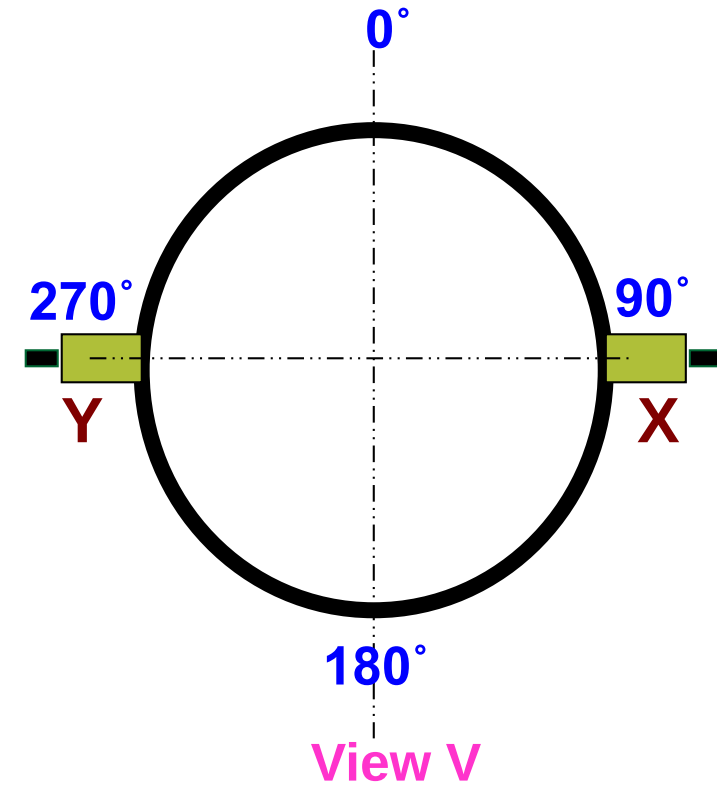
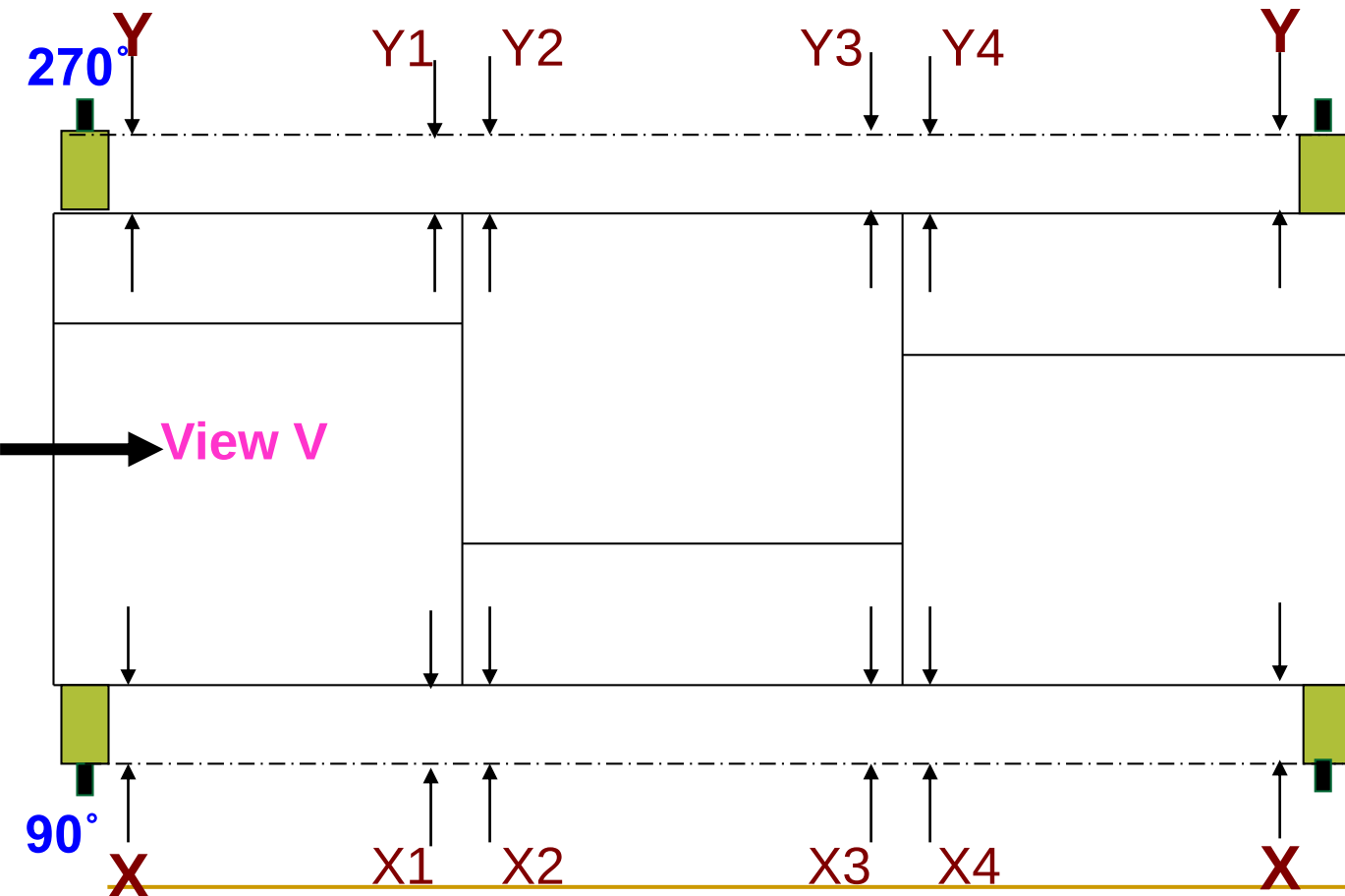


SURFACE ALIGNMENT CHECK

Alignment Check At 90° & 270°

AT 90° = X Max – X Min

AT 270° = Y Max – Y Min



TOLERANCES ON CIRC. OF SHELLS, D'ENDS , CONES & BELLOWS

- THE REQUIRED CIRCUMFERENCE SHALL BE COMPUTED BY THE FOLLOWING METHOD.

$$\text{REQUIRED CIRCUMFERENCE} = (ID + 2T) \times \pi$$

WHERE, I.D = INSIDE DIA. AS SPECIFIED IN DRAWINGS

T = ACTUAL THICKNESS MEASURED AT ENDS

PIE = VALUE OBTAINED FROM CALCULATOR

- MEASURE THE ACTUAL CIRCUMFERENCE ON THE JOB.
- ONLY CALIBRATED TAPES SHOULD BE USED FOR THE PURPOSE OF MEASUREMENT.
- COMPARE THESE TWO VALUES OF CIRCUMFERENCE AND CHECK THE ACCEPTABILITY BASED ON BELOW GIVEN TOLERANCE CHART.

TOLERANCE ON CIRCUMFERENCE

TOLERANCE ON CIRCUMFERENCE					
COMPONENTS	THICKNESS OF COMPONENTS IN MM				REMARKS
	UP TO 8	9 TO 18	19 TO 50	ABOVE 50	
ROLLED SHELLS AT L/S SET-UP STAGE	(+) 5 (-) 2	(+) 7 (-) 4	(+) 10 (-) 7	(+) 12 (-) 9	CIRCUM. TO BE CHECKED AT 3 LOCATIONS, 2 ENDS AND AT CENTRE
PRESSED / FORMED D'END, CONE & EXPANSION BELLOW AFTER COMPLETING WELD JOINT IF ANY	(+ / -) 5 (-0 / +10)**	(+ / -) 8 (-0 / +15)**	(+ / -) 10 (-0 / + 18)**	(+ / -) 15 (-0 / + 25)**	IF COMPONENT IS IN SET-UP STAGE WITHOUT WELDING PER JOINT 3MM SHRINKAGE SHALL BE ADDED TO BASIC CIRCUMFERENCE.

NOTES:

- THE ABOVE LIMITS ARE APPLICABLE ONLY IF NO OTHERS STRINGENT TOLERANCE IS SPECIFIED.
- ** THIS TOLERANCE IS APPLICABLE ONLY WHEN ABUTTING SHELLS HAS HIGHER THICKNESS WITH OUTSIDE TAPER AND INSIDE FLUSH.

REFERENCE LINE MARKING PROCEDURE

1 OPTICAL METHOD

2 PIN METHOD

DECIDING FACTORS

1. DIAMETER OF SHELL
2. THICKNESS OF SHELL
3. TOLERANCE ON TSR.

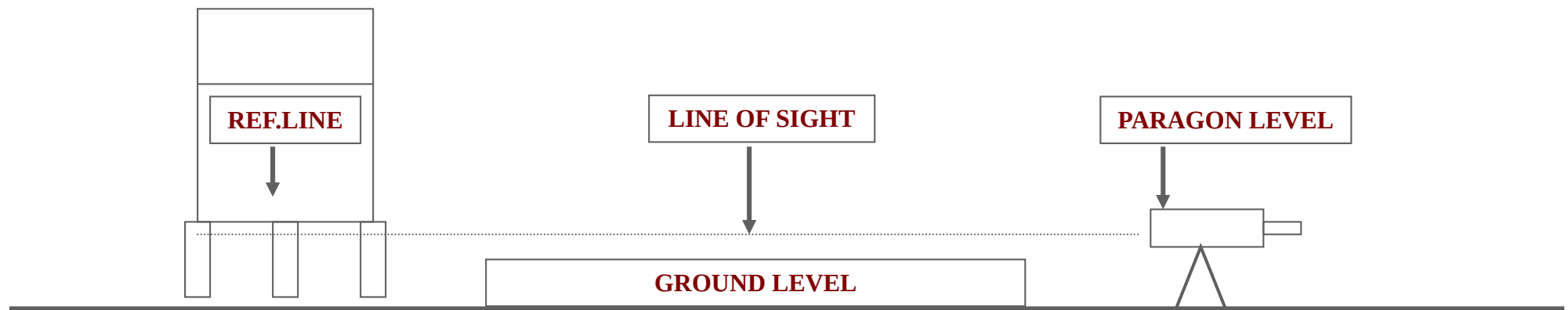
THE CHART BELOW RECOMMENDS THE METHOD (PIN OR OPTICS) TO BE FOLLOWED FOR MARKING THE REFERENCE LINE ON TOWERS WITH INTERNALS AS TSR

SHELL DIA	UP TO 3500		3500-4500		>4500	
**TOLERANCE ON TSR LEVEL WITHIN	>3	<, = 3	>3	<, = 3	>3	<, = 3
THICKNESS <, = 25	P	O	O	O	O	O
THICKNESS > 25	P	O	P	O	O	O

- **P** DENOTES PIN METHOD OF MARKING
- **O** DENOTES OPTICAL METHOD OF MARKING / MARKING ON MACHINE BED WITH SHELL AXIS VERTICAL.
- ** TOLERANCE ON TSR WITHIN 3 mm MEANS THAT THE SPECIFIED TOLERANCE IS ± 1.5 mm
- ALL DIMENSIONS ARE IN mm

REFERENCE LINE MARKING / CHECKING WITH OPTICAL INSTRUMENTS.

- PLACE THE SHELL WITH THE AXIS VERTICAL.
- THE BOTTOM EDGE OF THE SHELL SHALL BE AT LEAST 1 MT ABOVE THE GROUND LEVEL.
- SHELL OVALITY TO BE CORRECTED WITHIN **0.25 %** OF **I/D** AT BOTH THE ENDS USING SPIDERS.
- THE ALIGNMENT OF THE SHELL SHALL BE WITHIN **2 MM**. THIS IS TO BE ASCERTAINED BY DROPPING PLUMBS AT FOUR ORIENTATIONS **90 DEG.** APART.
- THE MARKING / CHECKING SHALL BE DONE ON SHELL **O/D** AS WELL AS **I/D** BY KEEPING THE PARAGON LEVEL OUTSIDE THE SHELL AS SHOWN BELOW



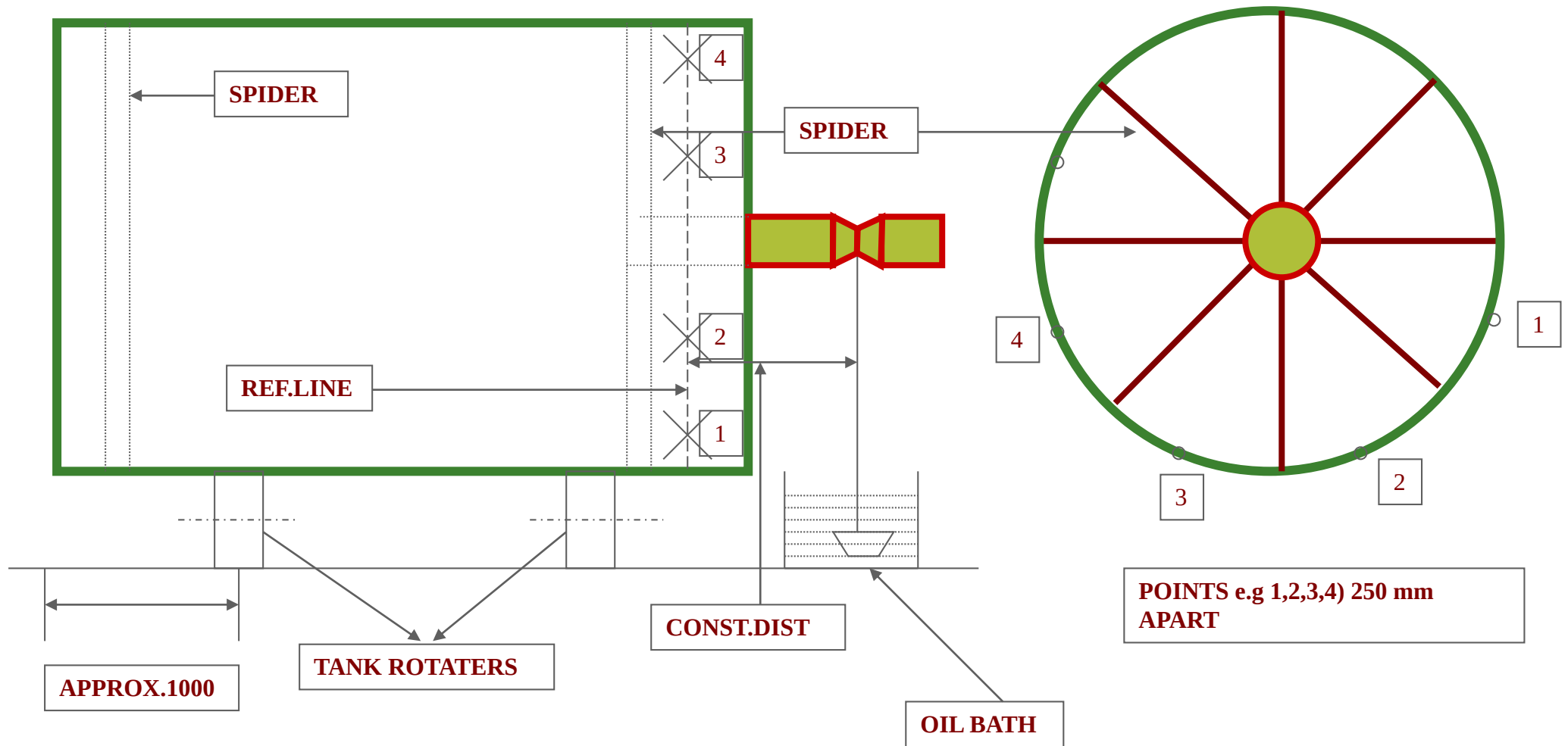
PROCEDURE FOR REFERENCE LINE MARKING BY PIN METHOD

- KEEP THE SHELL HORIZONTAL ON A PAIR OF TANK ROTATORS.
- CORRECT THE OVALITY TO 0.25 % BOTH ENDS.
- SPIDERS SHALL BE RIGID ENOUGH TO PREVENT BUCKLING.
- TACK WELD A PIN OF 10 DIA AT THE CENTRE OF THE SPIDER.
- THE PIN SHALL HAVE A MACHINED 'V' GROOVE FOR THE PLUMB.
- DROP A PLUMB ALONG THE GROOVE OF THE PIN.
- THE PLUMB IS TO BE SUSPENDED IN AN OIL BATH.

PROCEDURE FOR REFERENCE LINE MARKING BY PIN METHOD

- DIVIDE THE CIRCUMFERENCE OF SHALL APPROX. 250 mm APART ON **I/D** AND **O/D** AS SHOWN IN SKETCH.
- PUNCH MARK A CONSTANT DISTANCE FROM THE PLUMB ON **I/D** AND ON **O/D**
- JOIN THE PUNCH MARKS BY A FLEXIBLE STEEL RULE.
- MINIMUM **3 POINTS** ARE TO BE COVERED IN ONE SETTING OF SCALE
- ROTATE THE SHELL IN BOTH DIRECTIONS AND CONFIRM THE REFERENCE LINE MARKED ON **I/D & O/D**.
- WRITE THE REFERENCE LINE ELEVATION FROM **I/S & O/S** WITH PAINT.

PROCEDURE FOR REFERENCE LINE MARKING BY PIN METHOD



PROCEDURE FOR NOZZLE SET UP

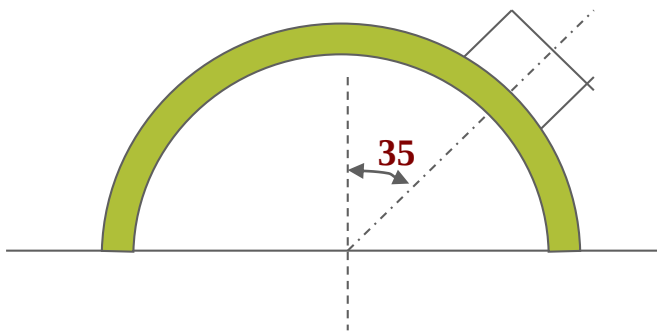
- Mark nozzle location on the shell surface with the required elevation and orientation
- Mark cut out circle with the required diameter
- Make the cut out and the weld edge preparation
- Clear NDT on WEP (PT, MT, UT) if applicable
- Set up the nozzle with the required height & within the tilt permissible
- Bolt holes on the nozzle flange shall straddle with vessel centre line
- Provide three temporary supports at equidistance
- Tack weld the nozzle in the grooves – Tack length 8 times the electrode diameter – Welding parameters as per SWP

INSPECTION PROCEDURE FOR NOZZLE SET UP

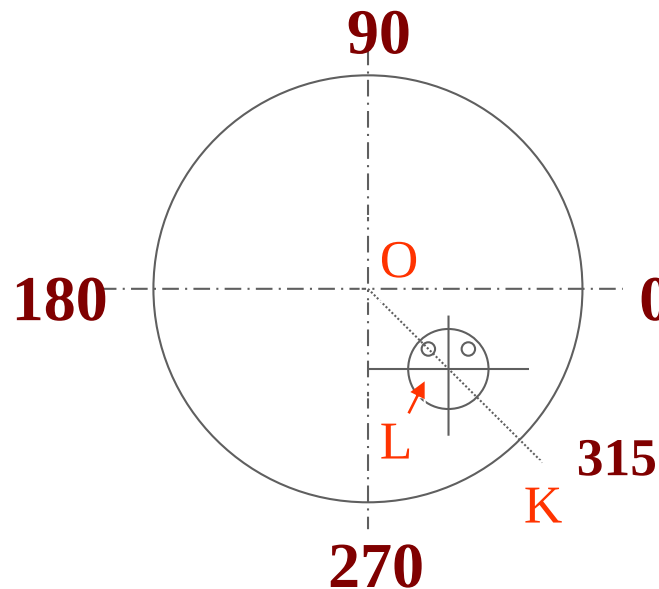
- Check & confirm the nozzle forging material is identified
- Check & confirm the gasket seating finish is as per drawing and free from any damage
- Measure and confirm orientation & elevation of nozzle location
- Check projection & Tilt of nozzle flange
- Inspect the tacks in the groove and make sure that they are free from visible defect

STRADDLING OF RADIAL NOZZLES ON D'ENDS

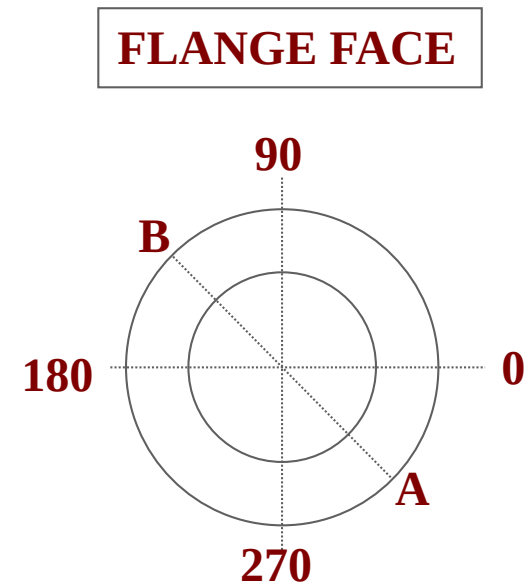
- NOZZLE INCLINED AT AN ANGLE OF 35 DEG. TO THE CENTRE LINE OF THE VESSEL (SEE SKETCH-1)
- ORIENTATION OF NOZZLE 315 DEGREES. (SEE SKETCH - 2)



SKETCH 1



SKETCH 2



SKETCH 3

STRADDLING OF RADIAL NOZZLES ON D'ENDS

- CHECK THE ORIENTATION MARKINGS & CENTRE POINT “O” ON THE D’END
- CALCULATE THE CIRCUMFERENTIAL DISTANCE FOR 45 DEG.(315-270 DEG.) AND MARK THE POINT “K” ON TAN LINE / EDGE OF D’END.
- CALCULATE THE CIRCUMFERENTIAL DISTANCE FOR 35 DEG BASED ON THE CROWN RADIUS AND MARK THE POINT “L” FROM D’END CENTRE “O”.
- MARK THE CUT OUT FOR NOZZLE ON D’END WITH “L” AS THE CENTRE.
- MAKE CUT OUT, WEP AND CLEAR NDT IF ANY ON THE WEP.
- DIVIDE FLANGE FACE INTO FOUR EQUAL QUADRANTS AND MARK THE CENTRE-LINES 0-90-180-270 ON THE FLANGE FACE. ALL FOUR LINES SHALL PASS THROUGH THE MIDPOINT OF TWO CONSECUTIVE BOLT HOLES
- MARK LINE A-B ON FLANGE FACE EQUALLY DIVIDING THE ANGLE 90 – 180 & 0-270.
- SET THE NOZZLE AT THE REQUIRED HEIGHT LEVEL ON D’END.
- SET THE FLANGE CENTRELINER ORIENTATIONS SUCH THAT THE LINE A-B MATCHES WITH THE LINE O-K ON D’END. THIS MAKES THE CENTRELINES ON D’END AND FLANGE FACE PARALLEL .

PROCEDURE FOR MEASURING DCBB DIMENSIONS

- CHECK OVALITY OF SECTION AT FOLLOWING PLACES

- a) OPEN END.

- b) 100 mm ON BOTH SIDE OF THE CIRCS. SEAMS.

- c) MIDDLE OF EACH SHELL COURSE.

- (OVALITY SHALL BE WITHIN 0.5 % OF THE NOMINAL DIAMETER.)

- INDIVIDUAL DCBB DIMENSIONS TO BE CONFIRMED BEFORE S/U .

- a) DCBB WIDTH, HEIGHT & THICKNESS.

- b) HOLE DIA. & NO. OF HOLES.

- c) HOLE TO EDGES DISTANCES.

- d) HOLE TO HOLE DISTANCES.

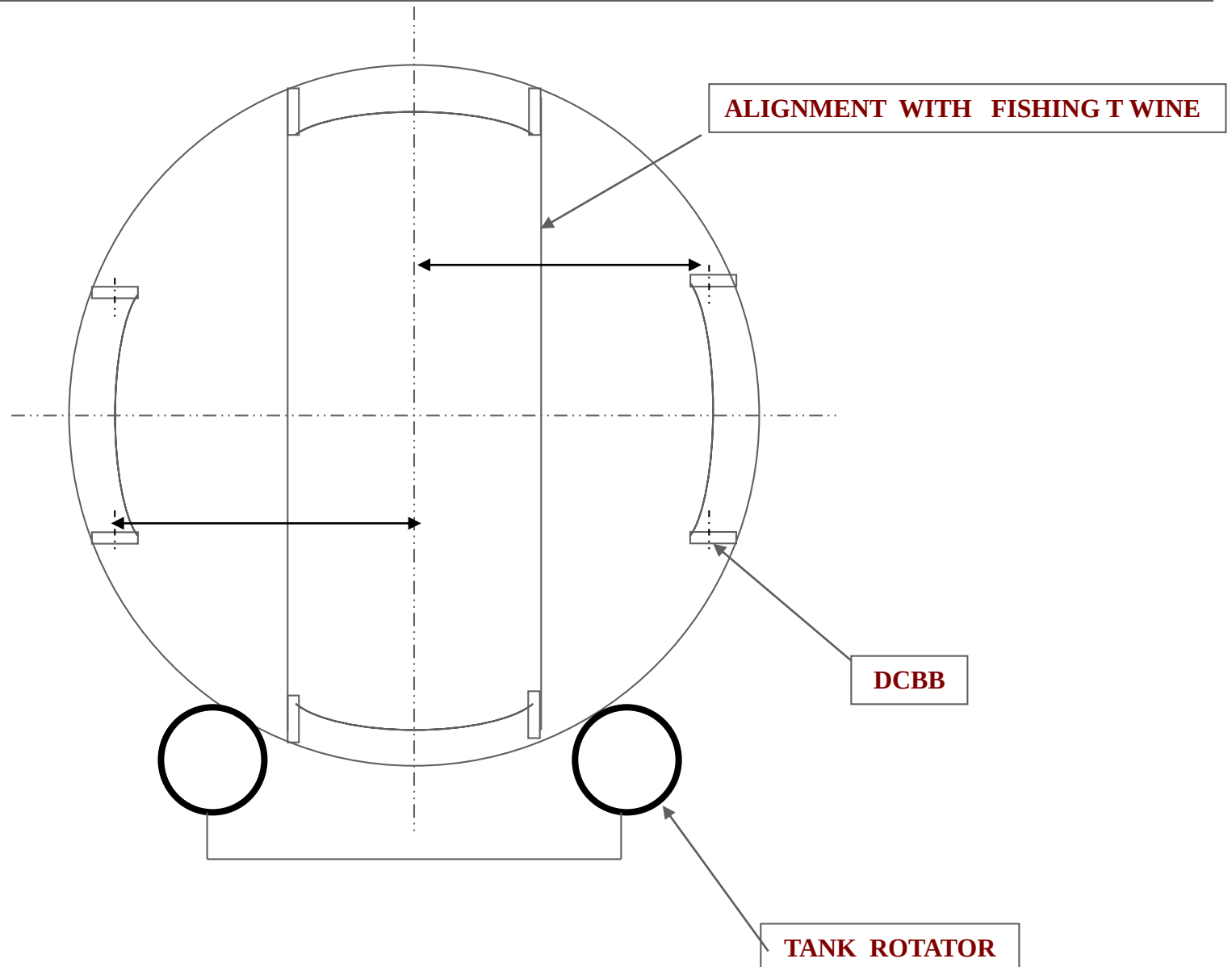
- e) DCBB ANGLE (IF APPLICABLE)

CHECK AND CONFORM TSR DIMENSIONS ARE WITHIN TOLERANCE.

PROCEDURE FOR MEASURING DCBB DIMENSIONS

- CHECK THE FILLET SIZE OF DCBB # SHELL & DCBB # TSR
- CHECK THE NDT OF DCBB # SHELL & DCBB # TSR
- CHECK THE CLEAN CORNER / NO WELD AREAS AS PER DRAWING
- CHECK ALL DRAWING DIMENSION OF DCBB AS SHOWN IN THE SKETCH.
- CHECK THE STRAIGHTNESS OF DCBB WITH 300mm LONG SCALE (IT SHALL BE WITHIN 1mm.)
- CHECK THE ALIGNMENT OF DCBB WITH FISHING TWINE AS PER SKETCH.

DCBB MEASUREMENT PROCEDURE



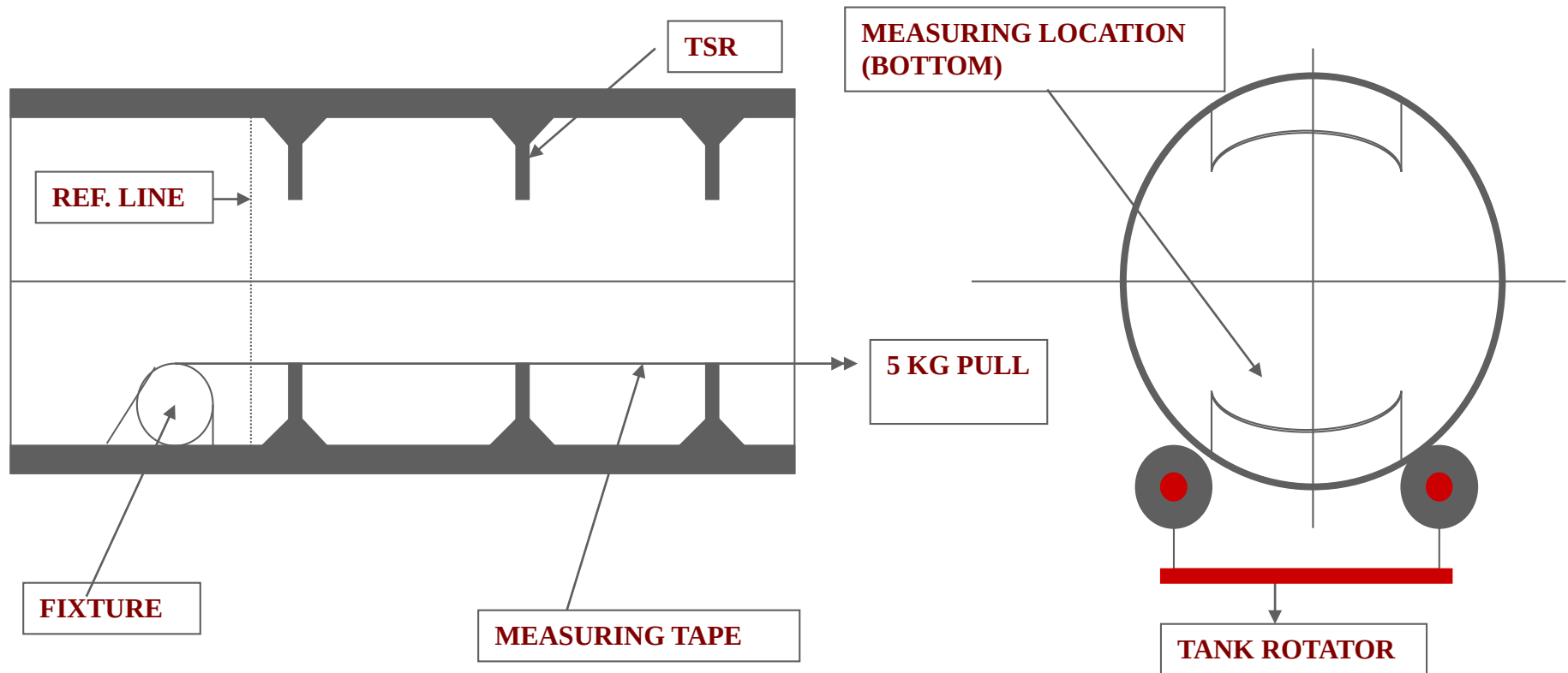
PROCEDURE FOR MEASURING TSR DIMENSIONS

- TAN LINE / REFERENCE LINE SHALL BE CONFIRMED BY INSPECTION.
- VERIFY TAN LINE / REFERENCE LINE ELEVATION.
- CLEAR WELD VISUAL INSPECTION OF TSR # SHELL WELD.
- CHECK FILLET SIZE OF TSR # SHELL JOINT AS PER DRAWING.
- CLEAR NDT OF TSR # SHELL SEAM..
- BUTT WELDS, IF ANY ON TSR SHALL BE GROUND FLUSH.
- DAMAGE IF ANY, ON TOP SURFACE OF TSR IS NOTICED, SAME SHALL BE WELD REPAIRED & FLUSH GROUND.
- CHECK THE TSR ELEVATION FROM TAN LINE / REFERENCE LINE
- USE ONLY CALIBRATED TAPE AND FIXTURE WITH SPRING BALANCE FOR MEASUREMENTS (ERROR TO BE ADDED / SUBTRACTED IN ALL MEASUREMENTS)

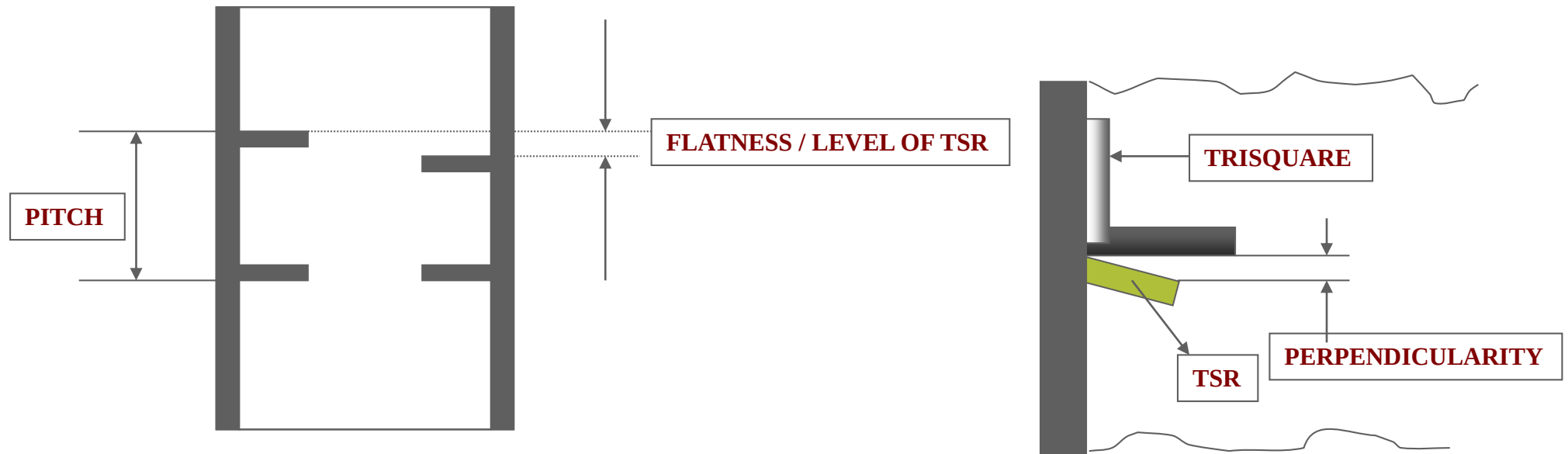
PROCEDURE FOR MEASURING TSR DIMENSIONS

- MEASURE THE TSR ELEVATION AT FOLLOWING LOCATIONS
 - a) MINIMUM TWO READINGS PER T.S.R. SEGMENT OF LENGTH < ONE METRE
 - b) FOR T.S.R. MORE THAN ONE METRE, MEASURE NEAR BOTH ENDS & EVERY ONE METRE FROM OPEN END. (i.e. ONE PASS, TWO PASS, OR FOUR PASS TRAY)
- CHECK THE FLATNESS OF TSR - (MAX. - MIN. READING IN ELEVATION IS THE TSR FLATNESS)
- CHECK THE PITCH BETWEEN THE ADJACENT TSR
- CHECK THE PERPENDICULARITY OF TSR
- CHECK THE STRAIGHTNESS WITH 300 mm LONG SCALE AND IT SHALL BE WITHIN 1mm

PROCEDURE FOR MEASURING TSR DIMENSIONS



PROCEDURE FOR MEASURING TSR DIMENSIONS



HEAT EXCHANGERS

TYPES OF SHELL & TUBE HEAT EXCHANGERS

- FIXED TUBE SHEETS
- FLOATING TUBE SHEET
- “U” BUNDLE WITH SINGLE TUBE SHEET

HEAT EXCHANGERS

FIXED TUBE SHEETS

- TWO TUBE SHEETS WITH TUBE BUNDLE ASSEMBLED IN BETWEEN, ARE FIXED TO BOTH ENDS OF THE SHELL.
- TUBE SHEETS ARE EITHER DIRECTLY WELDED TO SHELL OR BOLTED TO FLANGES WHICH ARE WELDED TO SHELL ENDS
- DIFFERENTIAL EXPANSION IF ANY, WILL DEVELOPE STRESSES IN TUBES & SHELL MATERIAL.
- TO TAKE CARE OF DIFFERENTIAL EXPANSION, SHELL MAY REQUIRE EXPANSION BELLOW .

HEAT EXCHANGERS

FLOATING HEAD TUBE SHEET

- ONE TUBE SHEET IS FIXED TO ONE END OF THE SHELL.
OTHER TUBE SHEET IS FLOATING WITHIN THE SHELL WITH A FLOATING HEAD COVER.
- THIS FACILITATES TUBES AND SHELL TO EXPAND
INDEPENDENTLY WITHOUT INDUCING ANY STRESSES
DUE TO DIFFERENTIAL EXPANSION.
- NO EXPANSION BELLOW IS REQUIRED ON SHELL TO TAKE
CARE OF DIFFERENTIAL EXPANSION

HEAT EXCHANGERS

“U” BUNDLE- KETTLE TYPE

- “U” BENT TUBE BUNDLE ASSEMBLED ON ONE TUBE SHEET.
- ASSEMBLED TUBE BUNDLE IS INSERTED IN THE SHELL.
TUBE SHEET IS BOLTED TO SHELL FLANGE.
- “U” TUBES CAN EXPAND FREELY INSIDE THE SHELL.
- NO STRESSES DUE TO DIFFERENTIAL EXPANSION
- NO EXPANSION BELLOW REQUIRED ON SHELL TO TAKE
CARE OF DIFFERENTIAL EXPANSION

HEAT EXCHANGERS

STANDARD CLASSIFICATION OF EXCHANGERS

TEMA CLASS – “R” “C” “B”

The Standard for Mechanical design and fabrication of unfired shell & tube heat exchangers specify by

- 1 TEMA Class “R” for severe requirements of petroleum / petroleum related application**
- 2 TEMA Class “C” for moderate requirements of Commercial and General process application**
- 3 TEMA class “B” for Chemical process service**

HEAT EXCHANGERS

COMPONENTS OF EXCHANGERS

Main Shell	Spacer Tube	Pass Partition Plate
Bonnet Shell	Tie Road	Jack Screw
Floating Head Cover	Girth Flange	Dowel Pin
Channel Shell / Header	Channel Caver	Expansion Bellow
Channel Shell Cover	Impingement Plate	Saddle / Skirt
Tubes/ Tube Bundle Straight Tube "U" Tube	Nozzle Inlet / Outlet Drain	Baffle Full size Segmental / Multi-segmental
Tube Sheet / Plate (With / without Cladding) Fixed TS Floating TS	Gasket CAF Jacketed Metallic Graphite	Hard Wear Studs & Bolts Nuts & Bolts Washers

HEAT EXCHANGERS

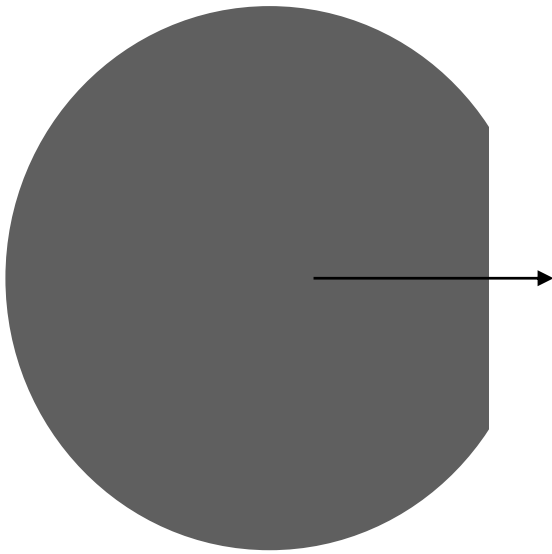
TYPE OF BAFFLES / SUPPORT PLATES

- **Single Segmental Baffle Cuts**
- **Multi - Segmental Baffle Cuts**
 - Double Segment
 - Triple Segment

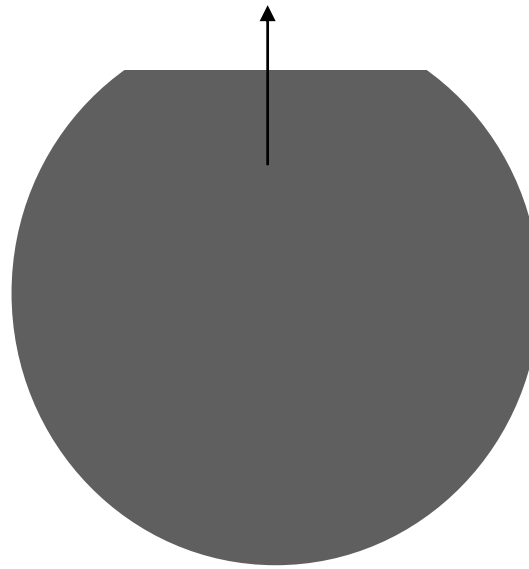
HEAT EXCHANGERS

TYPE OF BAFFLES / SUPPORT PLATES

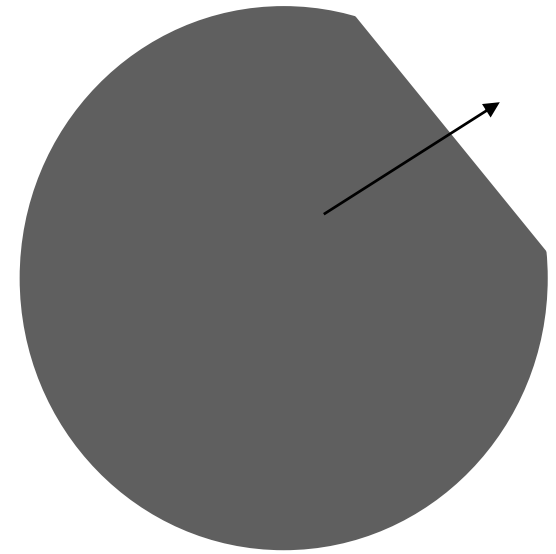
SINGLE SEGMENTAL BAFFLE CUTTS



VERTICAL



HORIZONTAL

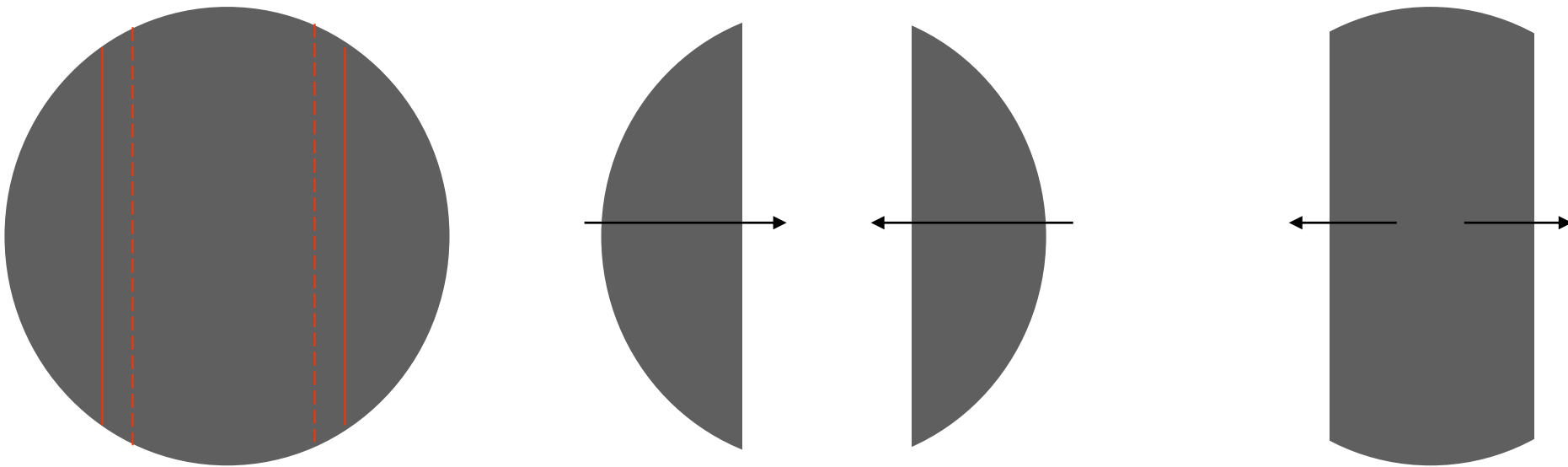


ROTATED

HEAT EXCHANGERS

TYPE OF BAFFLES / SUPPORT PLATES

MULTI - SEGMENTAL BAFFLE CUTTS

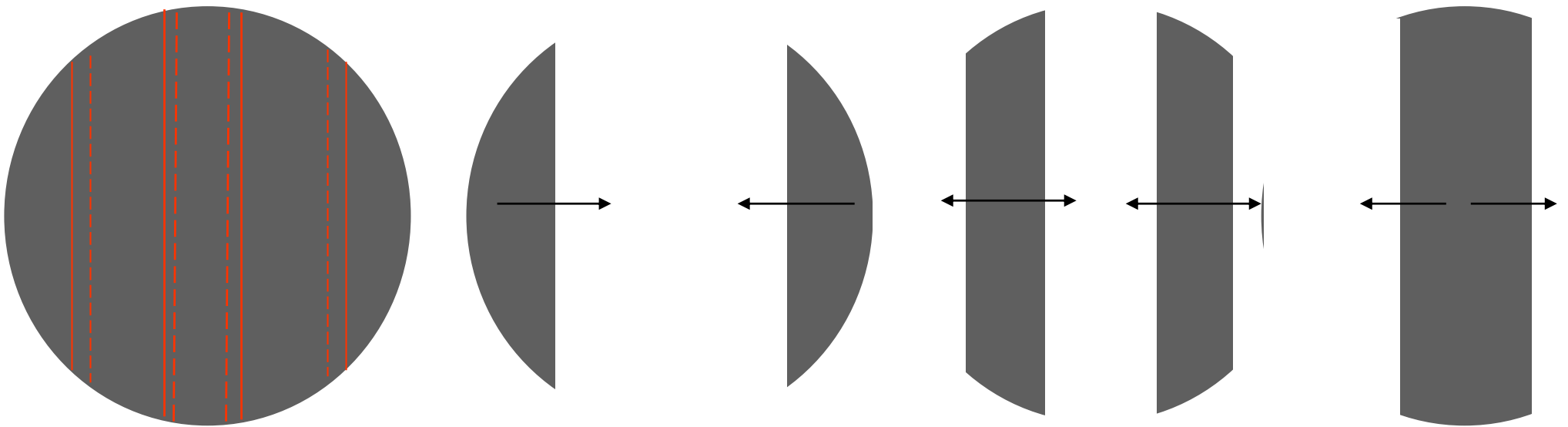


DOUBLE SEGMENTAL CUTTS

HEAT EXCHANGERS

TYPE OF BAFFLES / SUPPORT PLATES

MULTI - SEGMENTAL BAFFLE CUTTS



TRIPLE SEGMENTAL CUTTS

HEAT EXCHANGERS

Number Of Passes Fluids Flow Through Tube Holes

Single Pass

Double Pass

Four Pass / Multi - Pass

HEAT EXCHANGERS

TUBE HOLE DIAMETERS & TOLERANCES IN MM. TABLE RCB 7.41

Nominal Tube O/D	Nominal Tube Hole Diameter & Under Tolerance				Over Tolerance: 96% of Tube holes to meet Column (c) value, Remaining not to exceed column (d) value	
	Standard Fit – (a)		Special Close Fit – (B)			
	Nominal Diameter	Under Tolerance	Nominal Diameter	Under Tolerance	(C)	(D)
6.4	6.58	0.10	6.53	0.05	0.05	0.18
9.5	9.75	0.10	9.70	0.05	0.05	0.18
12.7	12.95	0.10	12.90	0.05	0.05	0.20
15.9	16.13	0.10	16.08	0.05	0.05	0.25
19.1	19.30	0.10	19.25	0.05	0.05	0.25
22.2	22.48	0.10	22.43	0.05	0.05	0.25
25.4	25.70	0.10	25.65	0.05	0.05	0.25
31.8	32.11	0.15	32.03	0.08	0.08	0.25
38.1	38.56	0.18	38.46	0.08	0.08	0.25
50.8	51.36	0.18	51.26	0.08	0.08	0.25

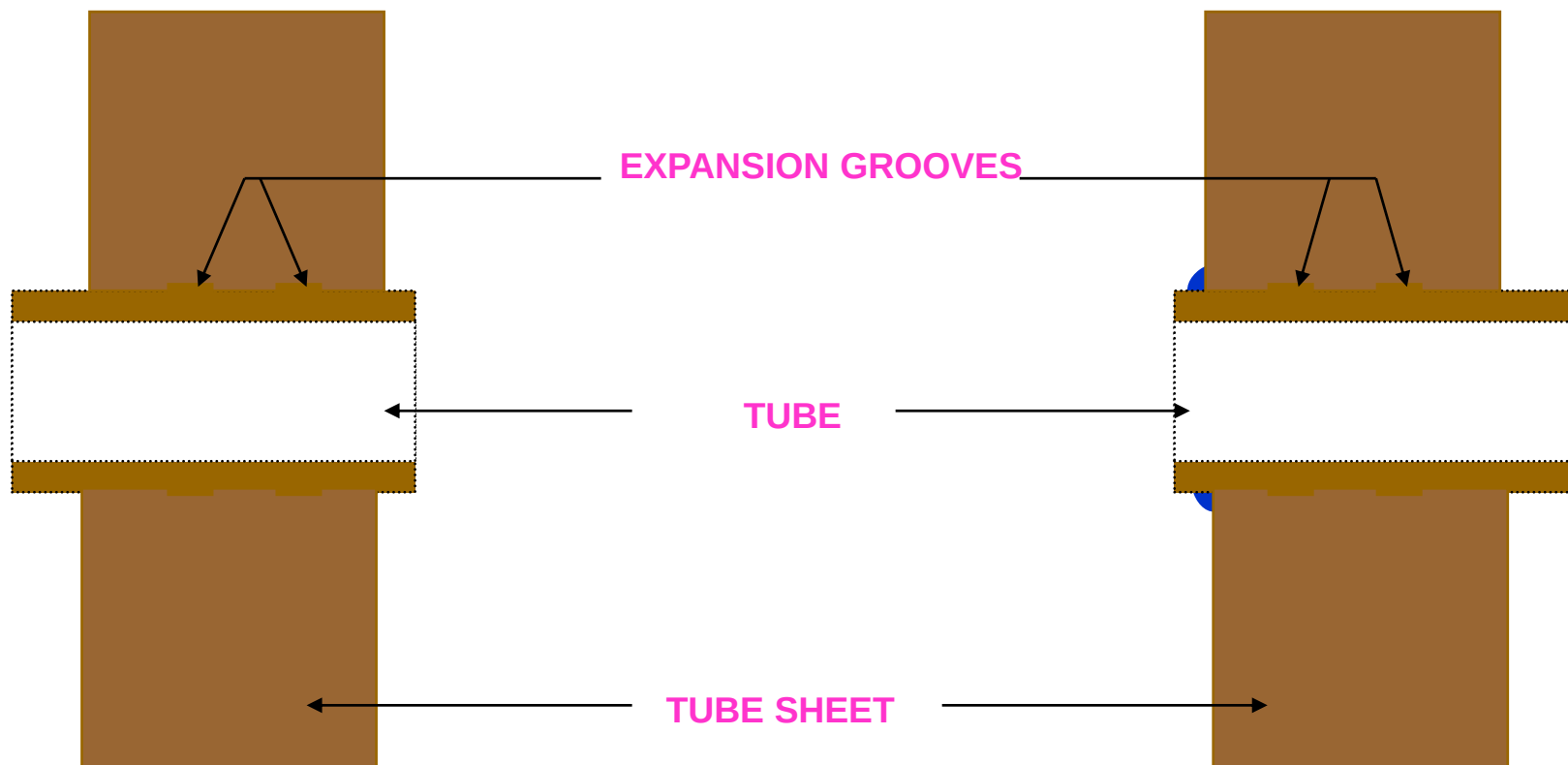
HEAT EXCHANGERS

Various Types Of T # TS Joints

- **Strength Expanded – Exp. Grooves in Tube holes**
- **Strength Expanded – Without Exp. Grooves in Tube holes**
- **Seal Welded & Strength Expanded (With or Without Expansion Grooves)**
- **Strength Welded (Groove Weld Joint) & Light Expanded**

HEAT EXCHANGERS

Various Types Of T # TS Joints

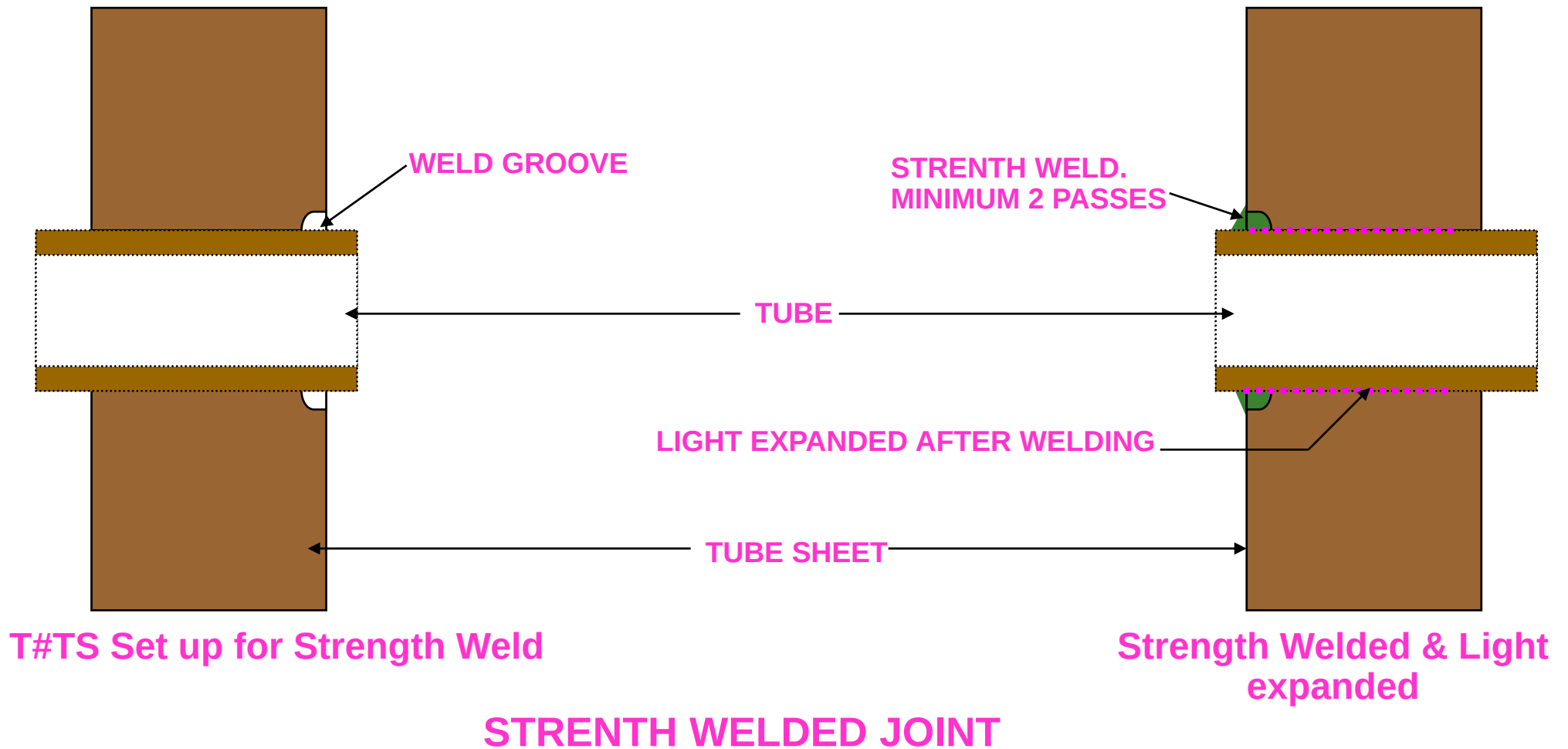


EXPANDED JOINT

EXPANDED & SEAL WELDED JOINT

HEAT EXCHANGERS

Various Types Of T # TS Joints



HEAT EXCHANGERS

TUBE HOLE GROOVING REQUIREMENT – RB 7.44

- Tube holes with expanded joints with tubes 15.9 mm and above O/D, shall be machined with at least two grooves
 - Tube sheets with thickness less than 25.4 mm may be provided with single groove
 - Groove dimensions shall be 3.2 mm wide & 0.4 mm deep.
 - When Hydraulic Expansion is used, groove width shall be 6.4 mm
 - When Clad Tube sheets are used, all expansion grooves shall remain within the base metal unless otherwise specified by the customer.
 - Strength Welded tubes do not require expansion grooves.
-

HEAT EXCHANGERS

TUBE HOLE GROOVING REQUIREMENT – RB 7.44



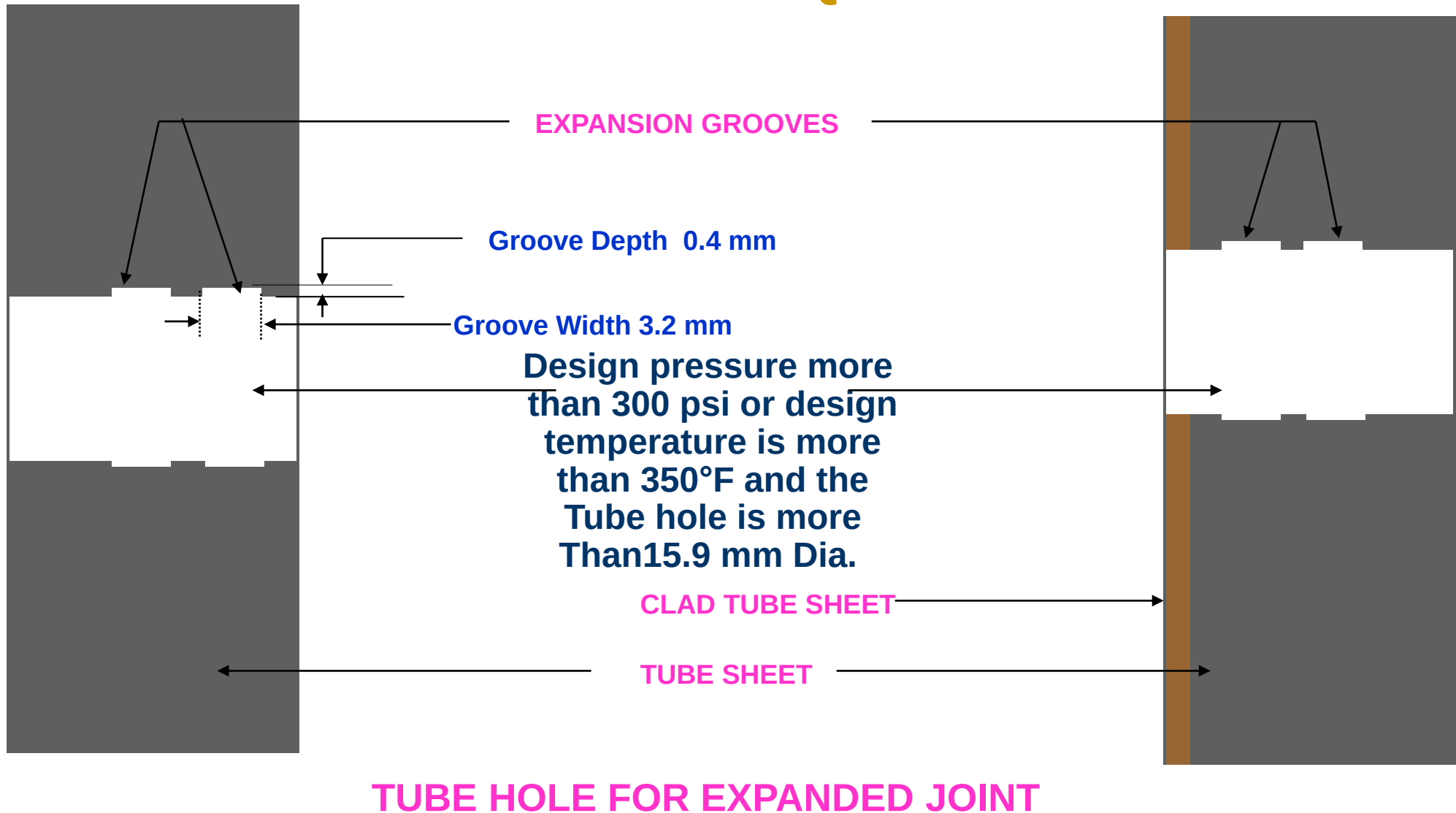
HEAT EXCHANGERS

TUBE HOLE GROOVING REQUIREMENT – C- 7.44

- Tube holes with expanded joints with tubes 15.9 mm and above O/D, shall be machined with at least two grooves when design pressure is over 300 psi (2068kpa) and / or design temperature is in excess of 350°F (177°C)
 - Tube sheets with thickness less than 25.4 mm may be provided with single groove
 - Groove dimensions shall be 3.2 mm wide & 0.4 mm deep.
 - When Hydraulic Expansion is used, groove width shall be 6.4 mm
 - When Clad Tube sheets are used, all expansion grooves shall remain within the base metal unless other wise specified by the customer.
-
- Strength Welded tubes do not require expansion grooves.

HEAT EXCHANGERS

TUBE HOLE GROOVING REQUIREMENT – C- 7.44



HEAT EXCHANGERS

Various Leak Tests Of T # TS Joints

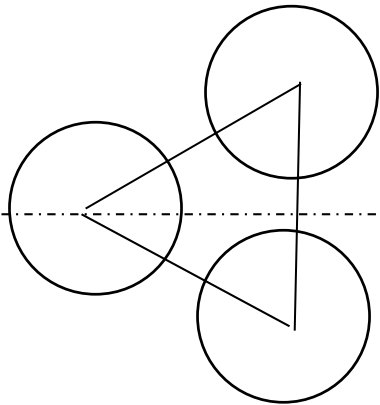
- Air & Soap Solution Test
- Halogen Leak Test
- Helium Leak Test
- Hot Oil Tests
- Kerosene Leak Test

~~Hydrostatic Pressure Test Can Also Reveal Leakage~~

HEAT EXCHANGERS

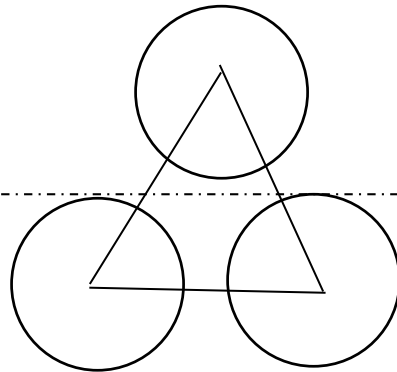
TUBE PETERN

30°



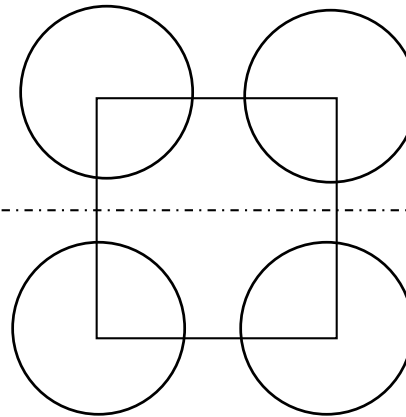
TRIANGULAR

60°



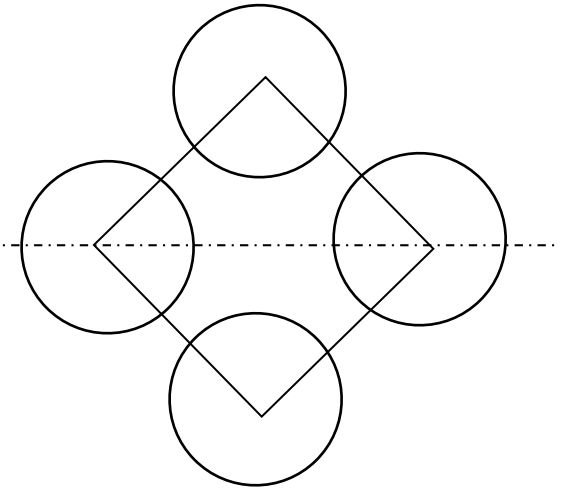
ROTATED
TRIANGULAR

90°



SQUARE

45°



ROTATED
SQUARE

HEAT EXCHANGERS

TWO DIFFERENT SEGMENTS IN OPERATION

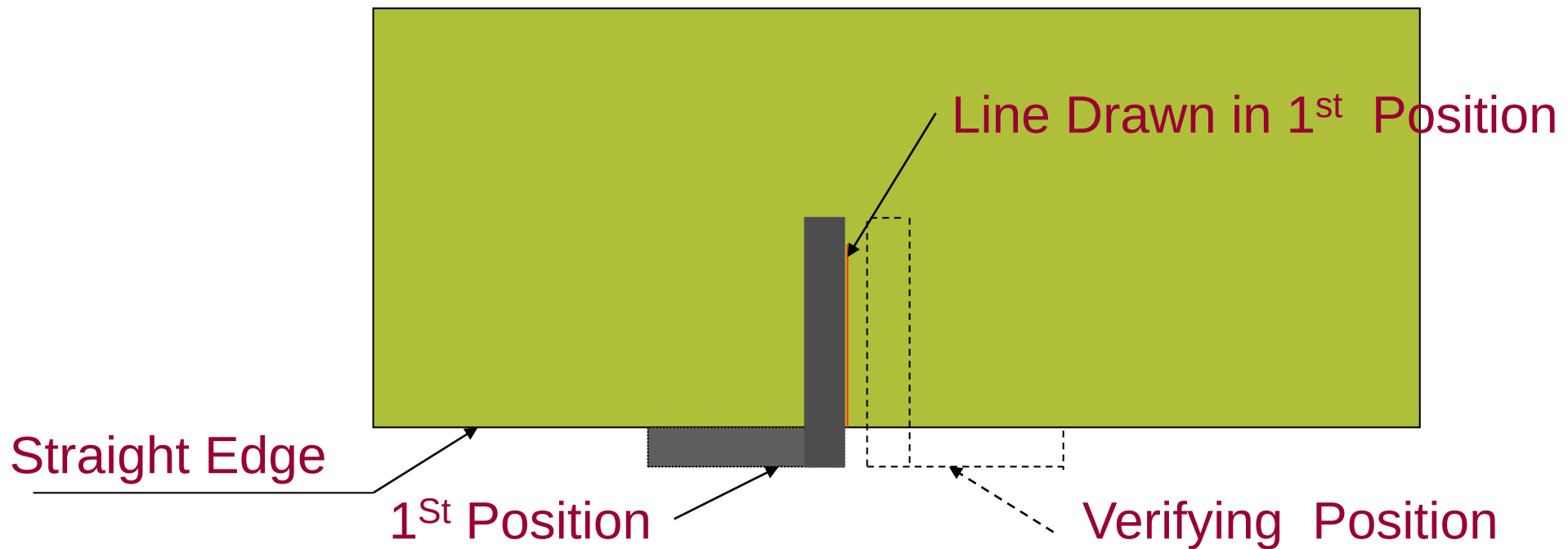
- 1 SHELL SIDE – TOTAL SHELL VOLUME EXCLUDING TUBE BUNDLE**
- 2 TUBE SIDE (CHANNEL SIDE) – TOTAL TUBE VOLUME INCLUDING CHANNEL INSIDE CONNECTED TO TUBES**

VERIFICATION OF INSPECTION TOOLS



VERIFICATION OF INSPECTION TOOLS

Verification Of Try square



VERIFICATION OF INSPECTION TOOLS

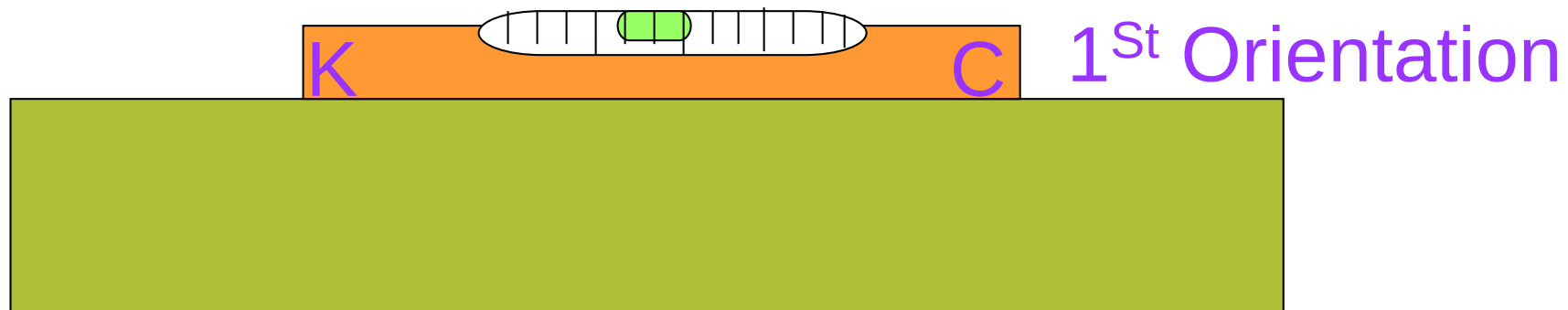
Verification Of Straight Edge



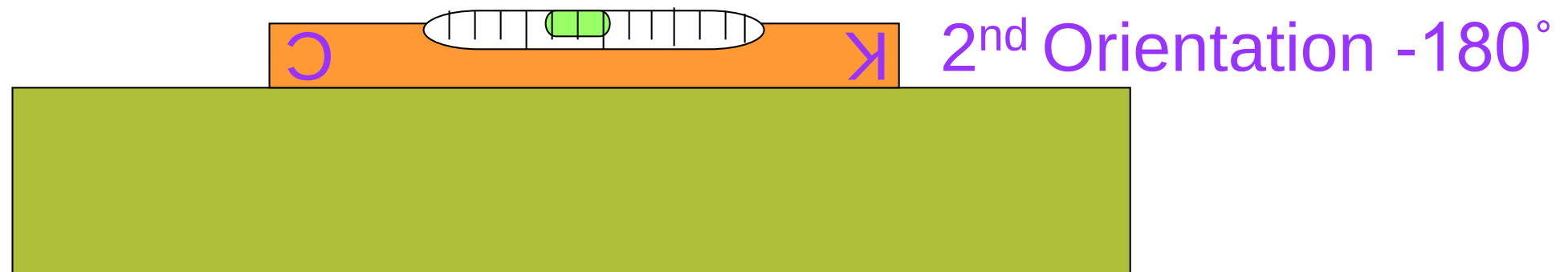
Look For Gap In Between The Two Edges

VERIFICATION OF INSPECTION TOOLS

Verification Of Spirit Level



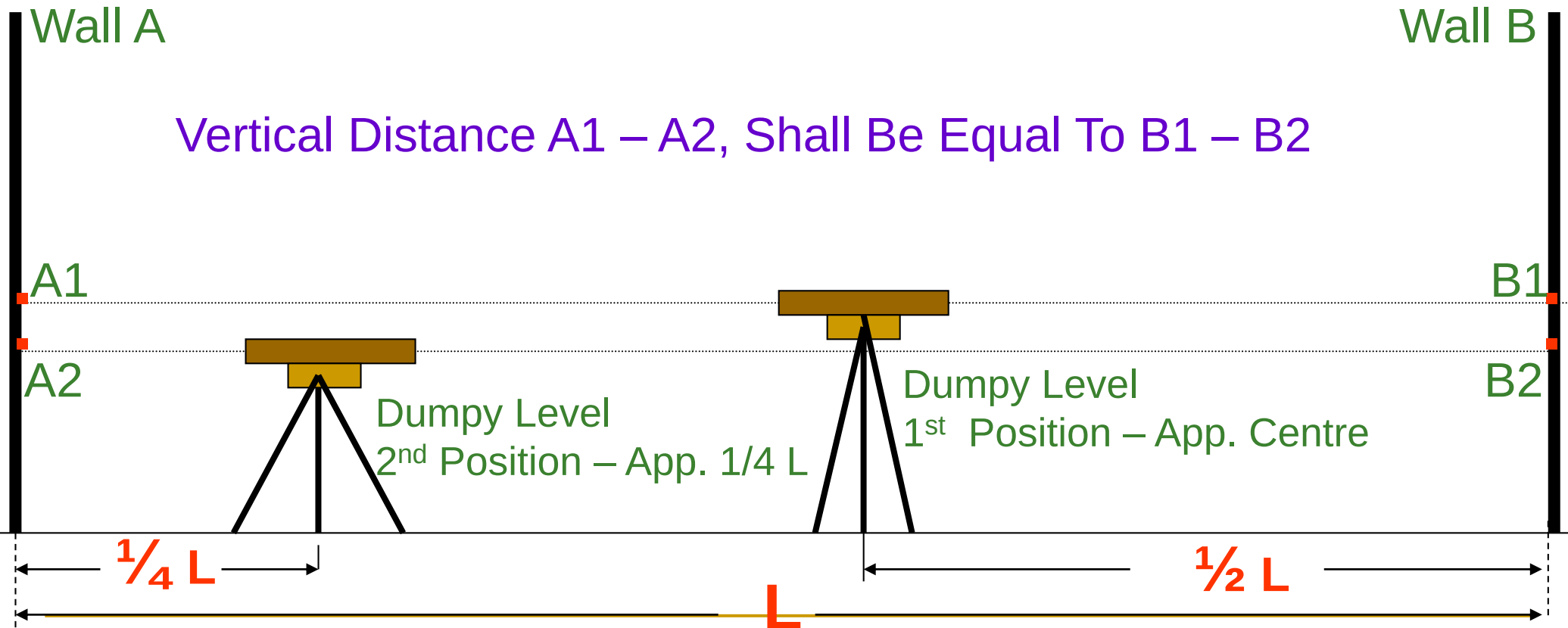
Spirit Level Location On the Job Shall Remain Same



Bubble Position In Spirit Level Shall Remain Same

VERIFICATION OF INSPECTION TOOLS

Verification Of Optical Instrument – Dumpy Level



PRESSURE TEST

- 1 Most Important Inspection stage
- 2 Ascertains Integrity Of Full Equipment
- 3 Testing Media – Water (Air May be Used With restrictions)
- 4 Testing Position As Stated In Drawing
- 5 Test Pressure & Testing Media As Given In Drawing

TEST PRESSURE

HYDROTEST PRESSURE AS PER ASME Sec. VIII Div 1 – UG 99

- Design Pressure $\times 1.3 \times$ Ratio of Stress Value of Material at Test Temperature to Design Temperature

PNEUMATIC TEST PRESSURE AS PER ASME Sec. VIII Div 1 – UG 100

- Design Pressure $\times 1.1 \times$ Ratio of Stress Value of Material at Test Temperature to Design Temperature

TEST PRESSURE

HYDROTEST PRESSURE AS PER ASME Sec. VIII Div 2 , AT-300

- Design Pressure $\times 1.25 \times$ Ratio of Stress Value of Material at Test Temperature to Design Temperature

PNEUMATIC TEST PRESSURE AS PER ASME Sec. VIII Div 2 , AT-400

- Design Pressure $\times 1.15 \times$ Ratio of Stress Value of Material at Test Temperature to Design Temperature

HYDROTEST

ENSURE FOLLOWING PRIOR TO WATER FILLING

1. COMPLETION OF WELDING ON PRESSURE PARTS
2. COMPLETION OF ALL NDT TO THE ACCEPTABLE STAGE
3. CLEARANCE OF ALL PENDING NCR / DCR, IF ANY.
4. FINAL CLEARANCE OF MATERIAL CLEARED PROVISIONALLY
5. TESTING OF P TC / MTC, IF ANY, TO THE ACCEPTABLE TEST RESULTS
6. ALL DIMENSIONAL CHECK WITHIN THE ACCEPTABLE LIMIT

HYDROTEST

ENSURE FOLLOWING PRIOR TO WATER FILLING

- 7 VESSEL IS KEPT ON HYDRO TEST SADDLES IN THE SPECIFIED ORIENTATION AS PER THE DRG. ISSUED BY DESIGN DEPT.
- 8 ALL LONG SEAMS & CIRC. SEAMS ARE MADE VISIBLE FOR INSPECTION.
- 9 IF JOB IS PRIMER COATED, ALL PRESSURE WELD JOINTS ARE CLEANED FREE FROM PAINT.
- 10 GASKETS & GASKET SEATINGS ARE CHECKED FOR ANY DAMAGE

HYDROTEST

ENSURE FOLLOWING PRIOR TO WATER FILLING

- 11 INSIDE SURFACE IS CLEANED
- 12 AIR VENTING ARRANGEMENTS ARE DONE INSIDE WHEREVER REQUIRED
- 13 JOB HARDWARES & GASKETS SHOWN IN DRAWING ARE ASSEMBLED EXCEPT HARDWARES SPECIFIED FOR HYDROTEST.
- 14 ALL FASTENERS ARE TIGHTENED TO REQUIRED TORQUE
- 15 ALL OPENINGS ARE CLOSED EXCEPT TOP ONE FOR FILLING WATER.

HYDROTEST

ENSURE FOLLOWING PRIOR TO WATER FILLING

- 16 ARRANGEMENT FOR PRESSURISING SHALL BE THROUGH ONE OF THE NOZZLES FROM BOTTOM
- 17 SQUARE BAR ARRANGEMENTS ON INLET AND OUT LET CONNECTIONS.
- 18 ARROW FOR DIRECTION OF WATER FLOW ON FITTINGS TO BE VERIFIED & CONFIRMED
- 19 TWO PRESSURE GAUGES OR ONE PRESSURE GAUGE AND ONE TRANSDUCER TO BE MADE AVAILABLE.
- 20 THE UPPER RANGE OF GRADUATIONS ON GAUGES - TWICE THE TEST PRESSURE (1.5 TO 4 TIMES THE TEST PRESSURE).

HYDROTEST

ENSURE FOLLOWING PRIOR TO WATER FILLING

- 21 GAUGES & TRANSDUCERS SHALL BE CALIBRATED WITH CALIBRATION STICKER
- 22 PPM REQUIREMENT OF TEST WATER SHALL BE VERIFIED AND CONFIRMED.
- 23 HYDROTEST PUMP (HIGH PRESSURE – LOW DISCHARGE OR LOW PRESSURE - HIGH DISCHARGE SHALL BE MADE AVAILABLE
- 24 HIGH DISCHARGE PUMPS SHALL NOT BE USED FOR VESSELS WITH VOLUM BELOW 10 CUB.MTR

HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

1. WATER SHALL BE FILLED FROM TOP NOZZLE AND CLOSED WITH TEST BLANK.
2. TEST BLANK SHALL BE WITH NIPPLE, SQUARE BAR, PRESSURE GAUGE AND PIPE CONNECTION FOR VENTING.
3. INLET VALVE SHALL REMAIN CLOSED TILL WATER FILLING
4. AFTER BLANKING THE TOP NOZZLE WITH GAUGE AND VENT PIPE, WATER SHALL BE PUMPED FROM BOTTOM

HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

5. VENT PIPE SHALL BE KEPT OPEN IN A BUCKET FULL OF WATER TO OBSERVE AIR BUBLES.
6. VENTING SHALL BE CONTINUED TILL THE AIR BUBLES IN THE BUCKET IS DISAPEARED.
7. CLOSE THE OUT LET VALVE ON TOP & CONNECT THE GAUGE TO LINE PRESSURE.
8. ISOLATE THE GAUGE AT THE BOTTOM FROM LINE PRESSURE AND PUMP THE WATER IN.
9. RAISE THE PRESSURE TILL 50% OF TEST PRESSURE.

HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

10. OPEN THE INLET GAUGE TO PRESSURE LINE AND VERIFY THE PRESSURE ON BOTH GAUGES.
11. INCREASE THE PRESSURE IN INCREMENTS OF 10% OF TEST PRESSURE
12. STOP PUMPING FOR 5 MINUTES AFTER EACH INCREMENT OF 10% OF RISE IN PRESSURE.
13. ISOLATE THE INLET PRESSURE GAUGE WHEN PUMP IN OPERATION.

HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

14. CONNECT THE INLET PRESSURE GAUGE TO LINE PRESSURE WHEN PUMP IS STOPPED FOR PRESSURE VERIFICATION
15. WHEN TEST PRESSURE IS REACHED, STOP PUMPING, CONNECT INLET GAUGE TO PRESSURE LINE AND HOLD FOR 30 MIN (AS SPECIFIED IN SPEC) AND OBSERVE THE VESSEL FROM DISTANCE.
16. FOR Sec. VIII Div.1 JOBS, REDUCE THE TEST PRESSURE TO ABOVE DESIGN PRESSURE AND INSPECT ALL CONNECTIONS FOR LEAKAGE. UG99 (g)

HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

17. FOR Sec. VIII Div. 2 JOB, REDUCE THE TEST PRESSURE TO DESIGN PRESSURE OR 3/4th TEST PRESSURE WHICHEVER IS MORE AND INSPECT ALL CONNECTIONS FOR LEAKAGE . AT-355
18. IF ANY LEAKAGE IS OBSERVED THROUGH GASKET CONNECTION, REPEAT THE TEST AFTER DEPRESSURISE THE VESSEL & TIGHTEN THE STUDS / NUTS.

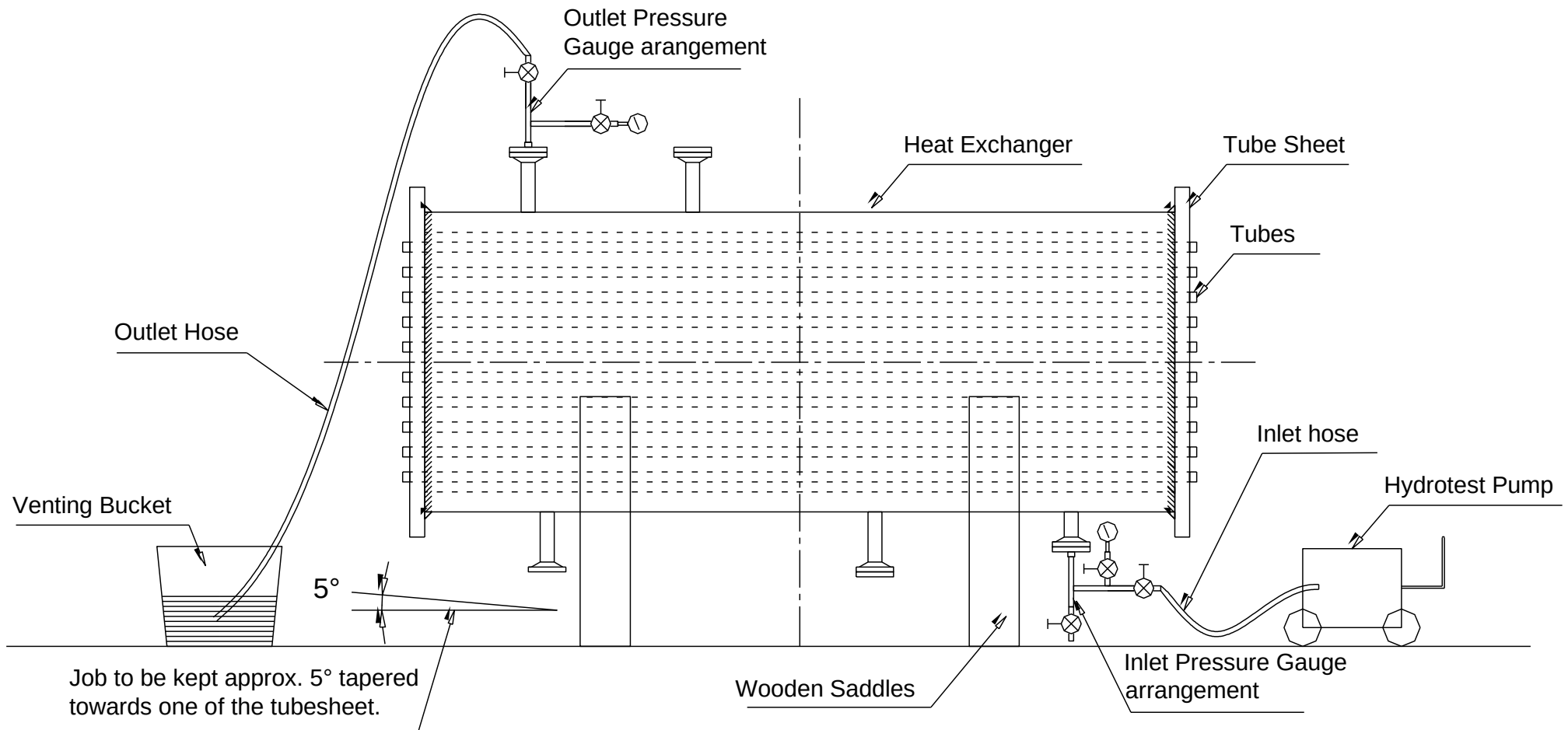
HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

19. IF ANY LEAKGE IS OBSERVED FROM WELD OR PARENT METAL, DRAIN THE WATER, REPAIR THE LEAK AND REPEAT THE TEST
20. TIME, TEMPERATURE & PRESSURE CHART WHEREVER SPECIFIED SHALL BE OBTAINED

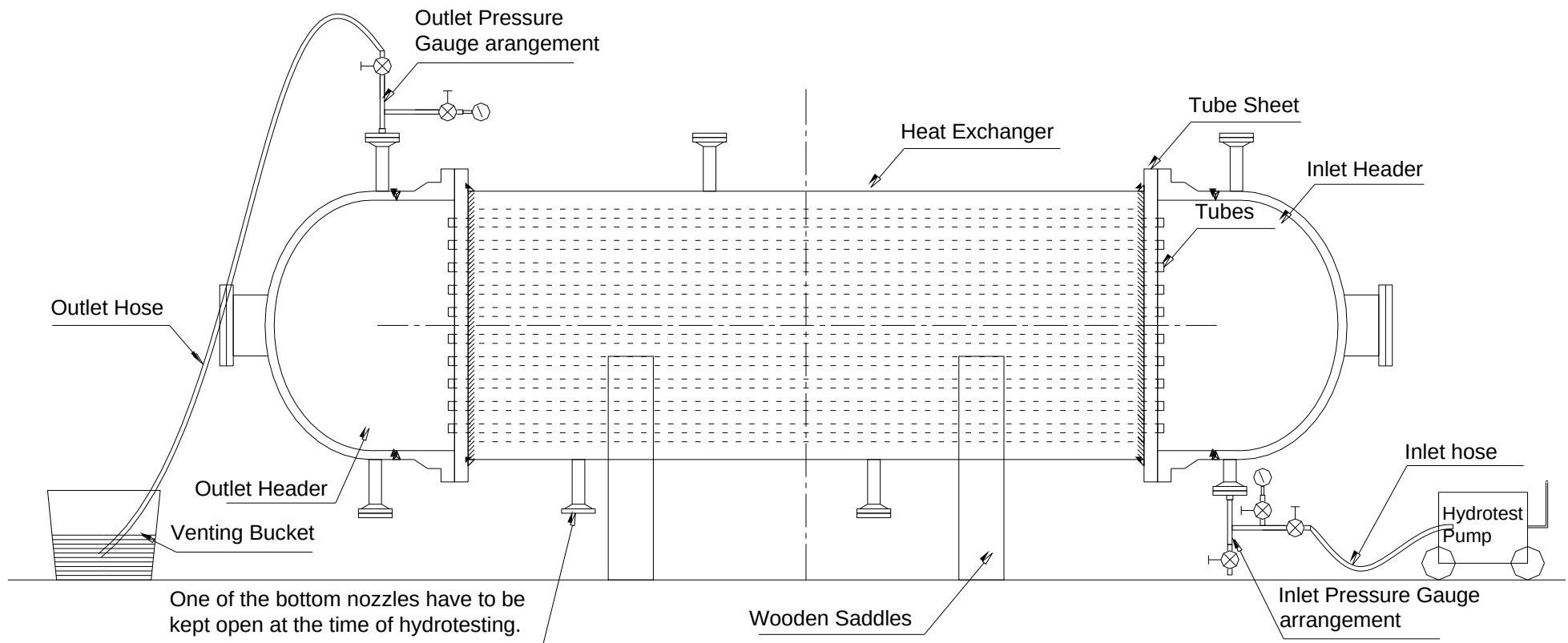
HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION



HYDROTEST

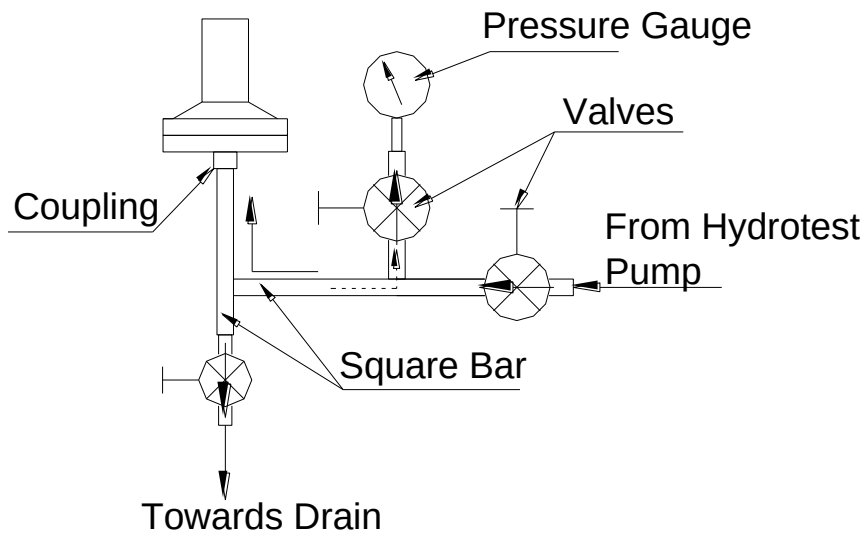
WATER FILLING, PRESSURISING & INSPECTION



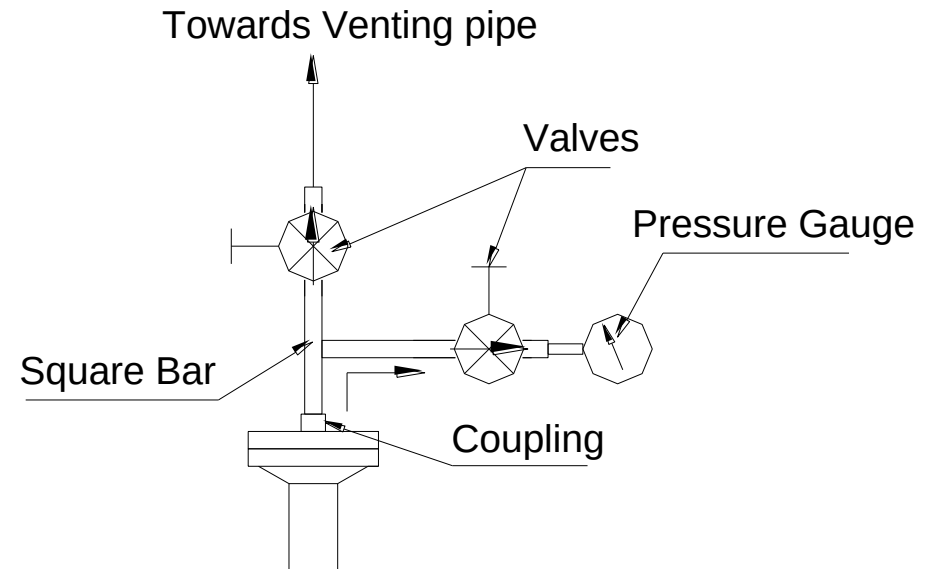
HYDROTEST

WATER FILLING, PRESSURISING & INSPECTION

Arrangement for Inlet Pressure Gauge



Arrangement for Outlet Pressure Gauge



HYDROTEST

IMPORTANT SAFETY POINTS IN HYDROTEST

- DRAIN THE VESSEL ONLY WHEN TOP OUT LET IS KEPT OPEN
- USE MINIMUM 2 GAUGES FOR ANY HYDROTEST
- NEVER USE HIGH DISCHARGE PUMPS FOR TESTING LOW VOLUM VESSELS. (VOLUM LESS THAN 10 M³).
- NEVER PRESSURISE ANY VESSEL ABOVE TEST PRESSURE
- DO NOT KEEP THE VESSEL UNDER HOT SUN WITH TEST PRESSURE FOR LONG