

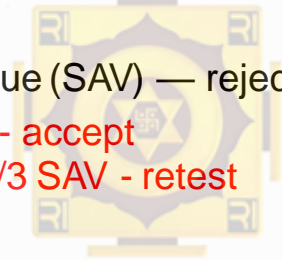
# API 653 Points to Remember

(Day 2)

PREPARED BY

RITABRATA INDUSTRIES

1. API 653 is code used for inspection, repair, and alteration for the aboveground storage tanks **which are placed in Service**. API 650 is the basic construction code for making **New Tanks**.
2. API 650 and API 653 are used for aboveground storage tanks at atmospheric pressure (maximum 2.5 psi above atmospheric) and temperatures not exceeding 90 °C.
3. Design metal temperature of tank is assumed to be 8 °C (15 °F) above the lowest one day mean temperature of tank site.
4. Where necessary, as per Fig. 2-1 (API 650), the tank materials shall be checked against brittle failure by conducting impact testing. Acceptance criteria shall be as per Table 2-4.
5. If average value of 3 specimen is < specified average value (SAV) — reject. But if average value of 3 specimen SAV and,
  - a. Value of one specimen is < SAV but 2/3 SAV - accept
  - b. Value of one specimen is < SAV and also < 2/3 SAV - retest
  - c. Value of two specimen is < SAV - retest



On retest for b and c all three specimen  $\geq$  SAV - accept

6. The required thickness of shell plates for tanks up to 60 m (200 feet) diameter shall be greater of  $t_d$  or  $t_t$ :

$$t_d = (4.9D (H - 0.3) G) / S d + CA \text{ and } t_t = (4.9 D (H - 0.3)) / S t \text{ (metric)}$$

$$t_d = (2.6D (H - 1) G) + C.A. \text{ and } t_t = (2.6D (H - 1)) / S t \text{ (US units)}$$

Where:

D = Tank Diameter m (ft)

H = Height shell course from top liquid level in m (ft)

G = Specific Gravity of liquid to be stored

Sd and St = Allowable stress for design and hydrostatic conditions in Mpa (psi)

C.A. = Corrosion allowance in mm (in)

7. Shell thickness calculated above (point no. 6) shall not be less than that required by Diameter - Thickness table in API 650. (3.6.1.1)

8. Values of Sd and St are taken from Table 3-2 of API 650. For unlisted material:

Sd = Lower of 2/3 (Y.S) or 2/5 (T.S.) and

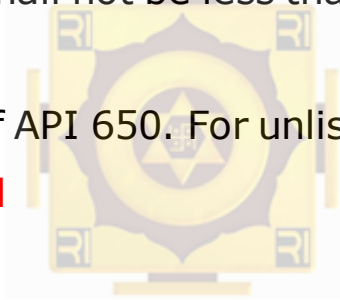
St = Lower of 3/4 (Y.S) or 3/7 (T.S.)

9. Minimum nominal thickness excluding corrosion allowance for roof plate shall be 5 mm (3/16") and for bottom plate shall be 6 mm (1/4").

10. All nozzles, manholes and other openings shall have dimensions thickness, reinforcement plates and weld sizes as per tables 3-6 and 3-7 of API 650.

11. Radiography inspection is required for all shell butt welds and annular plate butt welds and insert plates for manhole and nozzles.

12. For shell plates the number of radiographs required depend on whether the plate thickness is up to 10 mm (3/8), or above 10 mm to 25 mm (3/8" - 1") or above 25 mm (1"). (Fig. 6-1 of API 650).

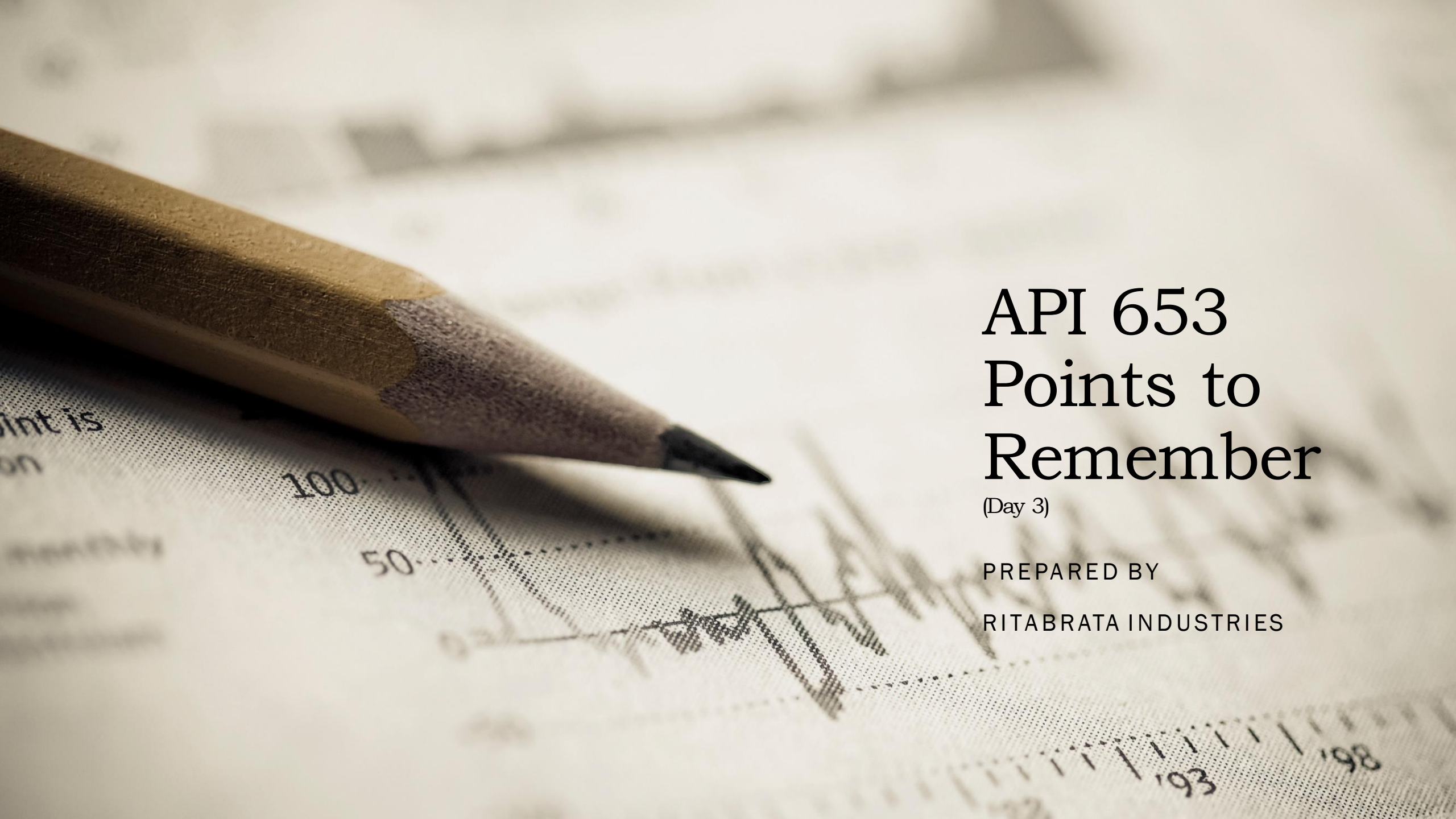


13. Radiography is also required on:

- i. 100% length of butt welds joining insert plate to shell, and
- ii. Annular bottom plate radial joints (1 spot on 10% of radial welds if double butt welded and 1 spot on 50% of radial welds if single welded with backing strip.)





A close-up photograph of a wooden pencil with a dark lead tip, resting diagonally across a document. The document features a line graph with a grid. The y-axis has labels '100' and '50'. The x-axis has labels '93' and '98'. The pencil is positioned over the graph, pointing towards the right. The background is softly blurred, showing more of the document and the pencil's body.

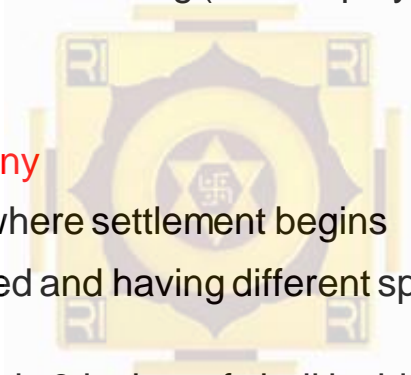
# API 653 Points to Remember

(Day 2)

PREPARED BY

RITABRATA INDUSTRIES

1. According to API 653, "Repairs" means any work necessary to maintain or restore the safe operating conditions (as per original design). "Alteration" means any work that changes the dimensions and/or configuration of tank (changing original safe operating conditions).
2. **"Authorized inspection agency"** is any one of the following (who employ API tank inspector):
  - An owner operator
  - Subcontractor to owner operator
  - Inspection organization of jurisdiction
  - Inspection organization of insurance company
3. **"Break-over point"** means area of tank bottom where settlement begins
4. **"Change of service"** means change in fluid stored and having different specific gravity or corrosivity or different temperature or pressure.
5. **"Critical zone"** means portion of tank bottom within 3 inches of shell inside and measured radially inwards
6. **"Repair organization"** means any of the following who carries out repairs / alterations according to API 653.
  - Owner-user
  - Subcontractor to owner-user
  - Subcontractor authorized or approved by jurisdiction
7. Tank roof plates which are so corroded that there are through holes, or the average thickness is less than 0.09 inch in any 100 sq. inch area, then plates must be repaired or replaced, i.e., tank cannot be permitted to continue operation.



8. If tank service is to be changed resulting in increase of internal pressure or operation above 900 C (2000 F), then requirements of API Appendix F and M must be fulfilled respectively. If service changes lower temperature, then material must be suitable as per impact test requirements of API 650.
9. Tank shell evaluation: 5 step method.
- a. Determine the minimum thickness ( $t_2$ ) at corroded area.
  - b. Calculate vertical critical length L for tank diameter D (in ft.)  
 $L = 3.7 \sqrt{Dt_2}$  or 40" whichever is less
  - c. Determine  $t_1$  which is minimum of  $t_{av}$  ( $t_{av}$  is average thickness of at least 5 readings over weakest L)
  - d. Determine  $t_{min}$  by formula,  $trim = 2.6 (DHG/SE)$  for local area  
or  $t_{min} = 2.6 * (D(H-1)G)/(SE)$  for full shell course.  
Take 'S' from Table 4-1 of API 653 code.
  - e. (i) Then  $t_1 \geq t_{min} + (CR \times interval)$ , and  
(ii)  $t_2 \geq 0.6 \times t_{min} + (CR \times interval)$  if conditions (i) and (ii) are okay - accept. If no repair or replace or reduce the liquid height till repair/ replacement can be done.
10. Widely scattered pits can be ignored if:
- a. No pit depth results in shell thickness being less than half the required thk - excluding C. A.
  - b. Sum of pit dimensions along any vertical line does not exceed 2 inches in a total length of 8".

11. Minimum thickness for bottom plates is given by:

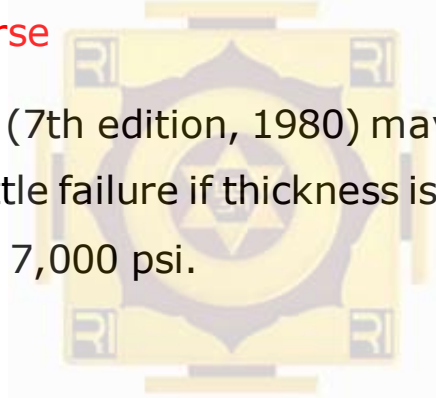
- Annular plates (product sp. gr.  $< 1.0$ ): Table 4-3 (API 653)
- (Product sp. gr.  $\geq 1.0$ ): Table 3-1 (API 650)
- Other bottom plates: Table 6-1 (API 653)

12. Min. thickness in "critical zone" is smaller of:(but not less than 0.1")

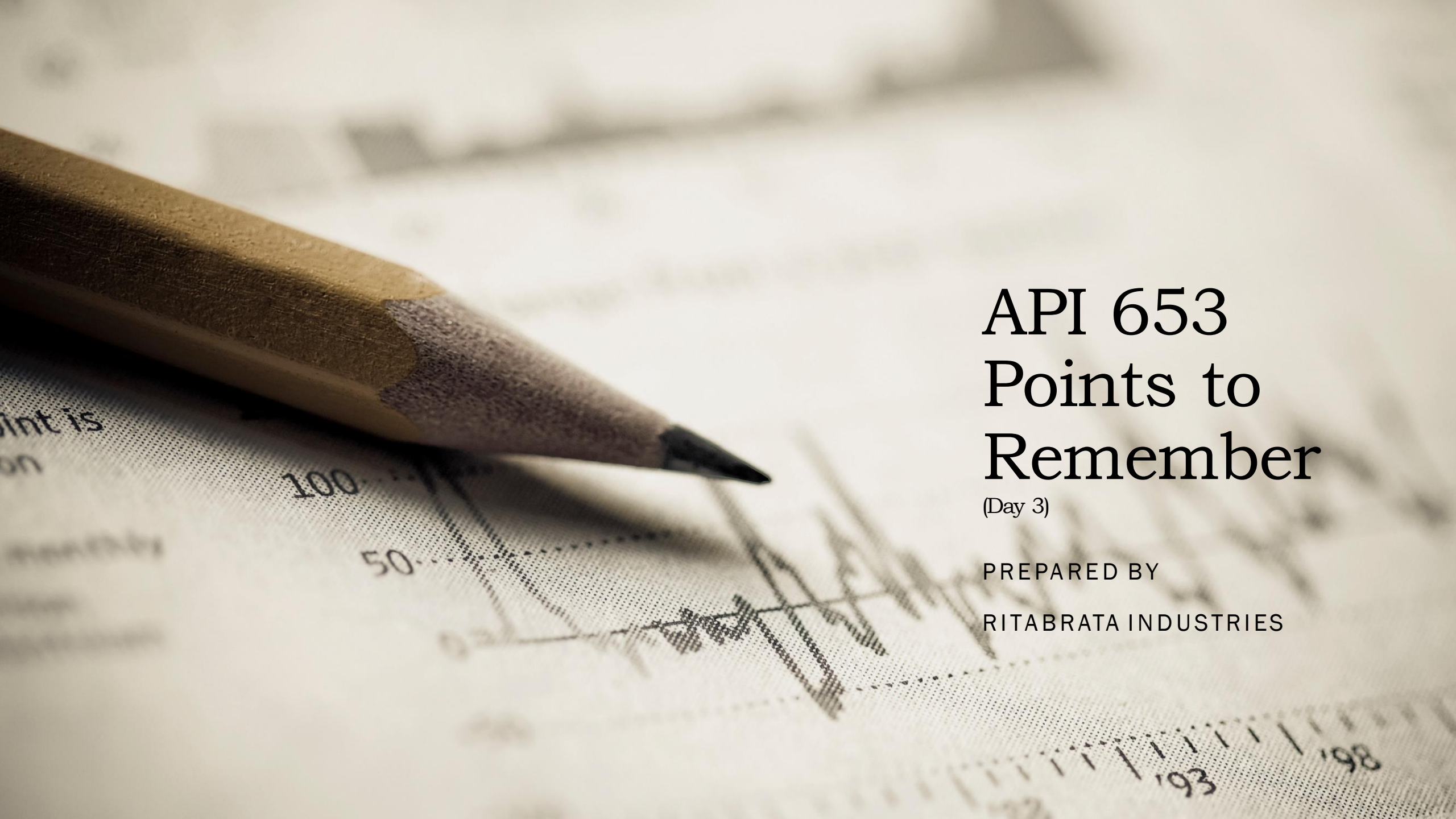
- Half of original bottom thickness in critical zone, and
- Half of  $t_{min}$  for first shell course

13. Tanks designed prior to API 650 (7th edition, 1980) may be assessed for brittle failure as per Fig. 5.2.

14. Tanks are not likely to fail in brittle failure if thickness is not more than  $\frac{1}{2}$ " or shell temperature is not less than 600 F or stress level is less than 7,000 psi.





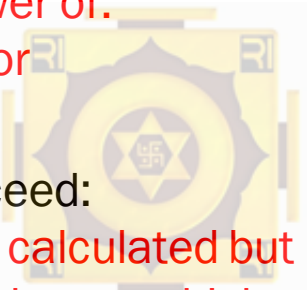
A close-up photograph of a wooden pencil with a dark lead tip, resting diagonally on a document. The document features a line graph with a grid. The y-axis has labels '100' and '50'. The x-axis has labels '93' and '98'. The pencil is positioned over the graph, pointing towards the right. The background is softly blurred, showing more of the document and the pencil's body.

# API 653 Points to Remember

(Day 3)

PREPARED BY

RITABRATA INDUSTRIES

1. Inspection Frequency (External) shall not exceed following
    - a. Routine-in Service inspection everyone month
    - b. External inspection (visual by authorized inspector):  
Lower of one-fourth remaining life (RCA/4N) or 5 years
    - c. Ultrasonic thickness inspection (external) of shell:
      - I. when corrosion rate is not known - maximum 5 years
      - II. when corrosion rate is known - lower of:
        - half remaining life (RCA/2N) or
        - 15 years
  2. Inspection Frequency (Internal) shall not exceed:
    - a. Based on MRT calculations, as per "Or" calculated but not exceeding 20 years
    - b. If corrosion rates are not known: Actual bottom thickness shall be determined not later than 10 years.
  3. Alternative to point no. 2 above for internal inspection interval may be altered based on RBI. The RBI basis shall be reviewed at intervals not exceeding 10 years by authorized inspector and tank engineer.
  4. If there is access to tank bottom to determine bottom thickness, externally, such inspection may be used in lieu of internal inspection. (Point No. 2)
  5. Inspection records include:
    - a. Permanent Records (Tank construction data)
    - b. Inspection history (Progressive Records)
    - c. Repair/alteration history (Repair/alteration records)
- 

6. New materials for repair/alteration/ reconstruction: All plate material used for shell and the bottom plates welded to shell shall be identified.
7. Thickness of shell plates to be used for checking the tank design shall be within 180 days before relocation.
8. The strength values  $S_d$  and  $S_t$  for reconstructed tank shall be on the basis of allowable stress as per table 3-2 of API 650.
9. The replacement shell plate thickness:  

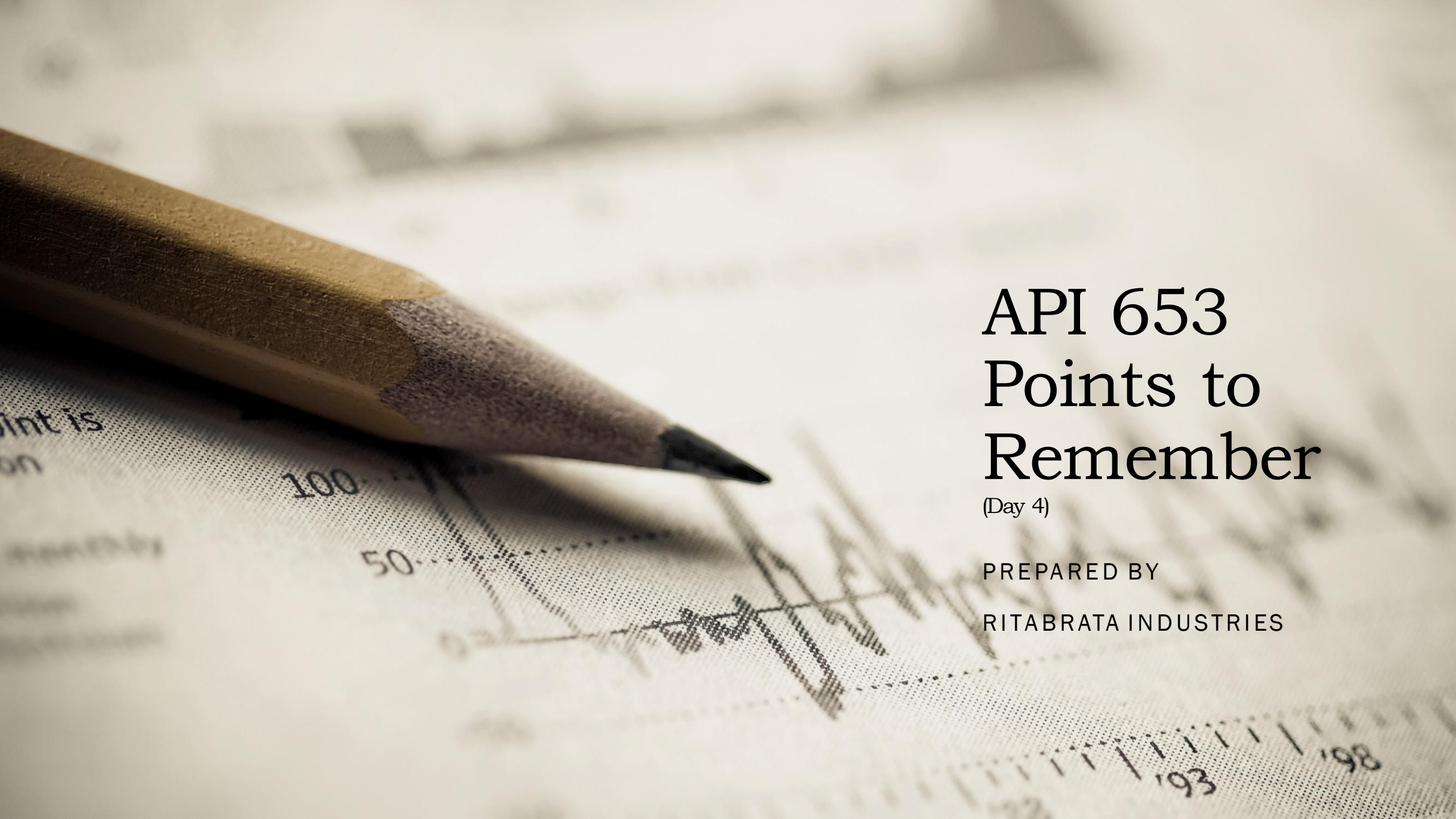
Thickness of the shell course where replacement is proposed and dimensions and spacing shall be as per Figure 9-1.
10. Lap-welded patch plates can be used only if:
  - a. owner specifies
  - b. only on shell plates  $S_t$  1/2 inch
  - c. must be within spacing requirements as per Fig. 9-1
  - d. maximum size 48" vertical x 72 horizontal and minimum dimension 4"
  - e. areas on which lap patch is to be put shall be UT checked
  - f. lap on lap is not permitted
11. All shell plate defects like the cracks, gauges, tears, widely scattered .pits and corroded areas shall be evaluated case by case as per chapter 4 of API 653.
12. New reinforcements can be added to existing unreinforced nozzles as per Fig. 9-3a and 9-3b.
13. Repairs within critical zone of the bottom require additional precautions like "Tombstone" type patch and additional PT or MPI testing after visual examination of patch welds, and weld shall be made by minimum 2 passes.



14. If impact test was not done on original tank material, the hot taps shall be limited to NPS 4 (max).
15. Toe-to-toe minimum spacing between hot tap and adjacent nozzle shall be  $= \sqrt{RT}$  (square root of RT) where R = tank shell radius in inches, T is shell plate thickness in inches.





A close-up photograph of a wooden pencil with a dark lead tip, resting diagonally across a document. The document features a line graph with a grid. The y-axis has labels '100' and '50'. The x-axis has labels '93' and '98'. The background is softly blurred, showing more of the document and the pencil's body.

# API 653 Points to Remember

(Day 4)

PREPARED BY

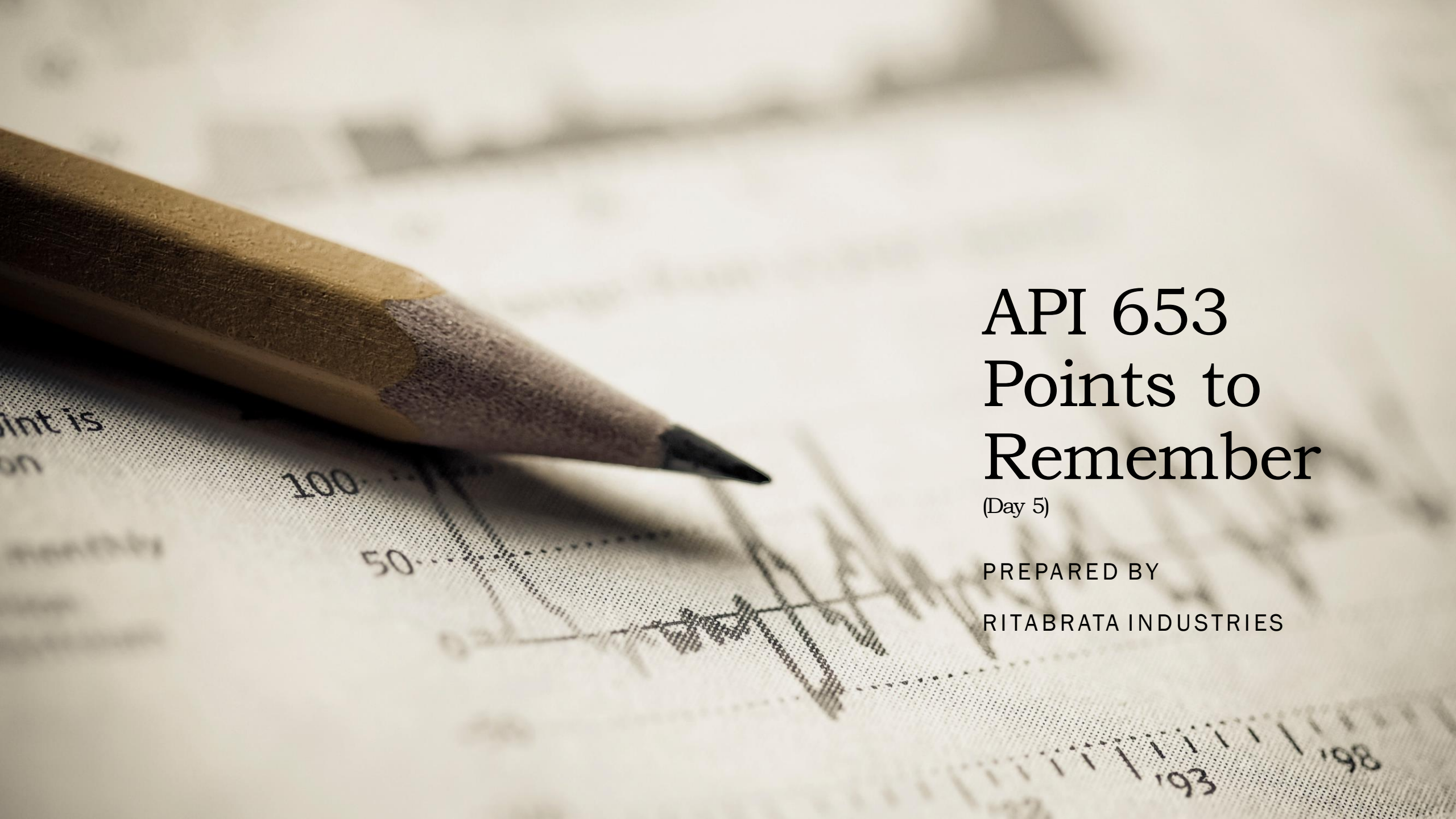
RITABRATA INDUSTRIES



1. For tank relocation, the bottom, shell or roof may be cut in any size from existing tank so that the pieces are suitable for transportation.
2. For dismantling the tank, the bottom may be cut 12" away from shell to bottom weld, if entire bottom plates are to be used.
3. Alternatively cut the bottom and shell at 1/2" from toe of shell to bottom weld and discard the weld portion.
4. For rest of the bottom, de-seaming of welds or cutting 2" away from weld may be done.
5. Shell plates 5½" thk may be dismantled by cutting through weld without removing HAZ. If shell plate thk > 1/2", discard welds + HAZ.
6. Alternatively, shell plates may be cut 6" away from existing welds.
7. NDT for Repair / Alteration:  
**PT / MT: For all fillet welds and fill-up (weld-build up) during repair or alteration**
8. Radiography:
  - a. New welds during repair or alteration between the plates such as:
    - (i) New to new plates - same as API 650
    - (ii) New to old plates or old to old plates. Additional examination:
      - 1 spot for each 50 feet for horizontal weld
      - 1 spot on each vertical weld
      - 1 radiograph on each T-joint
  - b. Repair of old butt-welds — entire length of repair

10. A full hydrostatic test (held for 24 hours) is required on major repairs and major alterations which include:
  - a. Installation of nozzles larger than NPS 12 below liquid level
  - b. Repair / Replacement of more than 12" length of vertical weld in shell or radial weld in anular plates
  - c. Any repair / replacement on shell to bottom weld
  - d. Jacking of tank shell
11. Exemption for hydrotest is possible only if owner / operator and the tank engineer give the exemption in writing.
12. Hydrostatic test of reconstructed tank is compulsory.
13. Out of plumbness for reconstructed tank is 1/100 of the tank height subject to maximum 5 inches.
14. For tank settlement survey, the number of elevation measurement points for tank diameter D ft. is given by:  
 $N = D/10$ , but minimum 8.
15. Permitted internal settlement (for bulge or depression) is given by:  
 $B = 0.37 R$   
Where B = Max. height of bulge or depth of settlement (inches)  
And R = Radius of largest inscribing circle (feet)
14. Based on Fig. B-10, and B-11 maximum allowable edge settlement is worked out depending on settled area being approximately parallel or perpendicular to shell.
15. As per API RP 575, the grounding connection inspection shall be included is external visual inspection. Total resistance from tank to soil should not exceed approximately 25 ohms.

16. Ultrasonic thickness measurements as a minimum must be made on at least one TML on each shell course. TMLs also shall be established on top uncoated portion of shell for floating roof tanks.
17. For internal inspection of tank bottoms, a preliminary random thickness scanning survey is carried out in X pattern across the tank and along the circumference. If significant corrosion is detected, entire bottom shall be scanned.
18. For internal inspection of shell, the major areas of focus shall be the vapour space, liquid-vapour interface and the bottom area.
19. Leak testing of shell may be done hydrostatically or by using diesel test or by vacuum box test.
20. Leak testing of bottom may be done by:
  - a. Using vacuum box test
  - b. By construction of clay dam around tank and filling under side by water (observe seepage inside)
  - c. Apply seal to tank outer perimeter and introduce compressed air below tank bottom, check welds by applying soap solution or by observing bubbles by filling inside of tank by water for 6" height
  - d. By injecting inert gas with tracer gas under the tank and using "sniffers" inside to detect leakage
21. Hammer test is never carried out on cast iron parts.
22. Corrosion rate curves are helpful as an important record of corrosion behavior of tank in past and anticipated remaining life in future.

A close-up photograph of a wooden pencil with a sharpened lead tip, resting diagonally across a document. The document features a line graph with a grid. The y-axis has labels '100' and '50'. The x-axis has labels '93' and '98'. The pencil is positioned over the graph, pointing towards the right. The background is softly blurred, showing more of the document and the pencil's body.

# API 653 Points to Remember

(Day 5)

PREPARED BY

RITABRATA INDUSTRIES

1. WPS gives parameters to be used in production job and must be within ranges qualified by the PQR test.
2. Essential variables (EV), if changed require new procedure qualification. Non-essential variables (NEV) may be changed without new procedure qualification.
3. Bend test crack shall not exceed 1/8" in any direction for face bend, root bend or side bend.
4. Supplementary essential variables (SEV) are considered as (EV) only if there is impact strength requirement. Otherwise, they are "non-essential" variables.
5. Tensile test for procedure qualification is passed if failure is in:
  - Weld metal at strength  $\geq$  Base metal SMTS or
  - Base metal at strength  $\geq$  95% of base metal SMTS.
6. P-numbers represent parent metal groupings of similar composition and properties, i.e., similar strength and ductility. F-numbers give similar usability aspects of filler material. A-numbers give similar chem. comp. In "As welded" condition
7. For performance, 1G is flat, 2G is horizontal, 3G is vertical and 4G is overhead position. Pipe 5G qualifies 1G, 3G and 4G, but pipe 6G qualifies all positions.
8. Welders who have not welded for more than 6 months on a process, their qualification will expire for that process.
9. In Galvanic corrosion, current flows from anode to cathode, therefore anode will lose metal and cathode will gain. If we make the "component to be protected" cathodic with respect to surrounding, it will not lose metal, thus will be protected.
10. As soil resistivity goes up, soil is less corrosive and vice-versa. (Soil resistivity  $<$  500 ohm-cm is highly corrosive,  $>$  10,000 ohm-cm, is least corrosive.) Ref. Table 1-API 651.



11. Cathodic protection methods: **Galvanic and impressed current**

**Galvanic current:** Easy to install, cheap, easy to maintain, but limited use. (Not suitable for large structure)

**Impressed current:** Expensive, but more effective, suitable for large structures. Requires constant monitoring.

12. CP system survey intervals:

**Impressed current:**

**Rectifier (power source) - Max. 2 months**

**Other components - Max. 1 year**

**Galvanic System (sacrificial anode system): Annually**

**CP survey records should be maintained normally for 5 years.**

13. There are two main classes of linings:

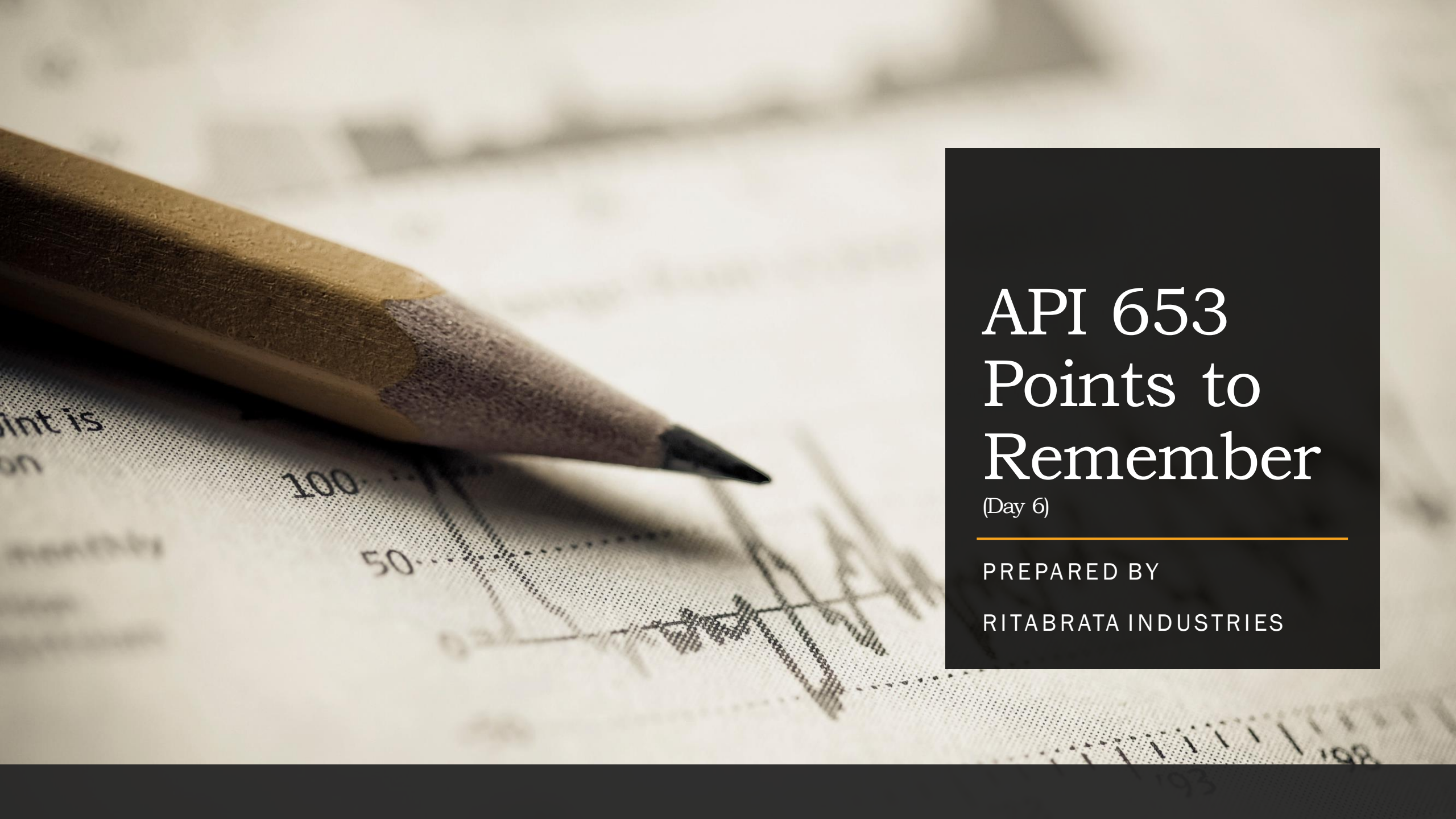
a. **Equal to or less than 20 mils (thin film linings) and**

b. **Greater than 20 mils (thick film linings).**

14. The principal advantages for thin-film lining are lower cost and ease of application compared to thick-film lining systems.

15. Thick-film, reinforced lining are less susceptible to mechanical damage than thin film linings. They can provide sufficient strength to bridge over small perforations of the supporting steel bottom that may develop due to external corrosion.

16. Temperature during blast cleaning and applying the linings shall be 3°C (5°F) above the dew-point temperature and relative humidity not to exceed 80%.



# API 653 Points to Remember

(Day 6)

---

PREPARED BY

RITABRATA INDUSTRIES

## 1. GENERAL:

- a. ASME Sec. V is NDT procedure/methods code and is applicable only if it is referenced by the relevant construction code. The extent of NDT and acceptance standards is given in relevant construction code.
- b. NDT equipment and their calibration shall be as per ASME Sec. V.
- c. Examiner is NDT person in employment of fabricator or repair organization. Inspector means Authorized Inspector who finally accepts/rejects NDT results.

## 2. FOR RT:

- A. Satisfactory radiograph shall meet requirements of density and IQI image (2T hole for hole type and designated wire for wire type).
- B. Backscatter:  
Light image of B on dark background - Unacceptable
- C. Density Limitations:  
Min 1.8 for X Ray / 2.0 for G-Ray  
Max 4.0 for X / G Ray  
Density Variation = -15 % to + 30%
- D. Double wall viewing (DWDI) - Up to 3.5" outside diameter
- E. Penetrameter Selection: Table T-276. Thickness includes weld reinforcement. But not backing.
- F. Penetrameter shall be normally placed on source side. If not possible, it may be placed on film side with lead letter "F".



### 3. FOR PT:

a. Control of Contaminants: Sulphur (for Nickel alloys) shall not exceed 1% of residue. Chlorine + Fluorine (for S.S. and Titanium) shall not exceed 1% of residue.

b. Temp. shall be between 10°C to 52°C, for standard procedures.

c. Penetrants are colour (visible) type and fluorescent type. Each of these have:

- water washable
- post emulsifying
- solvent removable

Thus, total 6 categories of penetrant are available.

d. Emulsifier is applied after applying penetrant and required dwell time is completed. Lipophobic emulsifier is applied without pre-rinsing. Hydrophobic emulsifier is applied after pre-rinsing.

e. For dwell time for penetrant and developer refer Table T-672.

f. After applying developer, interpretation shall be done within 10 to 60 minutes.

g. All penetrant materials should be from same manufacturer.

## 4. FOR MT:

a. Prod Technique:

- Use direct (rectified) current for magnetization
- Prod spacing 3" to 8"
- Useful for surface and sub-surface defects

b. Yoke Technique:

- Use D.C. or A.C. or permanent magnet
- Suitable for surface defects only



c. Calibration:

Equipment Ammeter to be calibrated once a year comparing with standard Ammeter, take 3 readings. Deviation shall not exceed  $\pm 10\%$  of full scale.

d. Lifting Power of Yokes

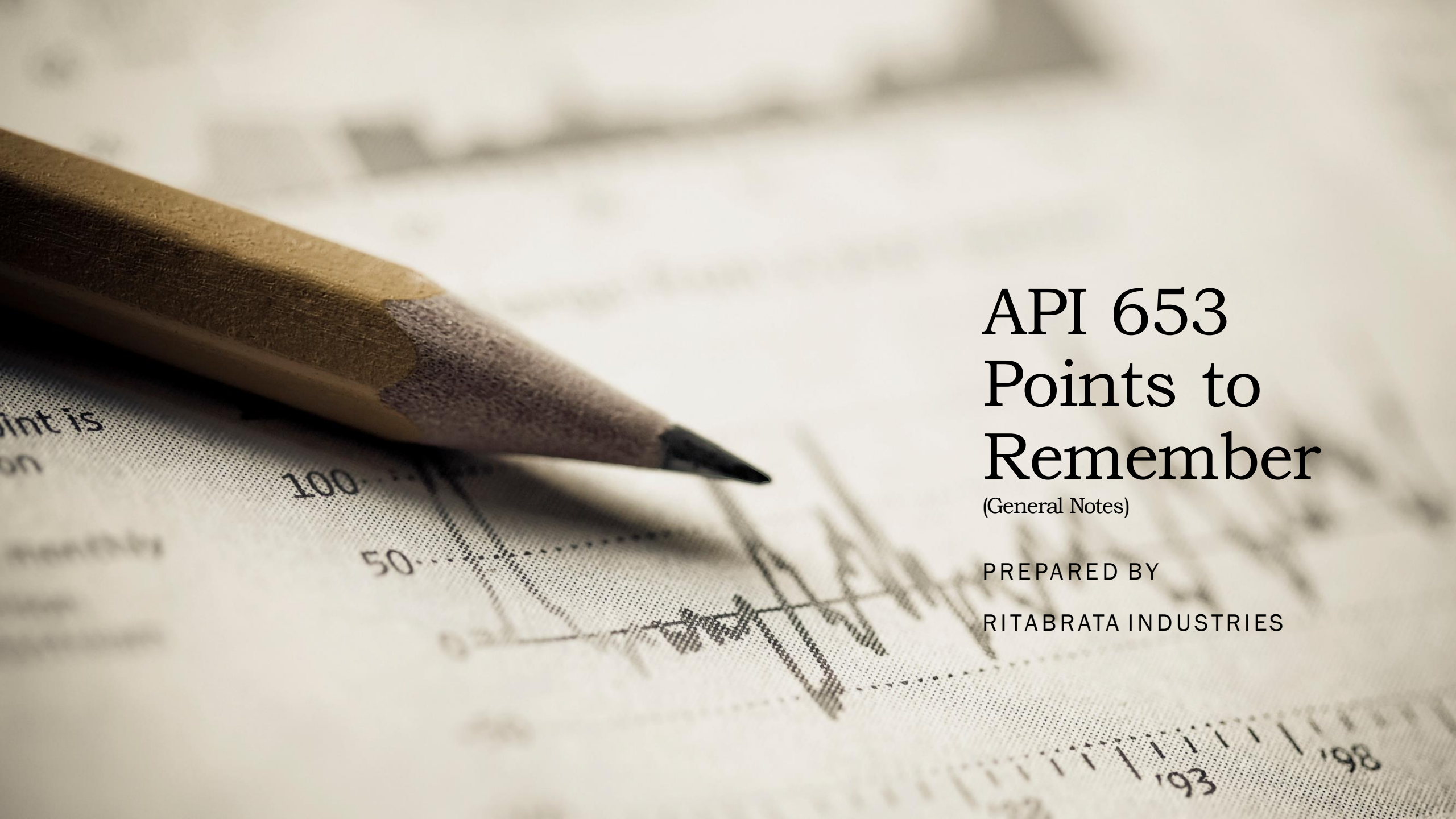
- AC shall have lifting power of at least 4.5 kg (10 lbs.)
- DC shall have lifting power of at least 18.1 kg (40 lbs.)

e. Minimum two examinations on each area, the second is perpendicular to first



## **5. SE-797 UT MEASUREMENT:**

- a. Pulse-echo method can be adopted up to 200 ° F
- b. Apparatus: 3 types
  - CRT read out
  - CRT + direct read out
  - Direct thickness read out
- c. Search Units: 3 types
  - Straight beam contact type
  - Delay line type (delay block to minimize dead zone)
  - Dual element type. There are two crystals set at a small range. Low roof angle used for higher range and higher angle for low range.
- d. High thickness measurement:
  - Use of multiple echoes is made. (i.e., for thickness between 50 mm and 60mm, use 10mm calibration block then 5th back echo will be 50 mm and 6th will be 60mm. Set the 5th echo to zero and 6th at the screen range. The screen is calibrated to 50-60mm.
- e. While taking measurement for high temperature condition a positive error of 1% per 55 ° C (100 ° F) results. Hence temperature correction is necessary
- e. CRT read out is recommended on corroded and rough surface



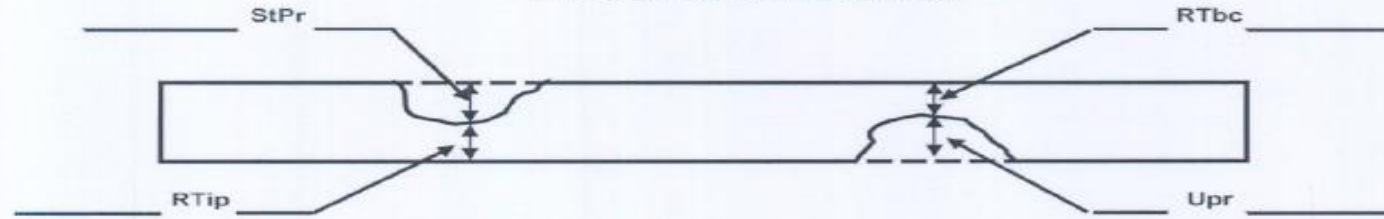
# API 653 Points to Remember

(General Notes)

PREPARED BY

RITABRATA INDUSTRIES

### BOTTOM PLATE EVALUATION



1)  $RTbc = \text{Orig. Thk.} - Upr$  or  $\text{---} - \text{---} = 4.85$

2)  $RTip = \text{Orig. Thk.} - StPr$  or  $\text{---} - \text{---} = 5.26$

5.26  
Smaller

3)  $StPr = \text{Corrosion Rate a year Top Side (microns)} \times 0.001$  equals  $.01017$

4)  $Upr = \text{Corrosion Rate a year Bottom Side (microns)} \times 0.001$  equals  $.01006$

$.01017 \times 1.3 = .010133$   
Total

5)  $MRT = \text{Min. Req. from Table 6-1 / Pg. 6-3} \times 25.4$  or  $0.10 \times 25.4 = 2.54$  mm

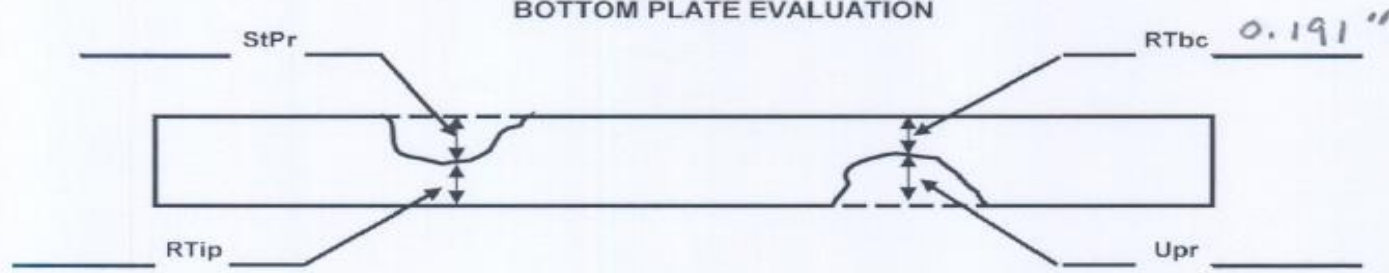
6)  $MRT = \text{Smaller of } (RTbc \text{ or } RTip) - \text{Or} \times (StPr + Upr)$   
 or  
 $\frac{2.54}{5.26} \text{ equals } \frac{5.26}{5.26} - \text{Or} \times .0133$

7)  $\text{Or} \times 0.0133 \text{ equals } 5.26 - 2.54 \text{ equals } 2.72$

8)  $\text{Or} \text{ equals } \frac{2.72}{0.0133} \text{ equals } \text{---} \text{ Yrs}$



# BOTTOM PLATE EVALUATION



1)  $RT_{bc} = \text{Orig. Thk.} - U_{pr}$  or  $\text{---} - \text{---} = 0.191$

2)  $RT_{ip} = \text{Orig. Thk.} - St_{pr}$  or  $\text{---} - \text{---} = 0.207$

0.191

Smaller

3)  $St_{pr} = \text{Corrosion Rate a year Top Side (microns)} \times 0.001$  equals  $0.00018$

0.00018

4)  $U_{pr} = \text{Corrosion Rate a year Bottom Side (microns)} \times 0.001$  equals  $0.00015$

0.00015

Total

0.00033

5)  $MRT = \text{Min. Req. from Table 6-1 / Pg. 6-3} \times 25.4$  or  $0.10 \times 25.4 = 2.54$  mm

2.54 mm

6)  $MRT = \text{Smaller of } (RT_{bc} \text{ or } RT_{ip}) - Or \times (St_{pr} + U_{pr})$

$2.54$  equals  $0.191$  minus Or  $\times 0.00033$

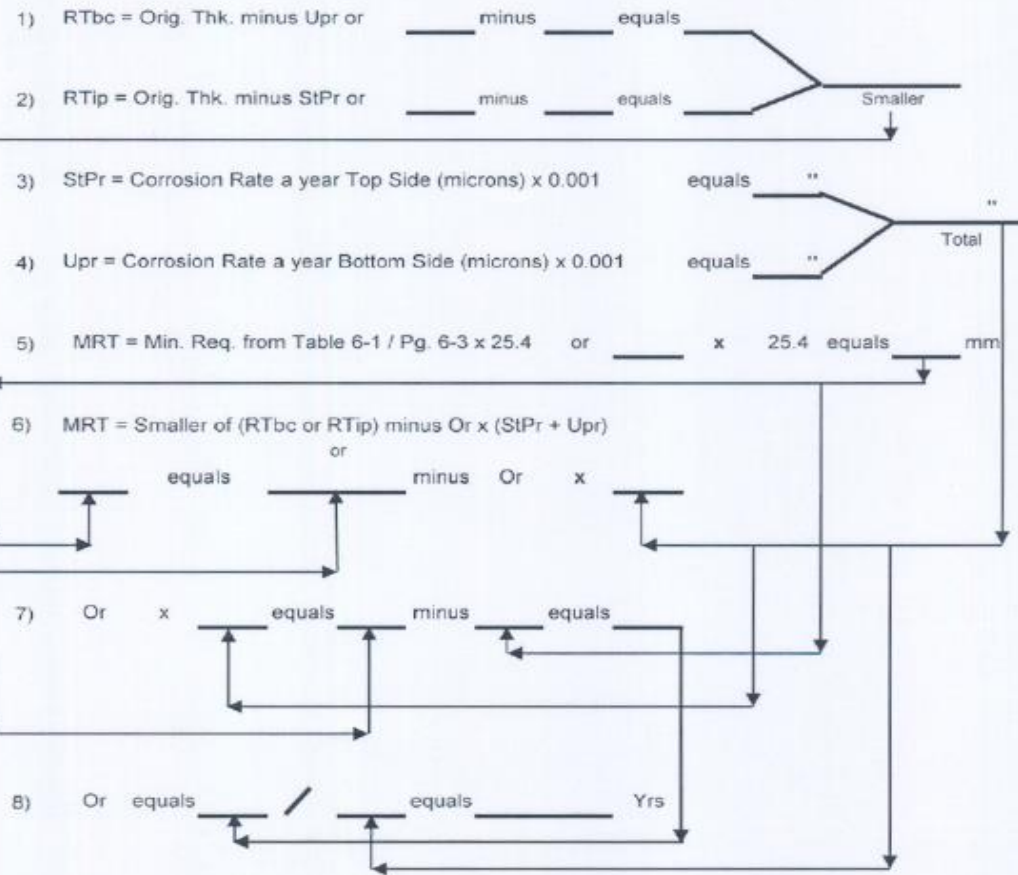
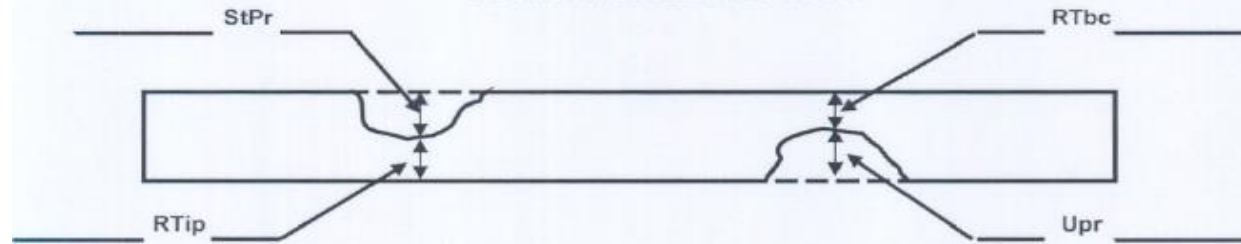
7) Or  $\times 0.00033$  equals  $0.191$  minus  $2.54$  equals

8) Or equals  $\text{---} / 0.00033$  equals  $\text{---}$  Yrs



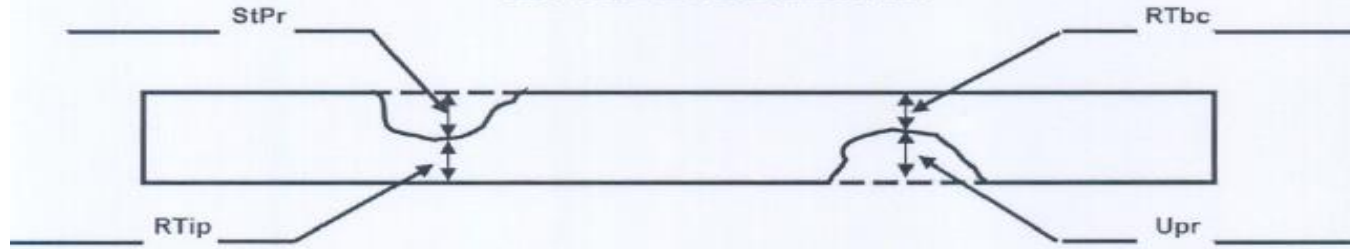


# BOTTOM PLATE EVALUATION





## BOTTOM PLATE EVALUATION



1)  $RTbc = \text{Orig. Thk.} - Upr$  or  $\text{---} - \text{---} = \text{---}$

2)  $RTip = \text{Orig. Thk.} - StPr$  or  $\text{---} - \text{---} = \text{---}$

Smaller

3)  $StPr = \text{Corrosion Rate a year Top Side (microns)} \times 0.001$  equals  $\text{---}$  "

4)  $Upr = \text{Corrosion Rate a year Bottom Side (microns)} \times 0.001$  equals  $\text{---}$  "

Total

5)  $MRT = \text{Min. Req. from Table 6-1 / Pg. 6-3} \times 25.4$  or  $\text{---} \times 25.4 = \text{---}$  mm

6)  $MRT = \text{Smaller of (RTbc or RTip)} - Or \times (StPr + Upr)$

or  $\text{---} - Or \times \text{---}$

7)  $Or \times \text{---} = \text{---} - \text{---} = \text{---}$

8)  $Or = \text{---} / \text{---} = \text{---}$  Yrs

