



Visual Inspection Workshop

INSTRUCTORS MANUAL



American Welding Society

Module #1 - VISUAL INSPECTION OF WELDING

Aims Of Module #1

- Consider Factors Putting Weld Quality At Risk
- Detail And Review Elements Of A Comprehensive Welding Inspection Program
- Review Individual Elements Of The Program



VIW 1-1

Reference Page 1-1

DISCUSS: Aims of Module #1

1. Many factors may put weld quality at risk-- leading to the need for knowledgeable 'inspection'
2. Codify and introduce a 4 phase, 24-point plan of inspection directed to 'building' quality into the job; known as the Welding Inspection Program
3. To review each element (point) of the program

Module #1 - DESIGN ROLE

- Overall Perspective
- Access For Welding
- Ability To Inspect
- Cost Effectiveness
- Minimizing Residual Stress
- Specify Suitable Base Metals



VIW 1-2

Reference Page 1-1

REVIEW:

- Weldment design, joint location, access for welding
- Joint design detail - best left to fabricator
- Joints and Welds best indicated by symbols
- Cost responsibility
- Minimizing residual stress by use of appropriate procedures and welding sequences aimed at minimizing distortion, residual stress.
- Specifying only 'weldable' base metals.

Module #1 - BASE METALS

- Not All Metals Are 'Weldable'
- Welding Can Cause Changes In Strength, Mechanical Properties
- Welding Has Potential To Change Metal's 'Structure'
- Need For Assurance 'Weldable' Metals Are Used (Traceability)



VIW 1-3

Reference Page 1-2

REVIEW:

- Weldability of metals
- Effects of welding heat on:
 - a) Strength, mechanical properties
 - b) Metallurgical structure
- Need to establish only 'weldable' metals used
- Role of base metal documentation, traceability

Module #1 - WELDING PROCEDURES, APPLICATION

- Welding Documentation
- Role Of Welding Procedures
- Welding 'Variables'
- Verifying Procedure Utility
- Welder Qualification
- Verifying Welder Skill



VIW 1-4

Reference Page 1-2


DISCUSS:

- Types of Welding Procedures, their sources
- Role of Welding Procedures- compatibility of :
 - base metals
 - filler metals
 - procedure of welding
- Welding 'variables'; scope, type, etc.
- Verification of Welding Procedure applicability
- Welder qualification - establishes welder ability . . .
- Verification of ongoing welder skill

Module #1 - JOB QUALITY

- Conformance To Specification

- Inspection Program Elements
 - Initial Review Of Documents
 - Pre-Welding Checks
 - In-process Inspections
 - Post Welding Activities


VIW 1-5

Reference Page 1-3

DISCUSS:

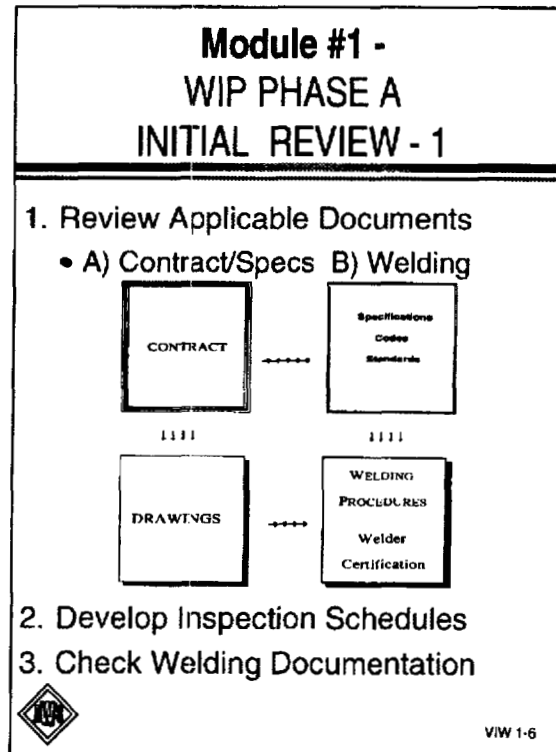
•QUALITY -- CONFORMANCE TO SPECIFICATION

•EMPHASIZE:

- Multi-disciplinary nature of welding
- Dominant role of Design, materials, etc..
- Need to ENSURE error opportunities are detected before or during welding -- corrective action before the event, rather than after.

•DISCUSS BRIEFLY - each Phase of Welding Inspection Program -
Refer to (Table 1.2)

(DISCUSSION OF NUMBERED ELEMENTS FOLLOWS)



EXPLAIN: Purpose of each step -- see text Page 1- 4

1. Review contract documents.

- Examine the referenced Specifications to become familiar with requirements.
- Examine and review the drawings; look for joint locations; 'unweldable' joints; procedures required.

2. Examine welding documentation; check procedures required; status of welders.

- Develop Inspection Plan; in liaison with production; develop Inspection Schedules.


3. Check Welding Documentation

**Module #1 -
WIP PHASE A
INITIAL REVIEW - 2**

4. Review Your Quality Documents;
 - Prepare Job Quality files

5. Review System For Handling Of Non-Conforming Product

6. Review Corrective Action Program
 - Concession, Repair, Disposition


VIW 1-7

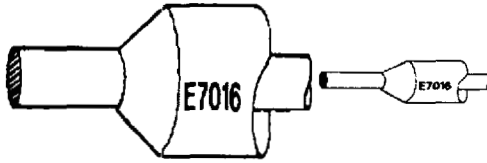

Purpose of each step - see text Page 1-5

Discuss each element of slide. Stress timely preparation for each issue to ensure being ready for production start.

4. Are your Quality reporting documents OK for job; Prepare filing system for job documentation

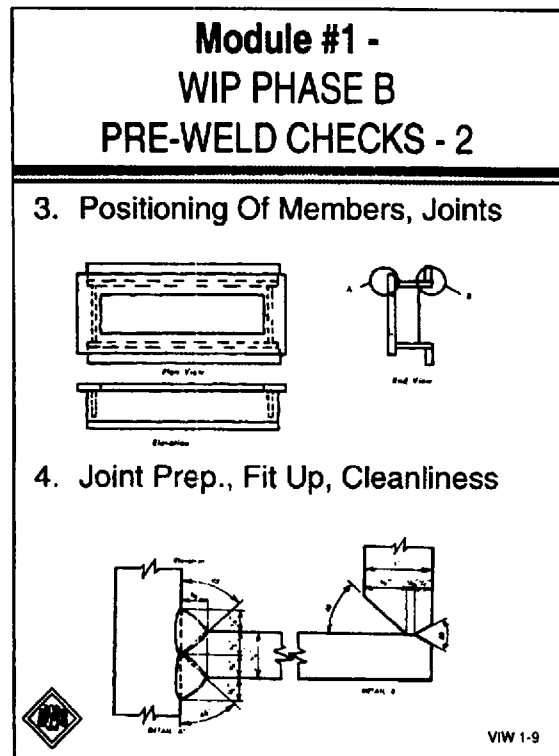
5. Non-conforming product handling; are procedures adequate, in place, are they observed ?

6. Corrective action procedures; repair? scrap? concession? Disposition after corrective action?

Module #1 - WIP PHASE B PRE-WELD CHECKS - 1	
1. Welding Equipment Suitability	
	
2. Base, Filler Metal Conformance	
CERTIFICATION OF TESTS	
CUSTOMER TECHNICAL INC.	RECEIVED MAY 10 1990
PURCHASE ORDER 563	DATE SHIPPED 5-1-90
DESCRIPTION 1 2" DIA. 100% DEF. NO. 9 5013 T-100	
2	
3	
4	
SPECIFICATION: ASME-SECTION 9	
PROPERTIES 1 2 3 4	
HEAT NO. 111490	
	
VIW 1-8	

EXPLAIN purpose of each step -- see text page 1-6

1. Suitability of welding equipment to do job as per WPS
Machine sizes, cable capacity, return lead clamps, etc..
2. Conformance of base, filler metals to applicable Specs
Verify from MTR's and Filler conformance

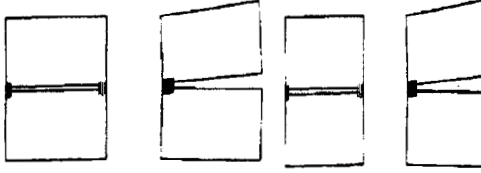


EXPLAIN purpose of each step -- see text pages 1-7 thru 1-9


3. Relationship of members, joint positions as per WPS
4. Details of joint preparation, fit up of members, cleanliness in the areas to be welded and adjacent thereto etc..


**Module #1 -
WIP PHASE B
PRE-WELD CHECKS - 3**

5. Joint Stability During Welding



6. Verify Preheat, Job Temperatures

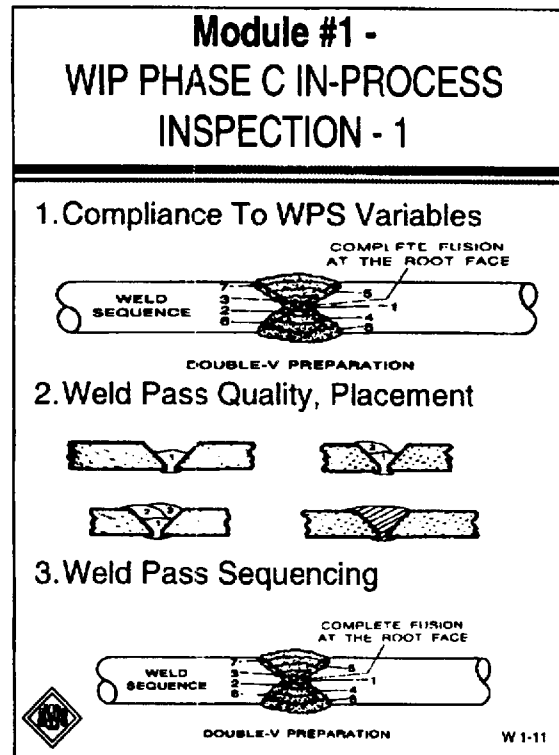




VIW 1-10

EXPLAIN purpose of each step -- see text page 1.9

5. Verify that joint member will be stable during welding; tacks, clamps
6. Check job, joint temperatures immediately prior to commencement of welding




EXPLAIN purpose of each step -- see text Pages 1-10 thru 1-12

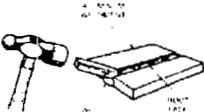
1. Compliance with all WPS provisions; especially welding parameters (meters, testers)
2. Placement and quality of key weld passes (root, etc..)
3. Sequencing and placement of individual weld passes

Module #1 -
WIP PHASE C IN-PROCESS
INSPECTION - 2

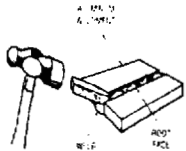

4. Interpass Temperature, Cleaning



5. Adequacy Of Back Gouging



6. Monitor In-Process NDE (If Any)

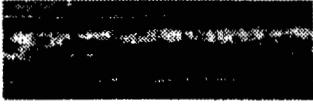
VIW 1-12

EXPLAIN purpose of each step -- see text Pages 1-10 thru 1-12

4. Verification of Interpass temperature and cleaning
5. Adequacy of back gouging (root treatment generally) Grinding and 'Arc-Air' most common
6. Monitoring of specified or necessary in-process NDE

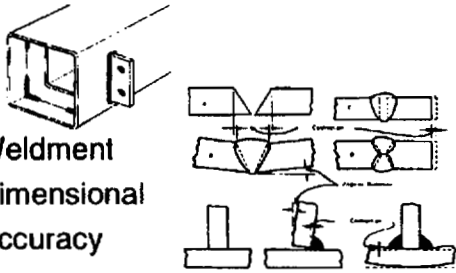

Module #1 -
WIP PHASE D
POST WELDING ACTIVITIES - 1

1. Verify Weld Appearance, Quality



2. Verify Weld Sizes, Lengths, Etc..

3. Weldment
Dimensional
Accuracy

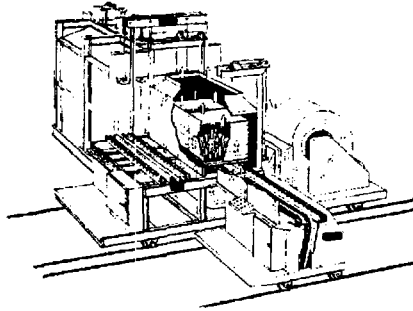
VIW 1-13

EXPLAIN purpose of each step -- see text Pages 1-14 through 1-16

1. Appearance and soundness of finished welds
2. Weld sizes, lengths, etc.
3. Dimensional accuracy of weldment, check for flatness, member straightness, etc.

**Module #1 -
WIP PHASE D
POST WELDING ACTIVITIES - 2**

- 4. Monitor/Evaluate Specified NDE
- 5. Monitor PWHT; Other Such Work



- 6. Finalize, Collate Job Documents



VIW 1-14

EXPLAIN purpose of each step -- see text Pages 1-16 thru 1-18


- 4. Carry out, monitor or evaluate all NDE reports
- 5. Monitor PWHT, other specified post weld work
- 6. Finalize, collate all inspection documentation

VIW Module #2

NDE OF WELDS & WELDING

AIMS Of Module #2

1. Consider
 - When, Where, Why
 - NDE may be necessary
2. REVIEW
 - NDE Processes Used In
 - Verification Of Weld Quality



VIW 2-1

INTRODUCE Module #2 refer Page 2-1

DISCUSS the aims as set in slide above

- Stress NDE is an adjunct to Visual Inspection NOT a substitute for it.
- Emphasize that each NDE method has its own area of application
NO UNIVERSAL METHOD.


VIW Module #2
VISUAL INSPECTION - VI

1. LIMITATIONS

- Surface Only
- Tight Discontinuities
- Code Mandated NDE

2. OTHER AIDS To VT

- Flashlight
- Borescope



VIW 2-2

REVIEW: Refer to Page 2-1

- Limitations of Visual Inspection
 - Confined to surfaces only
 - Very tight cracks, incomplete fusion
- NDE may thus be necessary when
 - Greater confidence level required
 - NDE is Code mandated
- Other aids to Visual Inspection
 1. Flashlight
 2. Borescope

VIW Module #2

LIQUID PENETRANT TEST - PT

1. Liquid Penetrant Applied
2. Dwell Time For Penetration
3. Excess Penetrant Removed
4. Developer Applied To Test Area
5. Test Area Examined



PT Applicable To All Metals;
Clean Surface To Allow Penetration



VIW 2-3

REVIEW PT refer to Pages 2-2 through 2-4

1. Application to welded joints

STRESS Clean surface -

Take each step in turn; review options, where applicable:

- Water washable, - Solvent soluble, - Emulsifiable
- Visible dye - Florescent dye

2. Importance of specified dwell time

3. Developer application -- Chalk suspension -- painted, aerosol OR by use of U-V light source -- see Figures for diagram references

Fig. 2.3 (method) and Fig. 2.4 (test kit) and for indications

Fig. 2.5 (visible dye - normal light)

Fig. 2.6 Florescent dye (U-V)

VIW Module #2

LIQUID PENETRANT FEATURES

> ADVANTAGES

- Portable; No Power Required *
- Suitable For All Metals
- Low Capital, Consumable Cost
- Prompt Results

> LIMITATIONS

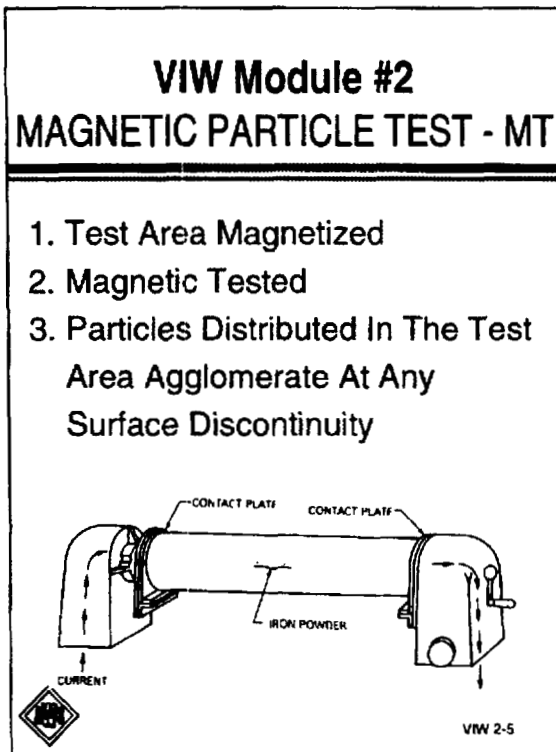
- Surface Discontinuities Only
- Requires 'Clean' Work Area
- Results Not Immediate (Dwell)
- No Permanent Record



VIW 2-4

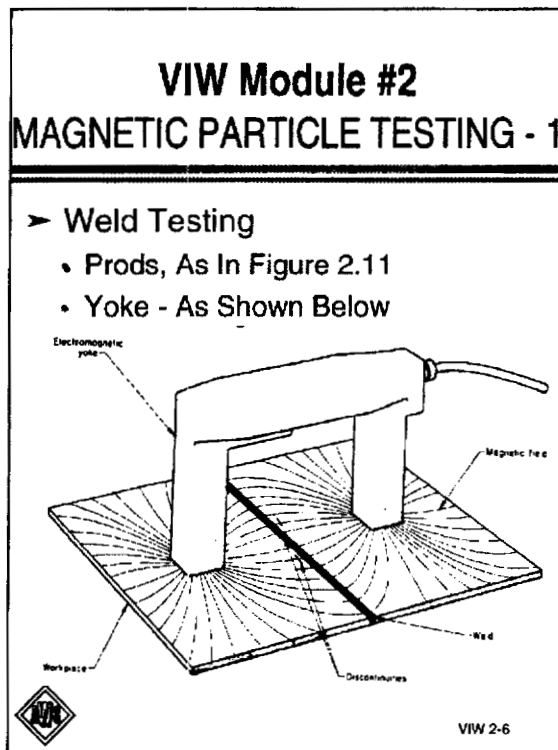
DISCUSS: Refer to Page 2-12

- Advantages of PT as set out above
- MENTION * Power required for light and U-V
- Limitation of PT as set out above



EXPLAIN: Refer to Page 2-4 and 2-5

- Mechanism of test
- Head Shot (circular magnetism); as above
- Longitudinal magnetism (for 'transverse' defects)



DISCUSS: Refer to pages 2-5 and 2-6

•Application of MT to welding:

1. Use of prods, as in Fig. 2.11
2. Use of Yoke, as in Fig. 2.12 and above

•Magnetic particles -- types visible light; U-V light

•Dispersion in test area -- puffer, aerosol (in liquid)

•Use of AC, DC, Half wave DC for magnetizing

REPEAT:

•Types of magnetism - influence of defect orientation

VIW Module #2

MAGNETIC PARTICLE TESTING - 2

➤ ADVANTAGES

- Portable; No Power Required
- Surface Condition Not Critical
- Low Capital, Consumable Cost
- Immediate Results

➤ LIMITATIONS

- Ferromagnetic Metals Only
- Some Systems Need Power
- May Require Demagnetizing
- No Permanent Record



VIW 2-7

REVIEW: Refer to pages 2.6 and 2.7

Advantages of MT

Limitations of MT

•Draw attention to Fig. 2.13 -

1. At left, a shaft as it appears visually
2. Center, same shaft MT with DC
3. At right, same shaft MT - half-wave AC

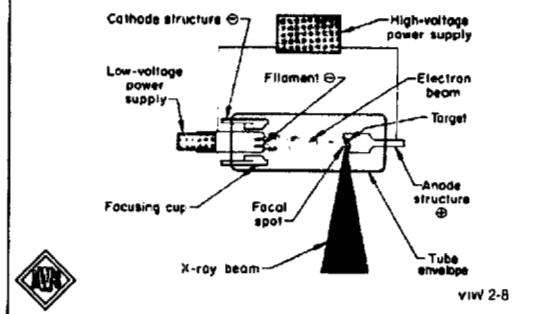
•Mention:

- Contrast medium
- Demagnetization (for machined parts mostly).
- Non-magnetic steels (3XX stainless; 14% Mn, etc..)

VIW Module #2

RADIOGRAPHY - RT (1)

- Radiography - X-rays; Gamma Rays
 - Gamma Rays - Isotopes Such As Ir 192, Co 60 Mostly Used
 - X-Rays Generated In 'Machine' 'Power' Function Of Voltage (kV)

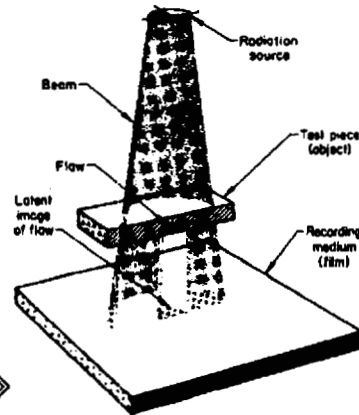


DISCUSS: Refer to Pages 2-7 and 2-8

- Potential need for test methods for subsurface defects
- Radiography oldest of such methods
- Use of isotopes Ir 192 -- Co 60 greater penetration
- Generation of X-rays -- voltage vs. useful thickness

VIW Module #2 RADIOGRAPHY - RT (2)

- Differential absorption of radiation
 - > Or < film image 'blackening'
 - based on job density/thickness



VIW 2-9

DISCUSS: Refer Pages 2-7 through 2-9

- Film 'blackening' as function of radiation
 - No defects (uniform density) - uniform image
- In presence of defect, more (or less for dense defects) radiation reaches film --film image changes
- Make up of film - substrate, 2-sided emulsion
 - Development as photographic film

VIW Module #2

RADIOGRAPHY - RT (3)

➤ **ADVANTAGES**

- Gamma Rays; No Power Required
- Subsurface Defects Detectable
- OK Up To 6" - 8" Job Thickness
- Permanent Record Of Test

➤ **LIMITATIONS**

- High Cost Equipment And Film
- Radiation Is A Safety Hazard
- Defect Orientation 'Normal' Only
- Requires Skilled Image Reading



VIW 2-10

REVIEW: Refer to Pages 2-8 and 2-9

- Text Fig. 2.15
- Role of IQI's and 'sensitivity'
- Image density and effect of 'readability'

- Text Fig. 2.17
- Defect in job and on film

- Advantages and limitations as outlined above

VIW Module #3 - WELD DISCONTINUITIES

- **Aims** - Review Discontinuities,
 - Consider Their Formation
 - Comment Of Potential Severity
- **Welded Joint Integrity**
 - DESIGN Of Weldment, Joints
 - BASE And FILLER METALS
 - Welding PROCEDURE
 - Welder SKILL
 - INSPECTION Program
- **Significance Of Discontinuities**
 - Based on
 - Linearity
 - End Condition

VIW 3-1

- **EXPLAIN:** Text reference Page /s 3.1
- **AIMS of Module #3**
 - Why, when, where are discontinuities formed
 - Review potential severity
 - Loss of section is ONE factor
 - More important is stress concentration
- Welded joint integrity based on the listed factors
- Significance (severity) of discontinuities based on:
 - A. Linearity (>3 x next largest dimension)
 - B. End condition - sharpness : stress concentration

VIW Module #3 - Weld DISCONTINUITIES - CRACKS (1)

- CRACK OCCURRENCE - If Load Exceeds Local Strength
- LOAD - Applied, From Welding
- STRENGTH - Microstructure
- HYDROGEN - Ferrous Metals
- WELDING - Potential To Affect Local Microstructure Of Metal And To Introduce HYDROGEN



VIW 3-2

•DISCUSS: Text Reference - Page/s 3.2

•

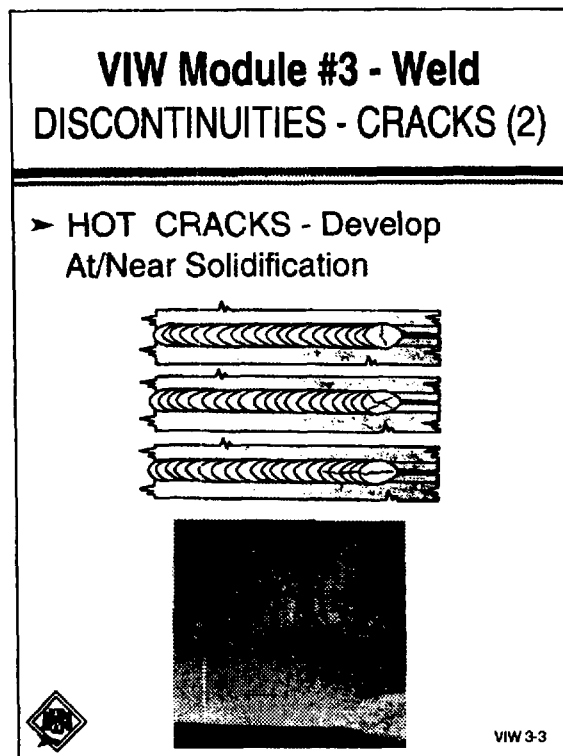
•CRACKS

- Occur when local load *
- Exceeds local strength **

•* Live load, Weld shrinkage; Restraint,

•** Dependent on microstructure

•Refer to Fig. 3.2 - Discuss how hydrogen embattles metal



•Text Reference - Page/s 3.2 and 3.3, Fig. 3.3

•**EXPLAIN:**

- ◆HOT cracks - at/near solidification
- ◆COLD cracks - at/below transition

•**DISCUSS:**

- ◆Hot crack formation
- ◆Impurities
- ◆Liquid films
- ◆W to D ratio
- ◆Off analysis steel (particularly Sulfur)

VIW Module #3 - Weld DISCONTINUITIES - CRACKS (3)

➤ COLD CRACKS

- Develop Below Transformation
- Fundamental Causes
 - Base Metal 'Weldability'
 - Weld Procedure 'Suitability'
- Generally Start From HAZ
 - Hardened By 'Cooling Rate'
 - Hydrogen May Have Influence
 - May Or May Not Break Surface
 - Single Or Branching Crack/s - Longitudinal Or Transverse
- Avoided By Controlling The Items Shown In Bold Italic Type



VIW 3-4

- Text Reference - Page/s 3.3 and 3.4, Fig 3.4, 3.5

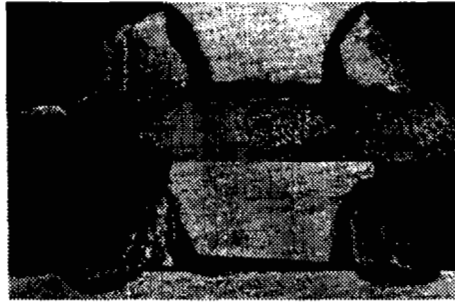
•REVIEW:

- Causes
 - Role of **WELDABILITY** (base metal)
 - **WELDING PROCEDURE** - leading to
 - **COOLING RATE**
 - **HYDROGEN**
 - Types and nomenclature of (cold) cracks
 - Delayed cracking

VIW Module #3 - Weld DISCONTINUITIES - FUSION

► Incomplete Fusion

- Between Weld And Base Metal
- Between Weld Passes
- At The Root Of A Joint



VIW 3-5

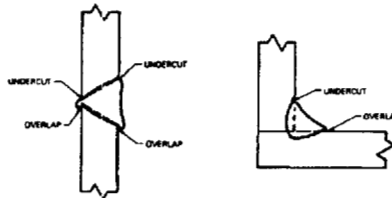
•Text Reference - Page/s 3.4 and 3.5, Fig 3.6

•EXPLAIN:

- FUSION basis of welding
- Incomplete fusion
 - - to the sidewall
 - - between weld passes
 - - at joint root
- Overlap - at toes of joints

VIW Module #3 - Weld DISCONTINUITIES - FUSION

- Incomplete Fusion Caused By
- Molten Weld Metal 'Running' Over Unmelted Base Metal
 - Faulty Electrode Manipulation
 - Overlap - Weld Metal Rollover

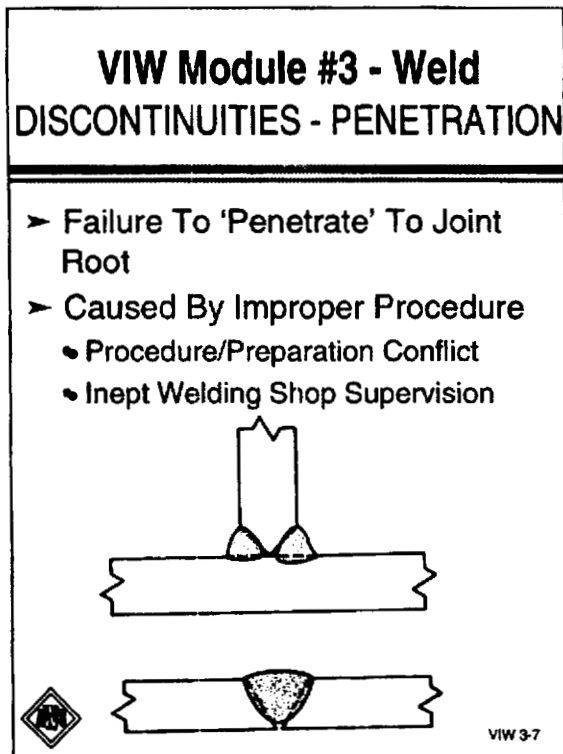


VIW 3-6

•Text Reference - Page/s 3.4 and 3.5, Fig 3.6

•**REVIEW:**

-
- Cause of incomplete fusion -- mostly arc manipulation
- Significance; difficulty of detection
- Overlap common -- look closely position fillet welds



•Text Reference - Page/s 3.5 and 3.6, Fig 3.7

•**REVIEW:**

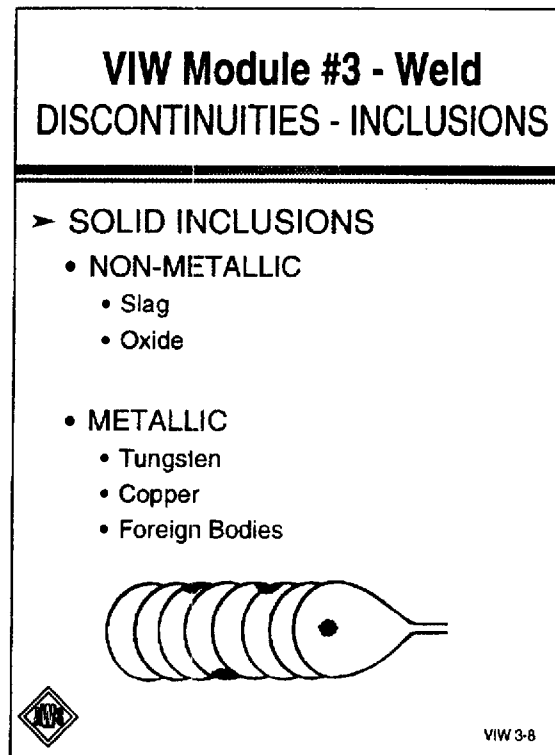
• Need for full penetration of joints--

• Differentiate:

- Incomplete Fusion
- Incomplete Penetration

• Procedure deficiency or failure to enforce procedure provisions

• Role of back gouging - relationship to Inspection



Text Reference - Page/s 3.5 and 3.6, Fig 3.7

DISCUSS:

- Solid Inclusions--
 - Differentiate
 - Nonmetallic
 - Metallic

VIW Module #3 - Weld DISCONTINUITIES - SLAG

➤ **SLAG - Causes**

- Unsuitable Weld Bead Shape



- Excessive Weaving



- Ineffective Weld Cleaning
- Poor Electrode Manipulation


VIW 3-9

Text Reference - Page/s 3.6 and 3.7, Fig 3.8

DISCUSS:

- Causes of slag inclusions
 - Weld bead shape
 - Electrode manipulation
 - Interpass cleaning

VIW Module #3 - Weld DISCONTINUITIES - METALS

➤ METALLIC -

- TUNGSTEN - Electrode Welding
- COPPER - PAW
- GMAW (Whiskers)
- Spatter In Front Of Arc
- 'Fillers' In Groove



VIW 3-10

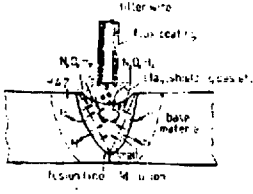
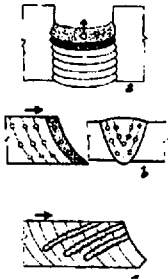
Text Reference - Page/s 3.6 and 3.7

REVIEW:

- Tungsten Inclusions (GTAW?, PAW?)
 - electrode 'spitting'
 - electrode-molten metal contact
- Copper (PAW)
 - constricting nozzle 'wear'
- Spatter in weld groove (GMAW?, FCAW?)
- "Fillers" - legal, otherwise
- Whiskers (GMAW)

VIW Module #3 - Weld DISCONTINUITIES - GASEOUS


➤ Gases Entrapped In Weld Metal - Introduced During Welding

➤ Types Of Porosity

- Isolated, Grouped, Cluster, Linear
- Piping, Vermicular

➤ Role Of CO, Hydrogen



VIW 3-11

Text Reference - Page/s 3.7, Fig 3.9

DISCUSS:

- Molten metal affinity for gases (above, left)
- 'Good' welding technique allows for escape
- Types of porosity
- Role of CO (carbon monoxide) in pore formation

VIW Module #3 - Weld DISCONTINUITIES - SHAPE

➤ SHAPE

- Influences Weld Size
- Stress Concentration
 - Critical For Cyclic Loading

(Refer To Reference Manual, Fig. 3.10)

➤ Many 'Defective' Weld Shapes

- Incomplete Fusion, Overlap
- Under Filled Groove Welds
- Under Sized Filler Welds
- Undercut; Grooves, Fillets



VIW 3-12

Text Reference - Page/s 3-8 to 3.10, Figs 3.10 to 3.12

REVIEW:

- Fig. 3.12 then Fig. 3.10

DISCUSS:

- Influence of shape
- Other shape discontinuities listed above

VIW Module #3 - Weld DISCONTINUITIES - WELDING

- SPATTER
 - Unsuitable Welding Parameters
 - Inappropriate Arc Manipulation
 - Usually No Major Significance
 - But Detracts From Appearance
- ARC STRIKE
 - Live Part Of Welding Circuit Makes Accidental Job Contact
 - Correction Action Required
- POOR TIE-IN
 - Improper Starting Technique



VIW 3-13

Text Reference - Page/s 3.10 and 3.11

REVIEW:

- Discontinuities listed on slide:
- Spatter as a 'side effect' of some parameter problem
- Arc strike
 - attention to detail
 - corrective action
- Poor tie-in - welding problem

VIW Module #3 - Weld DISCONTINUITIES - BASE METAL

- LAPS & SEAMS
- LAMINATIONS
- DELAMINATION
- LAMELLAR TEARING
 - Internal Weakness
 - May Be Exacerbated By Welding
 - CAUSATIVE FACTORS
 - Weld Shrinkage In Through Thickness Direction (z-z Axis)
 - Joint Design - z-z Axis Load



VIW 3-14

Text Reference - Page 3.11, Figs 3.13 and 3.14

REVIEW:

- Base metal discontinuities
 - Laps and Seams
 - Laminations
 - Delamination
- LAMELLAR TEARING
 - Weld shrinkage of Z-Z axis
 - Role of joint design if stress on Z-Z axis

Module #4 - WELDING CODES & SPECIFICATIONS

- **AIMS Of Module #4**
 - To Consider Role Of Codes, Etc. In Welding Inspection
 - To Review/Practice Method To Find "Code References"
- **INTRODUCTION To Module**
 - **JOB QUALITY** - Conformance To Specification
 - **INSPECTION** - Comparing The Requirements To The Job Produced



VIW 4-1

•Refer to text page/s 4-1

•**REVIEW:**

•Aims of Module #4 and amplify

•**DISCUSS:**

•**JOB QUALITY** definition

•**INSPECTION** - as on slide

**Module #4 -
FINDING CODE REFERENCES -
METHOD (0)**

- **FAMILIARITY With 'Code'**
 - Learn The Code's Structure
 - Learn The "Indexing" System
 - Find Out How 'References' Are Identified
 - Learn How Data Are Grouped
 - Sections - Cover What ?
 - Sub-Sections - Cover What ?
 - Paragraphs - Cover What ?
 - Sub-paragraphs - Cover What ?
- **Understand - Not Memorize**



VIW 4-2


- Refer to text page/s 4-1

•**REVIEW:**

- Steps in becoming familiar with a "CODE"
- Generally as outlined on slide

Module #4 -
FINDING CODE REFERENCES -
METHOD (1)

- Convert Required 'Information'
Into Form Of A QUESTION
- Identify In The 'Question' KEY
WORDS Or KEY PHRASES
- SEARCH Index (Content Table)
For Key Words/Phrases
- FIND The Required 'Reference'
In Code Text -- Confirm As
Applicable


VIW 4-3

•Refer to text page/s 4-1

•**REVIEW:**

- Individual steps as set out on Slide
- Give examples using Part B

Module #4 - FINDING CODE REFERENCES - PART B (1)

► Table of Contents - Front Cover

- Appendix I & II - Forms
- Appendix III - Prequalified CJP
- Appendix IV - Pipe Schedules
- Appendix V, VI, VII - Visual
- Appendix VIII - Bend tests
- Appendix IX & X - Weld metal
- Appendix XI - Welder qualification
- Appendix XII & XIII - Procedures
- Appendix XIV - Base/filler Metal
- Appendix XV - PH & IT Table



VIW 4-4

•Refer to text page/s 4-2 and 4-3

•REVIEW:

- Front Cover of Specification Part B
- Enumerate and give a short synopsis of each

Module #4 - FINDING CODE REFERENCES - PART B (2)

- APPENDIX - I
 - Form Procedure Test Record - Fields Numbered (For ID)
- APPENDIX - II
 - Form - Welder Test Record - Fields Numbered
- APPENDIX - III
 - Details - Prequalified CJP Groove Welded Joints
- APPENDIX - IV
 - Pipe Schedules; OD, Wall 't'



VIW 4-5

•Refer to text page/s 4-4 and 4-5

•**REVIEW:**

- Appendix I and II - Take important fields and ensure each term
- understood.

•Refer to Pages 4-6 and 4-7

•Appendix III - Take examples and work through


- -Groove preparations and other headings;
- -Emphasize Tolerances and Notes

•Appendix IV - Table of Pipe Schedules

- -Use for reference in qualification and for thickness

Module #4 -
FINDING CODE REFERENCES -
PART B (3)

- **APPENDIX - V**
 - Weld Profile Conformance Chart For Fillet, Groove Welds
- **APPENDIX - VI**
 - Amplifies Information Given In Appendix V
- **APPENDIX - VII**
 - Specifies Requirements for Visual Inspection Of Welds
- **APPENDIX - VIII**
 - Requirements For Bend Tests


VIW 4-6

•Refer to text page/s 4-8 and 4-9

•**REVIEW:**

•Appendix V and VI - Weld Profiles

- - Draw attention to "C" and to "R"

•Appendix VII - Quality of Weld Visual requirements

- - Clarify 'transverse', 'parallel' undercut

•Appendix VIII - Guided bend test requirements

Module #4 - FINDING CODE REFERENCES - PART B (4)

- APPENDIX - IX
 - Lists A-Numbers For Weld Metal Analyses
- APPENDIX - X
 - Lists F-Numbers for Procedure And Welder Qualification
- APPENDIX - XI
 - Welder Qualification Test Requirements
- APPENDIX - XII
 - Requirements For Fillet Weld Procedure Qualification



VIW 4-7

•Refer to text page/s 4-10 through 4-15 and Fig. 4.1, 4.2

•REVIEW:

•Appendix IX and Appendix X


- -Purposes of A-numbers (procedure qualification) and mention dilution (Fig 4.1)
- -F-numbers to qualify procedure and performance

•Appendix XI

- -Welder qualification requirements

•Appendix XII

- -Fillet weld procedure qualification - Refer to Fig. 4.2

Module #4 - FINDING CODE REFERENCES - PART B (5)	
➤	APPENDIX - XIII
•	Butt Weld Procedure Qualification Requirements
➤	APPENDIX -XIV
•	Base Metal Strengths With
•	Matching Filler Metals And Their Corresponding Strengths
➤	APPENDIX - XV
•	Table Of Steels, With Preheat And Interpass Temperatures for 4 Ranges Of Thickness
	VIW 4-8

•Refer to text page/s 4-14 through 4-19

•**REVIEW:**

•Appendix XIII

- -Butt weld procedure qualification - review details
- -NOTE - Tables within Appendix; main, other headings

•Appendix XIV

- -Base Metal and Matching Filler Metals - with strength
- -Metal groups; purpose; Applicable welding processes 'Matching' base metal and filler metal strengths
- - Electrode specifications (A5.x) and classifications (Exxxx)

•Appendix XV - Preheat and Interpass Temperatures

- -Metals in 2 columns in each group. NOTE Four thickness
- ranges
-

Module #4 -
FINDING CODE REFERENCES -
PRACTICE (1)

- **EXERCISE 1**
 - For Procedure Qualification 3G
Upwards - Record Where?
- **KEY TERMS - In levels**
 - Procedure Qualification (1st)
 - Position, Progression (2nd)
- **TABLE OF CONTENTS**
 - Procedure Qualification - Appendix I
- **In APPENDIX I**
 - Find 'Position' - Field 4
 - Find 'Progression' - Field 13



VIW 4-9

Refer to text page 4-20

- **WORK THROUGH EXAMPLES:**
 - Amplify as required

Module #4 -
FINDING CODE REFERENCES -
PRACTICE (2)

➤ **EXERCISE 2**

- Joint B-U2a, Members At 160 Square Groove, 7/16" Gap. Is Any Inspector Action Required?

➤ **QUESTION**

- What Angle/Root Opening Is Required For B-U2a ?

➤ **KEY TERMS**

- Prequalified Joints (1st Level)
Groove Angle, Root Opening

➤ **TABLE Of CONTENTS**

- Appendix III



VIW 4-10

Refer to text page 4-20

- **WORK THROUGH EXAMPLES:**
 - Amplify as required

Module #4 -
FINDING CODE REFERENCES -
PRACTICE (3)

- **EXERCISE 2 (Continued)**
 - Go To Appendix III
 - Note N-1600 OK -200 'Bevel'
 - If 20 Bevel, 1/2" Root Opening
 - Fit Up Tolerance +/- 1/16"
 - No Inspection Action Required
- **EXERCISE 3**
 - Welder To Be Qualified On 4" Sch 60 Pipe In 2G Position
 - For What Other Positions Will Welder Be Qualified If Test OK



VIW 4-11

Refer to text page 4-20

- **WORK THROUGH EXAMPLES:**
 - Amplify as required

**Module #4 -
FINDING CODE REFERENCES -
PRACTICE (4)**

- EXERCISE 3 (continued)
 - Welder Qualification - APPENDIX XI
 - Table 2 Shows 4" Sch 60 Not A Size For Welder Qualification
- Test Is Thus Invalid For Part B
- SUMMARY
 - Convert Input Data To Question
 - Select 'Key Word/s' From Same
 - Find Key Words In Index/T Of C
 - Find/Confirm Reference Found



VIW 4-12

Refer to text page 4-20

- WORK THROUGH EXAMPLE:
 - Amplify as required
- SUMMARIZE:
 - Method for finding specification references

Module #5 - MEASUREMENTS OF WELDING - INTRODUCTION

- **AIMS Of Module #5**
 - Introduce/Review Instruments, Gages Used In Weld Inspection
 - Practice Their Use In Inspection
 - Review Basic Welding Math
 - Practice US/ISO Conversions
- **INTRODUCTION**
 - Weld/Welding Measurements; Used To Establish 'Quality'
 - Math Required For Calculations
 - Conversions Used To Extend Instrument Functionality



VIW 5-1

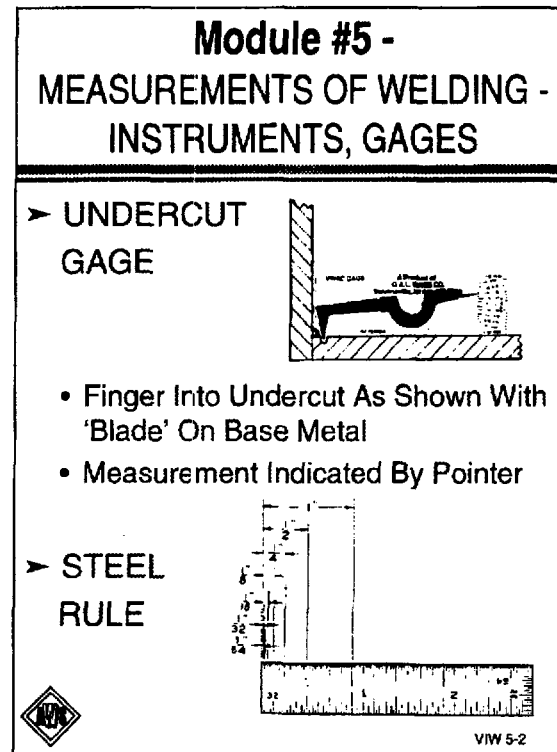
Refer to text page/s 5 -1

REVIEW:

- Aims of Module #5 and amplify

DISCUSS:

- Conformance to specification - requires
 - "Measurement" - mostly physical
 - Use of instruments, tools and gages
 - Need for familiarity with metric units



Refer to text page/s 5-2

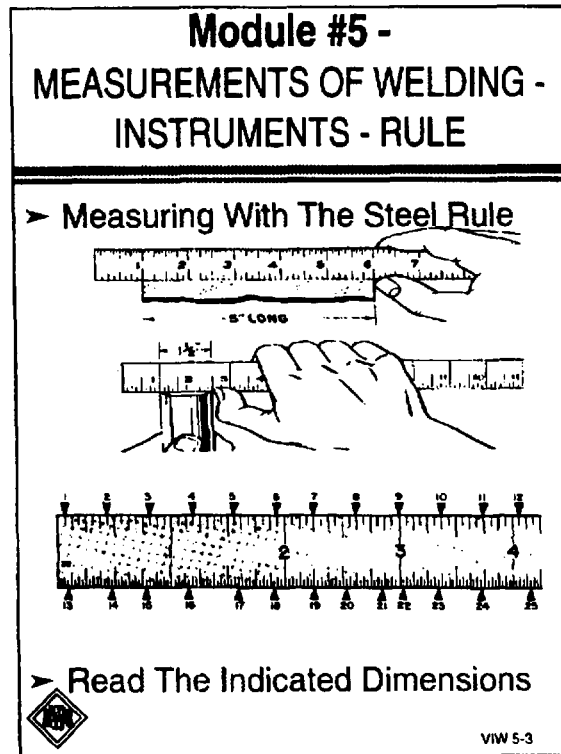
REVIEW:

- Inspection instruments in Fig. 5.1

DISCUSS:

- Use of UNDERCUT GAGE - Fig. 5.2
 - **Zeroing of instrument of plane surface**
 - **Need to have 'blade' at or near 'normal' (at a right angle) to the undercut weld axis**
 - **Unsuitability of instrument to measure undercut as in Appendix VII of Part B, paragraph (5)**

Refer to Fig. 1.21



Refer to text page/s 5-3

REVIEW:

- Steel rule in Fig. 5.3 and on slide

DISCUSS:

- Use of steel rule
 - Parallax
 - Measuring discontinuities - from 1" mark
 - Difficulty in measuring undercut

PRACTICE:

- READING INDICATED DIMENSIONS FROM SLIDE



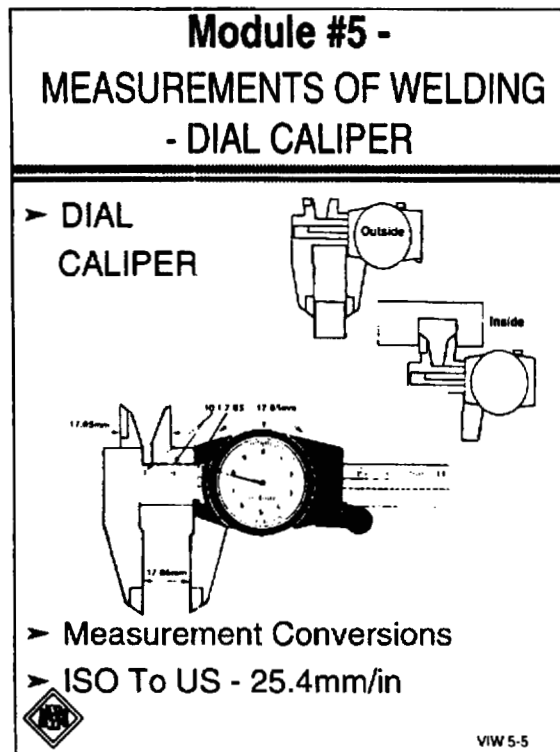
Refer to text page/s 5-4 and 5.5

REVIEW:

- Micrometer in Fig. 5.4 - name the parts

DISCUSS:

- Zeroing and calibration (see Fig. 5.5)
 - Practice on instrument in kit
 - Reading the instrument-Fig. 5.6 and Fig. 5.7
 - Read the dimensions from the slide.
-
- NOTE: MIC is the abbreviated form of 'MICROMETER', pronounced as the name mike.



Refer to text page/s 5-6 and 5.7

REVIEW:

- Construction of instrument

DISCUSS:

- Zeroing of instrument
- Taking 'outside' dimensions
- Taking 'inside' dimensions

PRACTICE:

- Determining indicated dimensions

Module #5 - MEASUREMENTS OF WELDING - US/ISO CONVERSION

➤ LINEAR DIMENSIONS

- BASIS - 25.4 mm/inch
- 2" @ 25.4mm/in. = 50.8 mm

➤ NOTE - Factor, Not An Equality

- 30 mm @ 25.4mm/in = 1.18 in
- 100mm @ 25.4mm/in = 3.739 in
- 154 mm @ 25.4 mm/in = ? in.
- 16.85 mm @ 25.4 mm/in = ? in
- 3.22 in @ 25.4 mm/in = ? mm
- 13/16 in @ 25.4 mm/in = ? mm



VIW 5-6

Refer to text page/s 5-7

REVIEW:

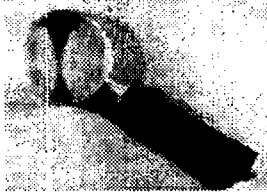
- Principle of linear conversions
- Applicability to all conversion FACTORS

DISCUSS:

- Examples on Slide and work examples

**Module #5 -
MEASUREMENTS OF WELDING -
INSTRUMENTS & AIDS**


➤ Magnifier - To Assist Accuracy



➤ Compare Instrument Uses

- Scale Rule And Micrometer
- Micrometer And Dial Caliper
- Dial Caliper And Scale Rule

➤ Work With/Without Magnifier

VIW 5-7

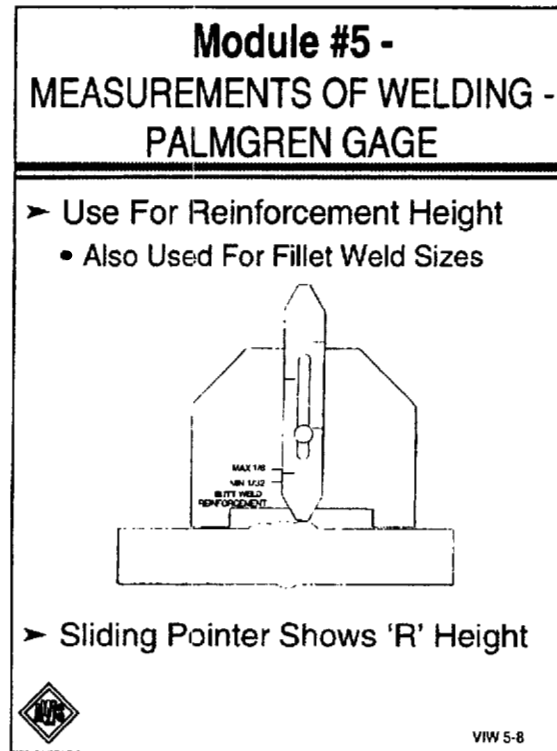
Refer to text page/s 5-8

REVIEW:

- Use of Magnifier in Fig. 5.12

PRACTICE:

- Use of linear measuring instruments
- Make comparisons as to what instrument to use in any given situation



Refer to text page/s 5-9

REVIEW:

- Inspection instrument in Fig. 5.13
 - a) Originally used to find fillet weld sizes but requires accurate right angle between members
 - b) Best suited to finding reinforcement ('R') height

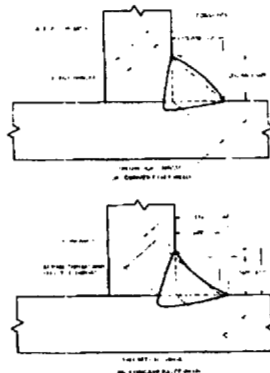
DISCUSS:

- Use of PALMGREN Gage
 - a) As fillet size gage
 - b) When used to find reinforcement height

Module #5 - MEASUREMENTS OF WELDING - FILLET WELDS

► FILLET WELDS

- Most Used
- Weld Strength - 'Effective Throat'
- Weld Cost - Function Of Weld Size



VIW 5-9

Refer to text page/s 5-9

REVIEW:

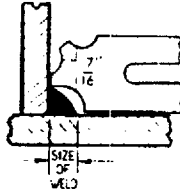
- Fillet weld dimensions Fig. 5.14

DISCUSS:

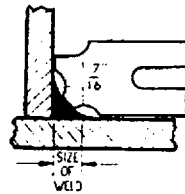
- Actual throat (as produced)
- Theoretical throat
- Effective throat

Module #5 - MEASUREMENTS OF WELDING - FILLET GAGES

CONVEX



CONCAVE



- Convex Gage Measures Weld Size From 'Leg' Length (2 Measurements)
- Concave Gage Measures Throat -- Weld Size Read Directly From Gage But Derived From: $S = T/0.707$



VIW 5-10

Refer to text page/s 5-10

REVIEW:

- Use of fillet weld gage - Fig. 4.16

DISCUSS:

- Determining which gage to use
- Use of CONVEX gage - double action
- Use of CONCAVE gage - single action

Module #5 - MEASUREMENTS OF WELDING - CALCULATIONS (1)

➤ Heat Input (In US Units)

- Heat Input $HI = E \times I \times 60 / v$
- Expressed As Joules/inch
- Welding - 25 volts, 200 amps
And 6 inches/min.. Find HI

=

$$25 \times 200 \times 60 / 6 = 50 \text{ kJ/in}$$

➤ Tensile (And Yield) Strength

- $TS = \text{Load (L)} / \text{Area (A)}$
- Expressed As psi or ksi
- $L = 10,000 \text{ lb.}; A = 0.2 \text{ sq. in}$
- $TS = 10,000 / 0.2 = 50 \text{ ksi}$



VIW 5-11

Refer to text page/s 5-11

REVIEW:

- Principle for determining Heat Input
- Joule = watt second
- Volts x Amps = watts

DISCUSS:

- US units (using 60 to convert minutes to seconds in the term 'v' (velocity or rate of travel))
- Tensile (and yield) strength calculations
- Strength + Load (at time of interest) divided by (original) Area

Module #5 - MEASUREMENTS OF WELDING - CALCULATIONS (2)

- % Elongation (% EI)
 - OL = Original Length (Gage)
 - FL = Final Length
- $\% EI = \{(FL - OL) / OL\} \times 100$
- If OL = 2" And FL = 2.75"
- $\% EI = 2.75 - 2 / 2 \times 100 = 37.5\%$
- % Reduction Of Area (% RA)
 - OA = Original A; FA = Final A.
- $\% RA = \{(OA - FA) / OA\} \times 100$
- If OA = 0.7 sq" & FA = 0.3 sq"
- $\% RA = 0.7 - 0.3 / 0.7 \times 100 = 57\%$



VIW 5-12

Refer to text page/s 5-12

REVIEW:

- Ductility measurements

DISCUSS:

- Use and application of formulas