



FACULTAD DE INGENIERÍA UNAM
DIVISIÓN DE EDUCACIÓN CONTINUA



...: Mecánica e Industrial

CURSOS ABIERTOS

CURSO CA 277

FABRICACIÓN DE RECIPIENTES A PRESIÓN CONFORME A LA SECCIÓN VIII, DIV 1 DEL CÓDIGO ASME

PERIODO
DEL 4 AL 8 DE ABRIL

APUNTES GENERALES

Instructor:
Ing. Orlando Rafael Rivera Mendoza

PALACIO DE MINERÍA
2005

UNIVERSIDAD NACIONAL AUTONOMA DE MÉXICO

**FACULTAD DE INGENIERIA
DIVISIÓN DE EDUCACIÓN CONTINUA**

CURSO / MODULO

FABRICACION

DE

RECIPIENTES A PRESION

CONFORME A SECCION VIII, DIV.1 DEL CODIGO ASME

Instructor : Ing. Orlando R. Rivera

Duración Total: 20 Horas

Lunes a Viernes de 17:00 a 21:00 Horas

UNIVERSIDAD NACIONAL AUTONOMA DE MÉXICO

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CONFORME A SECCION VIII, DIV.1 DEL CODIGO ASME

Este curso / módulo está enfocado a la formación de profesionales que deseen desempeñar una de las actividades más demandadas dentro del campo de los recipientes sujetos a presión. El programa incluye los temas de actualidad del Código ASME y los de mayor aplicación dictados por la industria del ramo.

OBJETIVO GENERAL:

Proporcionar los conocimientos mínimos requeridos para fabricar cualquier recipiente sujeto a presión conforme a los requisitos obligatorios establecidos en la Sección VIII, División 1 del Código ASME.

DIRIGIDO A:

El curso / módulo esta dirigido a firmas de ingeniería, fabricantes, compañías de inspección, empresas de consultoría, y en general a todos los ingenieros, personal técnico y profesionistas que deseen especializarse o actualizar sus conocimientos en estos temas del Código ASME.

2001 ASME BOILER AND PRESSURE VESSEL CODE

SECTIONS

- I Rules for Construction of Power Boilers
- II Materials
 - Part A — Ferrous Material Specifications
 - Part B — Nonferrous Material Specifications
 - Part C — Specifications for Welding Rods, Electrodes, and Filler Metals
 - Part D — Properties
- III Subsection NCA — General Requirements for Division 1 and Division 2
- III Division 1
 - Subsection NB — Class 1 Components
 - Subsection NC — Class 2 Components
 - Subsection ND — Class 3 Components
 - Subsection NE — Class MC Components
 - Subsection NF — Supports
 - Subsection NG — Core Support Structures
 - Subsection NH — Class 1 Components in Elevated Temperature Service
 - Appendices
- III Division 2 — Code for Concrete Reactor Vessels and Containments
- III Division 3 — Containment Systems for Storage and Transport Packagings of Spent Nuclear Fuel and High Level Radioactive Material and Waste
- IV Rules for Construction of Heating Boilers
- V Nondestructive Examination
- VI Recommended Rules for the Care and Operation of Heating Boilers
- VII Recommended Guidelines for the Care of Power Boilers
- VIII Rules for Construction of Pressure Vessels
 - Division 1
 - Division 2 — Alternative Rules
 - Division 3 — Alternative Rules for Construction of High Pressure Vessels
- IX Welding and Brazing Qualifications
- X Fiber-Reinforced Plastic Pressure Vessels
- XI Rules for Inservice Inspection of Nuclear Power Plant Components

ADDENDA

Colored-sheet Addenda, which include additions and revisions to individual Sections of the Code, are published annually and will be sent automatically to purchasers of the applicable Sections up to the publication of the 2004 Code. The 2001 Code is available only in the loose-leaf format; accordingly, the Addenda will be issued in the loose leaf, replacement-page format.

INTERPRETATIONS

ASME issues written replies to inquiries concerning interpretation of technical aspects of the Code. The Interpretations for each individual Section will be published separately and will be included as part of the update service to that Section. They will be issued semiannually (July and December) up to the publication of the 2004 Code. Interpretations of Section III, Divisions 1 and 2, will be included with the update service to Subsection NCA.

CODE CASES

The Boiler and Pressure Vessel Committee meets regularly to consider proposed additions and revisions to the Code and to formulate Cases to clarify the intent of existing requirements or provide, when the need is urgent, rules for materials or constructions not covered by existing Code rules. Those Cases which have been adopted will appear in the appropriate 2001 Code Cases book: (1) Boilers and Pressure Vessels and (2) Nuclear Components. Supplements will be sent automatically to the purchasers of the Code Cases books up to the publication of the 2004 Code.

THE SCOPE OF SECTION VIII, DIVISION 1

THE SCOPE OF SECTION VIII, DIVISION 1 IS INTENDED TO COVER, BUT NOT BE LIMITED TO:

- VESSELS CONTAINING WATER UNDER PRESSURE THAT EXCEED:
 - A DESIGN PRESSURE OF 300 PSI
 - A DESIGN TEMPERATURE OF 210 F.
- HOT WATER TANKS HEATED BY INDIRECT MEANS THAT EXCEED:
 - 200,000 BTU's/HR.
 - 210 F
 - 120 GALLONS
- VESSELS HAVING AN I. D. GREATER THAN 6 INCHES.
- VESSELS HAVING AN INTERNAL OR EXTERNAL OPERATING PRESSURE GREATER THAN 15 PSI.
- VESSELS HAVING A DESIGN PRESSURE NOT EXCEEDING 3,000 PSI.

HOWEVER, PLEASE NOTE THAT U-1(K) STATES THAT "ANY PRESSURE VESSEL WHICH MEETS ALL THE REQUIREMENTS OF THIS DIVISION, INCLUDING THOSE FOR INSPECTION, MAY BE STAMPED WITH THE 'U' SYMBOL EVEN THOUGH EXEMPTED FROM SUCH STAMPING". IN OTHER WORDS, "ANYTHING AND EVERYTHING".

THE SCOPE OF SECTION I POWER BOILERS

THE SCOPE OF SECTION I IS INTENDED TO COVER:

- POWER BOILERS-STEAM OR VAPOR EXCEEDING 15 PSI.
- ELECTRIC BOILERS-POWER OR HIGH TEMPERATURE BOILERS HEATED ELECTRICALLY.
- MINIATURE BOILERS-POWER OR HIGH TEMPERATURE BOILERS.
- HIGH TEMPERATURE WATER BOILERS-GREATER THAN 160 PSI AND/OR 250 F.
- UNFIRED STEAM BOILERS-SECTION 1 OR VIII, DIVISION 1.
- EXPANSION TANKS-SECTION 1 OR VIII, DIVISION 1.

THE SCOPE OF SECTION VIII, DIVISION 2

THIS CODE CONTAINS ALTERNATIVE RULES TO THE MINIMUM CONSTRUCTION REQUIREMENTS FOR INSPECTION AND CERTIFICATION OF VESSELS FALLING WITHIN THE SCOPE OF SECTION VIII, DIV. 1. THESE ALTERNATIVE RULES ARE MORE STRINGENT IN THE AREAS OF DESIGN, N.D.E. AND MATERIALS.

THE FABRICATION CODES

THESE CODES ARE REFERRED TO AS CONSTRUCTION CODES OR BOOK CODES. IN ANY CASE, THEY ARE THE CODES TO WHICH AN ITEM IS MANUFACTURED. THE BOOK CODES ARE:

- SECTION I, POWER BOILERS
- SECTION III, NUCLEAR
- SECTION IV, HEATING BOILERS
- SECTION VIII (DIVISIONS 1 AND 2) PRESSURE VESSELS
- SECTION X, FIBER GLASS VESSELS

THE REFERENCE CODES

THESE CODES ARE REFERRED TO BY THE BOOK CODES. THEY ARE TO BE USED ONLY WHEN REFERENCED BY THE BOOK CODES AND USED ONLY AS DESCRIBED IN THE BOOK CODE.

- SECTION II, MATERIALS
- SECTION V, N.D.E.
- SECTION IX, WELDING QUALIFICATIONS

REVISIONS TO THE CODE

- A REVISION TO THE CODE IS A CHANGE IN PREVIOUS REQUIREMENTS. THEY BECOME MANDATORY SIX MONTHS AFTER ISSUANCE.
- THESE REVISIONS ARE CALLED ADDENDA.

ADDENDA

ADDENDA ARE ISSUED:

- THE WINTER OF THE YEAR THE EDITION IS ISSUED.
- THE WINTER OF THE YEAR AFTER THE EDITION IS ISSUED.
- THE WINTER TWO YEARS AFTER THE EDITION IS ISSUED. WHEN THIS ADDENDA IS ADDED, THAT BOOK BECOMES IDENTICAL TO THE FOLLOWING EDITION. FOR EXAMPLE, A'88, ALONG WITH THE EARLIER ADDENDA TO THE 1986 CODE, MAKES IT IDENTICAL TO THE 1989 CODE.

THE ORGANIZATION OF SECTION VIII, DIVISION 1.

SUBSECTION A: THE GENERAL SECTION

- PART UG

SUBSECTION B: THE METHOD OF FABRICATION

- PART UW, WELDED VESSELS
- PART UF, FORGED VESSELS
- PART UB, BRAZED VESSELS

SUBSECTION C: THE MATERIALS SECTION

- PART UCS, CARBON/LOW ALLOY STEELS
- PART UNF, NON-FERROUS MATERIALS
- PART UHA, HIGH ALLOY STEELS
- PART UCI, CAST IRON MATERIALS
- PART UCL, CLAD VESSELS
- PART UCD, CAST DUCTILE MATERIALS
- PART UHT, HEAT TREATED MATERIALS
- PART ULW, LAYERED VESSELS
- PART ULT, LOW TEMPERATURE MATERIALS

1986 ASME BOILER AND PRESSURE VESSEL CODE

SECTIONS

- I Power Boilers
- II Material Specifications
 - Part A — Ferrous Materials
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- V Nondestructive Examination
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 - Division 2 — Alternative Rules
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- X Fiberglass-Reinforced Plastic Pressure Vessels
- XI Rules for Inservice Inspection of Nuclear Power Plant Components

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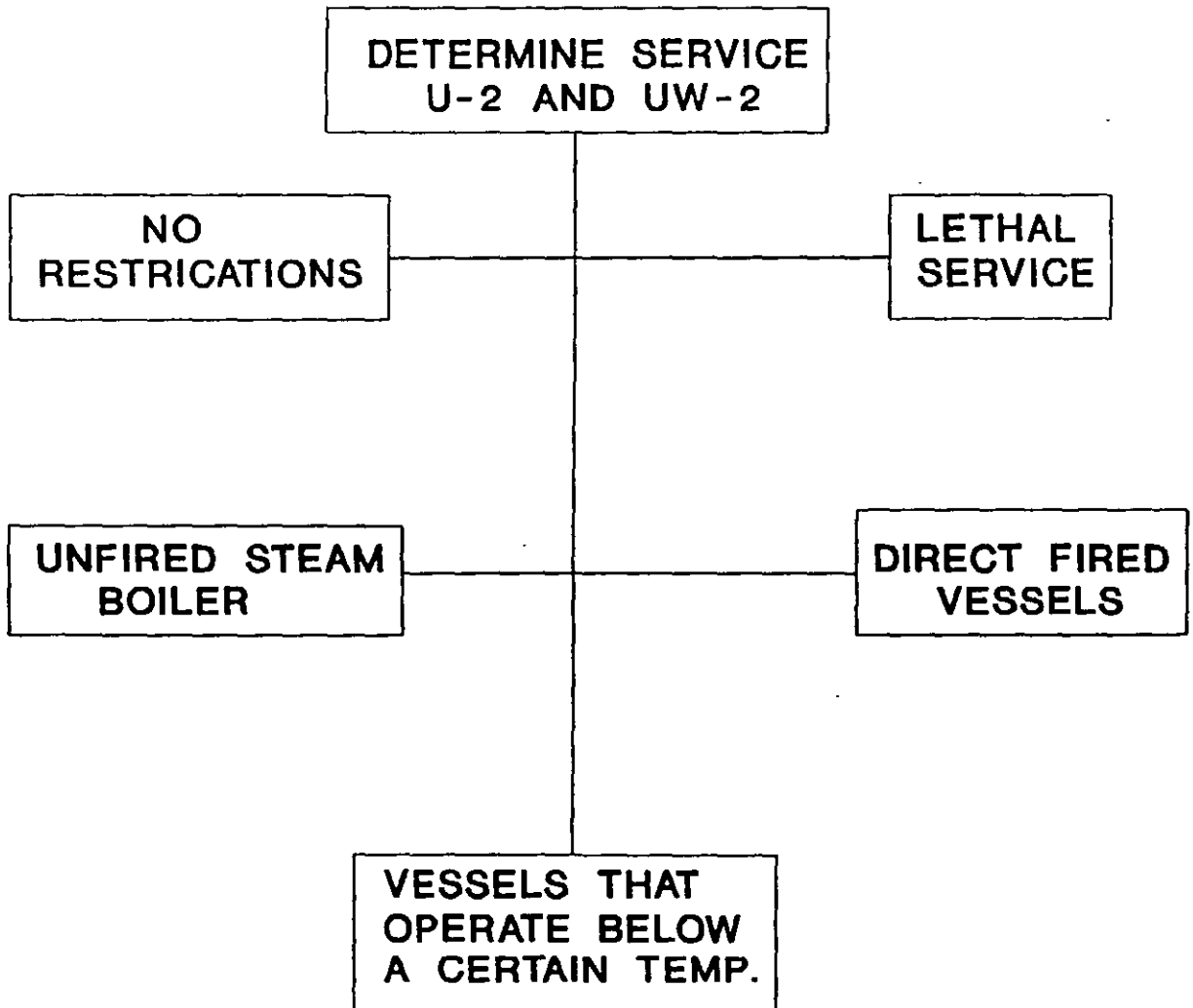
INTERPRETATIONS

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CODE CASES

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FABRICATION FLOW SECTION VIII, DIVISION 1

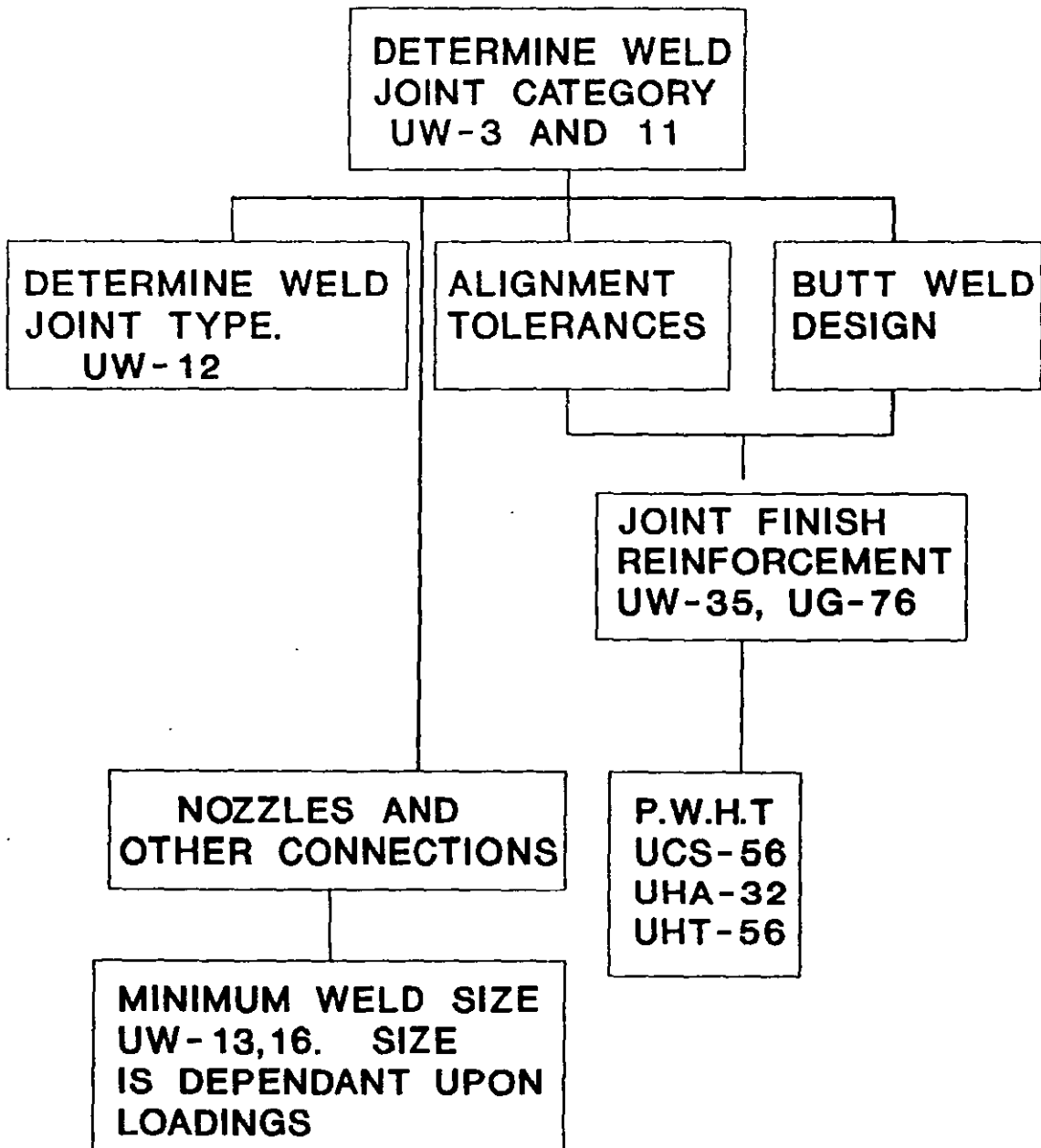


SEQUENCE OF FABRICATION REQUIREMENTS

AS WITH ALL OTHER CODE FUNCTIONS, WHEN FABRICATING, ALL SUBSECTIONS OF THE CODE MUST BE USED. FOR EXAMPLE:

- SUBSECTION A, PART UG: FABRICATION BEGINS AT UG-75. IT AND SUBSEQUENT PARAGRAPHS GIVE REQUIREMENTS ON FORMING, OUT-OF-ROUND, ETC.
- SUBSECTION B, PART UW, UF ETC.: THESE PARTS GIVE SPECIFICS ON FIT-UPS, REINFORCEMENT, ETC.
- SUBSECTION C, PART UCS, ETC.: THESE PARTS GIVE SPECIFIC REQUIREMENTS ON FORMING, HEAT TREATMENT, ETC.
- MANDATORY APPENDICES: SPECIAL FUNCTIONS SUCH AS, DEFINITIONS, JACKETED VESSELS, ETC.
- CODE CASES: REQUIREMENTS UNIQUE TO SPECIFIC ITEMS. FOR EXAMPLE, AT ONE TIME, REQUIREMENTS FOR "SQUARE VESSELS" WERE CONTAINED IN A CODE CASE.

EFFECTS ON FABRICATION FLOW

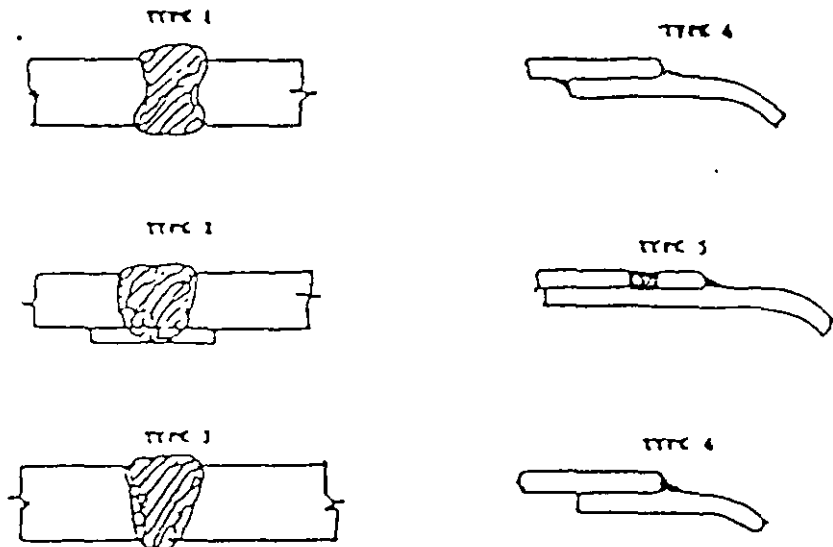


FABRICATION CONSIDERATIONS

THINGS TO CONSIDER BEFORE AND DURING FABRICATION ARE:

- DO MANHOLES, LUGS OR OTHER ATTACHMENTS MEET CODE REQUIREMENTS? ARE THEY FORMED PROPERLY?
- IS OUT-OF-ROUNDNESS WITHIN CODE TOLERANCE?
- IS ALIGNMENT SATISFACTORY FOR THE SHELL TO SHELL OR HEAD TO SHELL WELDS?
- DO ANY REQUIRED TAPER TRANSITIONS MEET THE CODE?
- IS WELD REINFORCEMENT WITHIN LIMITS?
- ARE WELDING PROCEDURES QUALIFIED IN ACCORDANCE WITH THE CODE?

EXAMPLES AND LIMITATIONS OF UW-12



JOINT TYPE CONFIGURATIONS

LIMITATIONS ON JOINT TYPES

(NOTES: This table applies when there are no special service restrictions.)

TYPE JOINT	CIRCUMFERENTIAL			LONGITUDINAL	
	Thickness	Diameter	Notes	Thickness	Notes
1	All	All		All	
2	All, except (1) $\leq 5/8$ for offset joint (2) for hemi heads $\leq 3/8$ "	All		All	
3	$\leq 5/8$ "	≤ 24 o.d.		Not Permitted	
4	$\leq 5/8$ "	All		$\leq 3/8$	
5	(1) Head shell $\leq 1/2$ " (2) Shell Jacket $\leq 5/8$ "	≤ 24 o.d. All	Not permitted for hemi heads	Not Permitted	
6	(1) Heads convex to Pressure $\leq 3/8$ " (2) All heads $\leq 1/4$ "	All ≤ 24 o.d.			

MAJOR CHANGES TO UW-11 AND UW-12

THE 1986 ADDENDA TO SECTION VIII, DIVISION 1 MADE MAJOR CHANGES TO DESIGN CRITERIA. THE ADDENDA RESULTED IN THE FOLLOWING:

- PARTIAL R.T. WAS DELETED.
- DESIGN IS NOW BY JOINT RATHER THAN BY VESSEL.
- STRESS REDUCTION WAS ELIMINATED.

THIS LEFT THREE TYPES OF R.T., FULL, SPOT AND NONE.

SPECIAL REQUIREMENTS FOR RADIOGRAPHY

SERVICE	FULL R.T. REQUIRED
LETHAL	ALL BUTT WELDS
UNFIRED STEAM BOILER > 50 P.S.I.	ALL BUTT WELDS
BUTT WELDS > THAN A SPECIFIED THICKNESS	PER UW-II(a)(2)
ELECTROSLAG WELDS	ALL BUTT WELDS

SPECIAL SERVICE VESSELS

UW-12 PROVIDES RESTRICTIONS ON JOINT
TYPES DEPENDING ON THE SERVICE OF THE
VESSEL. THESE RESTRICTIONS ARE:

LETHAL SERVICE	
CATEGORY	TYPE
A	1
B	1 OR 2
C	1 OR 2
D	FULL PEN.

UNFIRED STEAM BOILERS	
CATEGORY	TYPE
A	1
B	1 OR 2
C	--
D	--

LOW TEMPERATURE	
CATEGORY	TYPE
A	1*
B	1 OR 2
C	FULL PEN.
D	FULL PEN.

DIRECTLY FIRED VESSELS	
CATEGORY	TYPE
A	1
B	1 OR 2
C	--
D	--

CORROSION ALLOWANCE

SECTION VIII, DIVISION 1 DISCUSSES CORROSION ALLOWANCE IN UG-25 AND UCS-25 IF THE CODE DOES NOT PROVIDE FOR A CORROSION ALLOWANCE, THEN THE OWNER MUST STATE WHETHER ONE IS REQUIRED. UG-25(f) REQUIRES THAT A VESSEL SUBJECT TO CORROSION BE PROVIDED WITH A DRAIN AT THE LOWEST POINT. THIS IS MANDATORY WHETHER THE CORROSION ALLOWANCE IS CODE REQUIRED OR NOT.

REQUIRED SHELL MINIMUM WALL (CIRCUMFERENTIAL STRESS)

IN TERMS OF INSIDE RADIUS;

$$t = \frac{PR}{SE - 0.6P}$$

IN TERMS OF OUTSIDE RADIUS;

$$t = \frac{PR_o}{SE + 0.4P}$$

SECTION VIII, DIVISION 1 MATERIAL SELECTION

IN SELECTING MATERIAL FOR A SECTION VIII, DIV.1 VESSEL, INFORMATION WILL BE OBTAINED FROM VARIOUS SOURCES:

- SUBSECTION A FOR GENERAL REQUIREMENTS.
- SUBSECTION B FOR FABRICATION METHODS THAT MAY AFFECT MATERIAL SELECTION AND ANY SPECIAL SERVICE RESTRICTIONS.
- SUBSECTION C FOR SPECIFIC MATERIAL REQUIREMENTS AND THE STRESS TABLES.
- MANDATORY APPENDICES FOR ANY SPECIAL APPLICATIONS.
- SECTION II FOR DETAILED MATERIAL REQUIREMENTS.
- CODE CASES IF APPLICABLE.

SUBSECTION A

GENERAL REQUIREMENTS

RELATIVE TO MATERIALS, SUBSECTION A IS ORGANIZED AS FOLLOWS:

- UG-4 GENERAL REQUIREMENTS
- UG-5 PLATE
- UG-6 FORGINGS
- UG-7 CASTINGS
- UG-8 PIPE AND TUBES
- UG-9 WELDING MATERIALS
- UG-12 BOLTS AND STUDS
- UG-13 NUTS AND WASHERS
- UG-14 RODS AND BARS

WELDED PRESSURE PARTS

UG-11 ALLOWS FOR THE USE OF WELDED PRESSURE PARTS FOR OTHER THAN THE SHELL OR HEAD. AGAIN, UG-44 IS REFERENCED BUT, A REFERENCE IS ALSO MADE TO A 'MANUFACTURER'S STANDARD. THIS MANUFACTURER'S STANDARD MUST:

- COMPLY WITH UW-26 THROUGH UW-40
- BE SUPPLIED WITH A CERTIFICATE OF COMPLIANCE WHERE MARKINGS ARE NOT APPLICABLE

RADIOGRAPHY AND ANY HEAT TREATMENT MAY BE DONE BY THE PARTS MANUFACTURER BUT, MUST BE CERTIFIED AND THE CERTIFICATION RECORDS MUST ACCOMPANY THE PART.

CLASS OF MATERIALS

MATERIAL PARAGRAPHS IN SUBSECTION C ARE USUALLY FOUND IN UXX-5 THROUGH UXX-15. THE PARTS OF THIS SUBSECTION ARE:

- | | | |
|-------|-------|-------|
| • UCS | • UCI | • UHT |
| • UNF | • UCL | • ULW |
| • UHA | • UCD | • ULT |

UG-11

STANDARD PRESSURE PARTS

UG-11 REFERENCES TWO TYPES OF STANDARD PRESSURE PARTS. THEY ARE:

- A.N.S.I. STANDARDS BY REFERENCE TO UG-44 AND,
- MANUFACTURER'S STANDARDS

UG-44

A.N.S.I. STANDARDS

UG-44 LISTS THE A.N.S.I. STANDARDS THAT ARE ACCEPTABLE FOR USE IN SECTION VIII, DIVISION 1. THE ACCEPTABLE YEAR OF THESE DOCUMENTS IS FOUND IN TABLE U-3.

UCS-6 PLATE MATERIAL

UCS-6 DISCUSSES CARBON AND LOW ALLOY PLATE MATERIAL. IT PLACES SEVERE RESTRICTIONS ON THE USE OF SA-36 AND SA-283. IT STATES THAT THESE MATERIALS MAY BE USED FOR PRESSURE PARTS PROVIDED:

- THEY ARE NOT USED IN LETHAL SERVICE.
- THEY ARE NOT USED FOR UNFIRED STEAM BOILERS.
- THE DESIGN TEMPERATURE IS BETWEEN -20 AND 650 F.
- FOR SHELLS, HEADS, OR NOZZLES, THE MAXIMUM THICKNESS ON WHICH STRENGTH WELDING MAY BE PERFORMED IS 5/8 OF AN INCH.

WELDING QUALIFICATIONS OF PART ULT

PART ULT HAS SOME WELDING QUALIFICATION REQUIREMENTS THAT EXCEED THE REQUIREMENTS OF SECTION IX. THESE REQUIREMENTS ARE:

- FOUR TENSION TESTS(2 ARE NORMAL)
 - TWO AT ROOM TEMPERATURE
 - TWO AT THE MINIMUM TEMPERATURE

CARBON AND LOW ALLOY STEELS

PART UCS OF SUBSECTION C COVERS CARBON AND LOW ALLOY STEELS. THE PARAGRAPHS DEALING WITH MATERIALS SPECIFICS ARE:

- UCS-6 PLATES
- UCS-7 FORGINGS
- UCS-8 CASTINGS
- UCS-9 PIPES/TUBES
- UCS-10 BOLTS
- UCS-11 NUTS/WASHERS
- UCS-12 RODS/BARS

UCS-5

UCS-5 IS A GENERAL PARAGRAPH COVERING CARBON AND LOW ALLOY STEELS. IT REPEATS UG-4(a) AND MAKES REFERENCE TO THE STRESS TABLES. IT ALSO STATES THAT NO WELDING OR OXYGEN CUTTING IS ALLOWED ON MATERIALS IF THE CARBON CONTENT EXCEEDS 0.35%.

GENERAL DELIVERY SPECIFICATIONS

SOME OF THE GENERAL DELIVERY SPECIFICATIONS
IN SECTION II ARE:

- PIPE SA-530
- TUBE SA-450
- STAINLESS PLATE SA-480
- CARBON AND LOW ALLOY PLATE SA-20
- STRUCTURAL PLATE AND SHAPES SA-6

MATERIAL TESTING AND EXAMINATION

THE BASIC MATERIAL SPECIFICATION REQUIRES TESTING AND EXAMINATION OF MATERIALS. THE BASIC SPECIFICATION WILL REFERENCE THE GENERAL DELIVERY SPECIFICATION, SA-370 FOR ANY MECHANICAL TESTING OF STEEL PRODUCTS AND E-30 FOR CHEMICAL ANALYSIS. THE RESULTS OF ANY TESTS WILL BE RECORDED AS REQUIRED BY THE SPECIFICATION.

SA-285 TABLE 1 CHEMICAL REQUIREMENTS

ELEMENTS	% GRADE C
CARBON, MAX.	0.28
MANGANESE, MAX.	
HEAT ANALYSIS	0.90
PRODUCT ANALYSIS	0.98
PHOSPHORUS, MAX.	0.035
SULPHUR, MAX.	0.040

SA-285 TABLE 2 PHYSICAL REQUIREMENTS

PROPERTY	K.S.I. GRADE C
TENSILE STRENGTH	55 TO 75
YIELD STRENGTH, MIN.	30
ELONGATION IN 8"	23
ELONGATION IN 2"	27

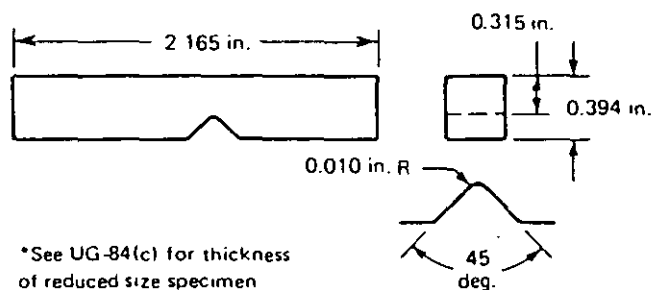
MISCELLANEOUS MATERIAL PARAGRAPHS

AGAIN, IT SHOULD BE STRESSED, THAT WHEN DEALING WITH CODE MATERIALS, ALL PARTS OF SECTION VIII, DIVISION 1 MUST BE USED. SOME OF THE MATERIAL PARAGRAPHS ARE:

- UG-84
- UCS-66
- UHA-51

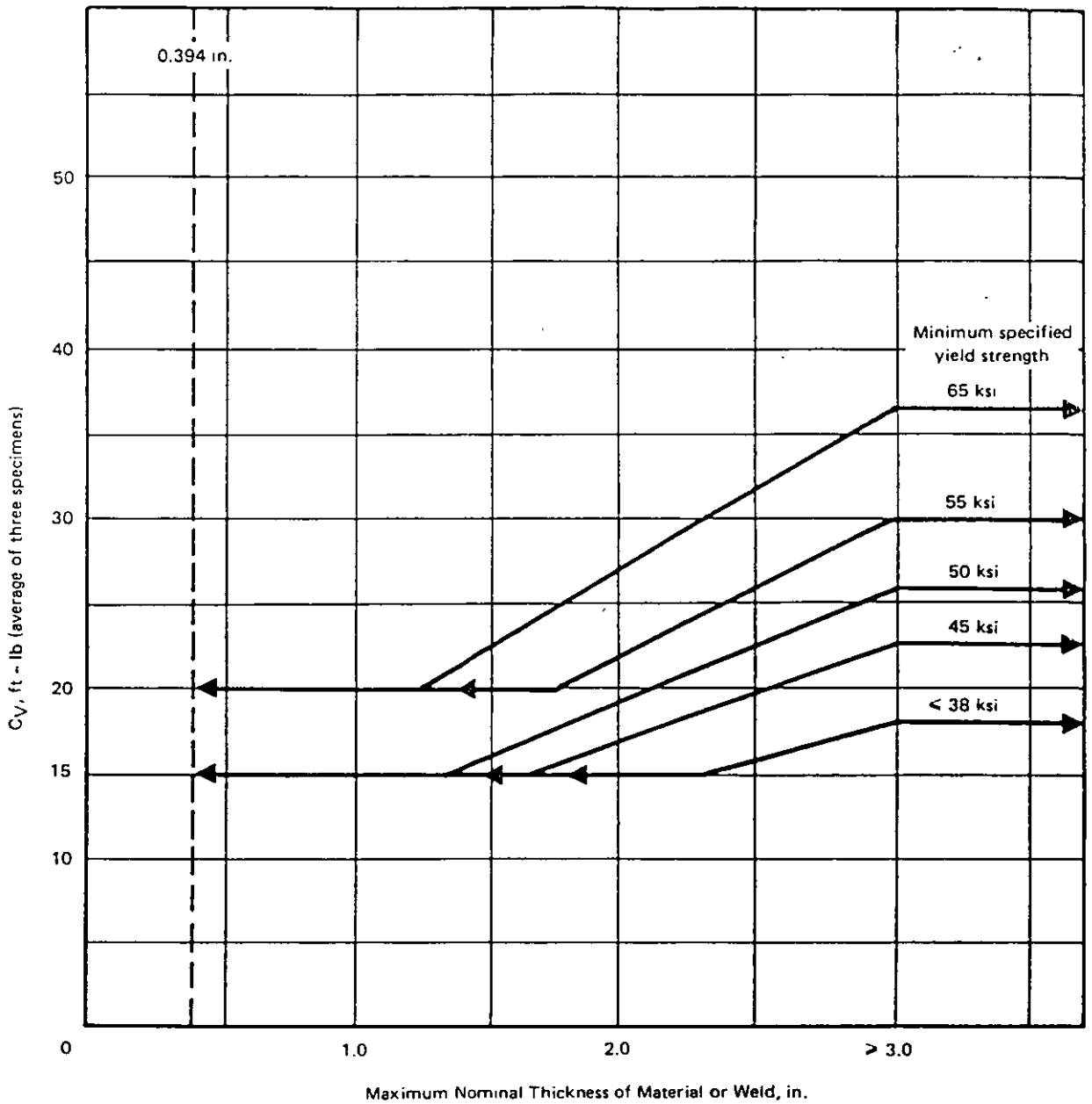
UG-84 CHARPY IMPACT TESTING

UG-84 DESCRIBES THE PROCEDURES TO BE USED IF IMPACT TESTING IS REQUIRED. IT SHOULD BE ASSUMED THAT IMPACTS ARE REQUIRED UNLESS AN EXEMPTION CAN BE FOUND IN SUBSECTION C. UG-84 GOES ON TO SAY THAT PROCEDURES AND APPARATUS SHALL CONFORM TO THE REQUIREMENTS OF SA-370.



*See UG-84(c) for thickness of reduced size specimen

FIG. UG-84 SIMPLE BEAM IMPACT TEST SPECIMENS (CHARPY TYPE TEST)



GENERAL NOTES:

- (a) Interpolation between yield strengths shown is permitted.
- (b) The minimum impact energy for one specimen shall not be less than 2/3 of the average energy required for three specimens.
- (c) Materials produced and impact tested in accordance with SA-320, SA-333, SA-334, SA-350, and SA-352 (see Table UG-84.3) do not have to satisfy these energy values. They are acceptable for use at minimum design metal temperature not colder than the test temperature when the energy values required by the applicable specification are satisfied.

FIG. UG-84.1 CHARPY V-NOTCH IMPACT TEST REQUIREMENTS FOR FULL SIZE SPECIMENS FOR CARBON AND LOW ALLOY STEELS LISTED IN TABLE UCS-23

A87
A88

MATERIAL TRACEABILITY

UG-77

UG-77 COVERS THE FABRICATOR'S RESPONSIBILITY ONCE MATERIAL HAS BEEN ACCEPTED AS MEETING THE REQUIREMENTS OF THE CODE. THESE RESPONSIBILITIES ARE:

- EACH PIECE OF PRESSURE RETAINING MATERIAL MUST RETAIN THE ORIGINAL MARKINGS OR A CODED MARKING ACCEPTABLE TO THE A. I. MUST BE USED.
- MARKING SHALL BE CORRECTLY TRANSFERRED IF THE MATERIAL IS DIVIDED.
- TRACEABILITY MUST BE MAINTAINED UNTIL THE VESSEL IS COMPLETE.

CONTROL OF MATERIAL DURING FABRICATION

A FABRICATOR MUST HAVE A DESCRIPTION IN HIS QUALITY CONTROL MANUAL ON HOW HE INTENDS TO CONTROL MATERIAL. SOME OF THE REQUIREMENTS THAT MUST BE COVERED ARE:

- STORAGE
- ISSUE
- EXAMINATION
- IDENTIFICATION
- REPAIR

MATERIAL IDENTIFICATION

UG-93

PRIOR TO USING MATERIAL IN A CODE VESSEL, TRACEABILITY MUST BE ESTABLISHED BY THE FABRICATOR. TO STRESS UG-93, MATERIALS MUST BE TRACEABLE AS FOLLOWS:

- PLATE: AN M.T.R. OR C. of C. AS REQUIRED BY THE SPECIFICATION.
- OTHER PRODUCT FORMS: EACH PIECE MUST BE MARKED WITH THE SPECIFICATION, GRADE, TYPE AND CLASS WHEN THE SPECIFICATION COVERS SUCH MARKING. TUBING MAY BE MARKED BY BUNDLE.
- WHEN THE SPECIFICATION HAS NO MARKING REQUIREMENT FOR EACH PIECE, THE THE MATERIAL MAY BE IDENTIFIED BY BUNDLE, LIFT OR CONTAINER. THE HANDLING OF THIS TYPE OF MATERIAL MUST BE DESCRIBED IN A QUALITY CONTROL SYSTEM.

FORMING

THE CODE ALLOWS SEVERAL TYPES OF FORMING. SOME ARE:

- COLD WORKING TO SHAPE, AND
- HEAT TO SHAPE.

IN EITHER CASE, IT MUST BE REMEMBERED THAT FLAT SPOTS AT LONGITUDINAL JOINTS MUST BE AVOIDED.

FORMING CARBON STEELS

THE CODE PLACES CERTAIN REQUIREMENTS ON THE FORMING OF CARBON AND LOW ALLOY STEELS. THESE ARE:

- COLD FORMING BY BLOWS IS NOT PERMITTED.
- FORMING BY BLOWS IS PERMITTED IF THE MATERIAL IS AT THE FORGING TEMPERATURE AND THE MATERIAL IS P.W.H.T.'d.
- IF A PART IS COLD FORMED BY OTHER THAN THE CERTIFICATE HOLDER, CERTIFICATION TO UCS-79 MUST BE SUPPLIED BY THE PART MANUFACTURER.

CONTROL OF WELDING MATERIAL

A FABRICATOR MUST ALSO DESCRIBE, IN HIS Q.C. SYSTEM, CONTROL OF WELDING MATERIAL. THESE REQUIREMENTS ARE:

- STORAGE
- IDENTIFICATION
- ISSUE
- RECONDITIONING
- EXAMINATION

FORMING REQUIREMENTS

FORMING REQUIREMENTS FOR FABRICATION INCLUDE:

- THERE CAN BE NO ADVERSE CHANGE TO THE MATERIAL PROPERTIES DURING FORMING.
- RESTRICTIONS ARE FOUND IN SUBSECTION C OF SECTION VIII, DIVISION 1.
- THERE CAN BE NO FLAT SPOTS ALONG THE LONGITUDINAL JOINTS.
- MUST MEET THE CIRCULARITY REQUIREMENTS OF UG-80 OR 81.
- DIMENSIONS AND TOLERANCES MUST MEET THE REQUIREMENTS OF THE DRAWING.
- MUST INCLUDE MINIMUM THICKNESS REQUIREMENTS AFTER FORMING.
- ALIGNMENT TOLERANCES FOR BUTT WELDED JOINTS MUST BE MAINTAINED.

SHELL OUT OF ROUNDNESS

UG-80 GIVES THE TOLERANCE FOR OUT OF ROUNDNESS FOR A SHELL. IT BASICALLY STATES THAT THE MAXIMUM I.D. MINUS THE MINIMUM I.D. SHALL NOT EXCEED 1% OF THE NOMINAL I.D.

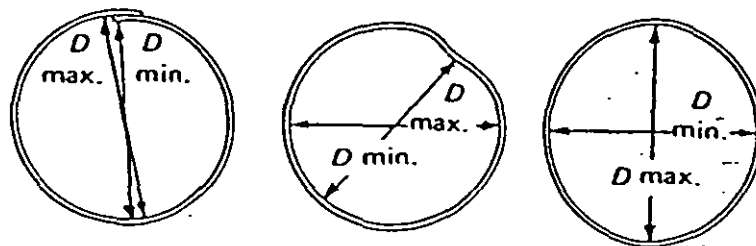


FIG. UG-80.2 EXAMPLE OF DIFFERENCES BETWEEN MAXIMUM AND MINIMUM DIAMETERS IN CYLINDRICAL, CONICAL, AND SPHERICAL SHELLS

COLD FORMED PARTS

UCS-79

UCS-79 REQUIRES HEAT TREATMENT OF THE PART OR VESSEL IF FIBER ELONGATION IS GREATER THAN 5% OF THE AS ROLLED CONDITION AND:

- THE VESSEL WILL BE IN LETHAL SERVICE,
- IMPACT TESTING IS REQUIRED,
- PRE-FORMING THICKNESS EXCEEDS 5/8",
- THE THICKNESS IS REDUCED BY MORE THAN 10% OR,
- FORGING TEMPERATURE WAS BETWEEN 250 AND 900 F.

NOTE: IF NONE OF THE ABOVE ARE TRUE, THE % MAY BE AS HIGH AS 40%.

FIBER ELONGATION

FIBER ELONGATION MAY BE DETERMINED BY THE FOLLOWING FORMULA FOUND IN UCS-79:

- FOR DOUBLE CURVATURE:

$$\% \text{ ELONGATION} = \frac{75t}{R_f} \left(1 - \frac{R_f}{R_o}\right)$$

- FOR SINGLE CURVATURE:

$$\% \text{ ELONGATION} = \frac{50t}{R_f} \left(1 - \frac{R_f}{R_o}\right)$$

CUTTING, FITTING AND ALIGNMENT

SEVERAL PARAGRAPHS IN THE CODE COVER CUTTING FITTING AND ALIGNMENT. AREAS ADDRESSED ARE:

- CUT EDGES MUST BE SMOOTH AND CLEAN. (UW-31)
- TACK WELDS MUST BE MADE USING A QUALIFIED PROCEDURE WHETHER THEY ARE LEFT IN PLACE OR NOT. (UW-31)
- TACK WELDS TO BE LEFT IN PLACE MUST BE MADE BY A QUALIFIED WELDER. (UW-31)
- NONPRESSURE PARTS WELDED OVER PRESSURE RETAINING WELDS MUST BE NOTCHED OR THE PRESSURE RETAINING WELD MUST BE GROUND FLUSH. (UG-82)
- WHEN PRESSURE PARTS ARE WELDED OVER PRESSURE RETAINING WELDS, THE WELDS MUST BE GROUND FLUSH. (UG-82)

ALIGNMENT OF LONGITUDINAL JOINTS

UW-9 (d) GIVES THE REQUIREMENTS FOR ALIGNMENT OF LONGITUDINAL JOINTS IN SHELLS OF VESSELS WITH MORE THAN ONE COURSE. IT STATES THAT THE JOINTS MUST BE STAGGERED AT LEAST 6 TIMES THE THICKNESS OF THE THICKER PLATE OR, THE JOINT MUST BE RADIOGRAPHED AT LEAST 4" ON EACH SIDE OF EACH INTERSECTION.

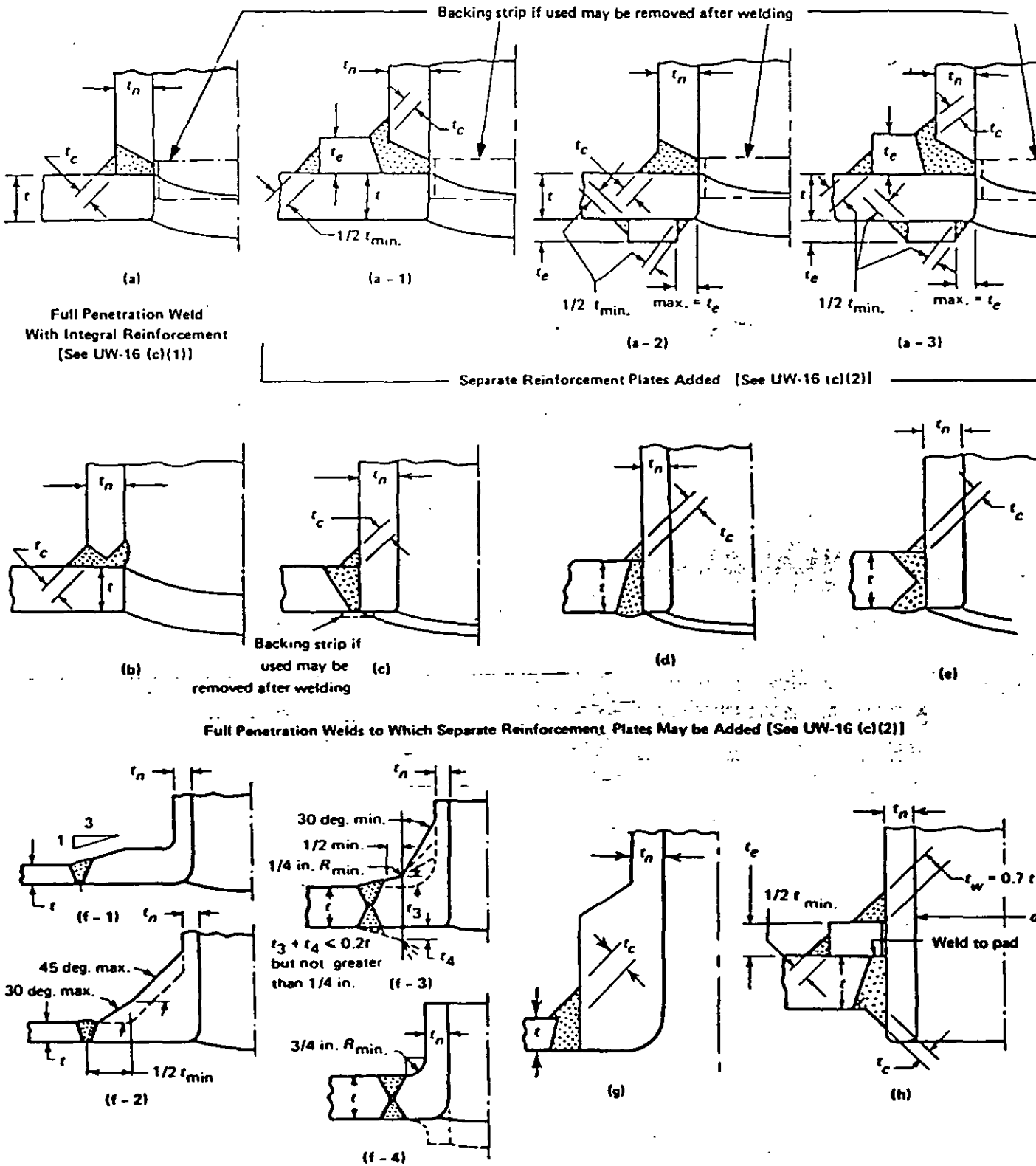


FIG. UW-16.1 SOME ACCEPTABLE TYPES OF WELDED NOZZLES AND OTHER CONNECTIONS TO SHELLS, DRUMS, AND HEADERS

NOTE: Sketches (a), (b), (c), (d), (e), (f-1) through (f-4), (g), (x-1), (y-1), and (z-1) are examples of nozzles with integral reinforcement.

QUALIFICATION OF A W.P.S.

UW-28

UW-28 GIVES THE REQUIREMENTS FOR THE QUALIFICATION OF A W.P.S FOR USE IN CONSTRUCTION. THESE REQUIREMENTS ARE:

- THE PROCEDURE TO BE USED MUST BE RECORDED. IN OTHER WORDS, QUALIFIED.
- FOR PROCEDURES TO BE USED ON PRESSURE RETAINING/LOAD BEARING ITEMS, QUALIFICATION TO SECTION IX IS REQUIRED.
- FOR PROCEDURES USED ON NON-PRESSURE RETAINING/NON-LOAD BEARING ITEMS WITH THE MANUAL, SEMIAUTOMATIC OR MACHINE METHOD, QUALIFICATION TO SECTION IX IS REQUIRED.

AN UNQUALIFIED W.P.S.

UW-28

UW-28 ALSO STATES:

- FOR PROCEDURES USED ON NON-PRESSURE RETAINING/NON-LOAD BEARING ITEMS WITH THE AUTOMATIC METHOD NEED NOT BE QUALIFIED BUT, MUST HAVE A W.P.S. IN OTHER WORDS, IT MUST MEET ALL THE REQUIREMENTS OF SECTION IX WITH THE EXCEPTION OF TESTING.

WELDING PROCESSES OF SECTION VIII, DIVISION 1

THE WELDING PROCESSES PERMITTED BY
SECTION VIII, DIVISION 1 ARE:

- ALL THE PROCESSES LISTED IN SECTION IX.
- ATOMIC HYDROGEN METAL ARC.
- FLASH
- INDUCTION
- RESISTANCE
- PRESSURE THERMIC
- PRESSURE GAS

WELDING LIMITATIONS

SOME LIMITATIONS ON WELDING ARE GIVEN.
TWO SPECIFICALLY GIVEN ARE:

- STUD WELDING MAY ONLY BE USED FOR
NONPRESSURE/NON-LOAD BEARING PARTS.
- ELECTROSLAG WELDING MAY ONLY BE USED
FOR FERRITIC AND SOME AUSTENITIC
STEELS THAT ARE GIVEN IN UW-5(d).

MANUFACTURER'S RESPONSIBILITIES FOR QUALIFICATION OF PROCEDURES

THE MANUFACTURER MUST:

- PREPARE A WRITTEN W.P.S.
- PREPARE A P.Q.R. BASED ON WELDING OF THE COUPON. PHYSICAL TESTING MAY BE DONE BY A LAB.
- LIST THE PARAMETERS FOR CONSTRUCTION.
- RECORD WELDING DATA AND THE RESULTS ON THE P.Q.R.
- ESTABLISH A Q. C. PROGRAM TO CONTROL QUALIFICATIONS.
- THE QUALITY OF WELDING DONE BY HIS ORGANIZATION.
- METALLURGICAL COMPATIBILITY OF THE FILLER METAL AND THE BASE METAL.

UW-35

UW-35 DISCUSSES FINISHED LONGITUDINAL AND CIRCUMFERENTIAL JOINTS. IT STATES , IN PART, THAT FOR FILLET AND GROOVE WELDS:

- THERE CAN BE NO REDUCTION BELOW THE MINIMUM REQUIRED THICKNESS.
- THERE CAN BE NO REDUCTION BELOW $1/32"$ OR 10% OF THE NOMINAL THICKNESS, WHICHEVER IS LESS.

QUALIFICATION OF WELDERS AND WELDING OPERATORS

UW-29 STATES THAT:

- WELDERS AND WELDING OPERATORS MUST BE QUALIFIED TO SECTION IX IF THEY ARE WELDING PRESSURE RETAINING PARTS OR LOAD CARRYING PARTS TO PRESSURE BOUNDARY MATERIAL.
- WELDERS OR OPERATORS MAY BE QUALIFIED ON THE FIRST PRODUCTION JOINT THEY WELD.
- STUD WELDERS MUST BE QUALIFIED AT THE BEGINNING OF EACH SHIFT.
- THEY NEED NOT BE TESTED IF THEY ARE WELDING NON-PRESSURE OR NON-LOAD CARRYING PARTS USING AN AUTOMATIC PROCESS HOWEVER, THEY MUST STILL MEET ALL OTHER REQUIREMENTS OF SECTION IX.

UW-35 REINFORCEMENT

UW-35 ALSO DISCUSSES REINFORCEMENT. THE TABLE IS SHOWN BELOW.

Material Nominal Thickness, in.	Maximum Reinforcement, in.	
	Circumferential Joints in Pipe and Tubing	Other Welds
Less than $\frac{3}{32}$	$\frac{3}{32}$	$\frac{1}{32}$
$\frac{3}{32}$ to $\frac{3}{16}$, incl.	$\frac{1}{8}$	$\frac{1}{16}$
Over $\frac{3}{16}$ to $\frac{1}{2}$, incl.	$\frac{5}{32}$	$\frac{3}{32}$
Over $\frac{1}{2}$ to 1, incl.	$\frac{3}{16}$	$\frac{3}{32}$
Over 1 to 2, incl.	$\frac{1}{4}$	$\frac{1}{8}$
Over 2 to 3, incl.	$\frac{1}{4}$	$\frac{5}{32}$
Over 3 to 4, incl.	$\frac{1}{4}$	$\frac{7}{32}$
Over 4 to 5, incl.	$\frac{1}{4}$	$\frac{1}{4}$
Over 5	$\frac{5}{16}$	$\frac{5}{16}$

UHT-84 WELD FINISH

AGAIN, A REVIEW OF ALL PARTS OF THE CODE MUST BE MADE WHEN DOING CODE WORK. A FABRICATION REQUIREMENT CAN BE FOUND IN UHT-84. THIS PARAGRAPH OVERRIDES PART UW. UHT-84 STATES THAT THE REQUIREMENTS OF UW-35(a & b) MUST BE MET EXCEPT FOR SA-517 MATERIAL. FOR THAT MATERIAL, REINFORCEMENT MAY NOT EXCEED 10% OF THE PLATE THICKNESS OR 1/8" WHICHEVER IS LESS. IT GOES ON TO SAY THAT NO UNDERCUT IS ALLOWED.

GENERAL WELDING REQUIREMENTS

SOME GENERAL REQUIREMENTS RELATIVE TO WELDING ARE:

- IF REINFORCEMENT IS EXCESSIVE, SIMPLY GRINDING OFF THE TOP WILL NOT SUFFICE. THE PURPOSE OF REMOVING REINFORCEMENT IS TO REDUCE THE ANGLE BETWEEN THE BASE METAL AND THE WELD. THE WELD CAP MUST BE BLENDED SMOOTHLY WITH THE BASE METAL.
- UW-36 REQUIRES THAT FILLET WELDS MUST HAVE COMPLETE PENETRATION.
- UW-38 CONTAINS REQUIREMENTS FOR THE REMOVAL OF WELD DEFECTS. IT STATES THAT DEFECTS MAY BE REMOVED THERMALLY OR MECHANICALLY.
- UW-39 COVERS AN AREA THAT IS MISSED QUITE FREQUENTLY ON WELD PROCEDURES, AND THAT IS PEENING. PEENING IS USED TO CONTROL DISTORTION, RELIEVE RESIDUAL STRESSES AND IMPROVE THE QUALITY OF THE WELD. IT MUST BE ADDRESSED ON A WELDING PROCEDURE IN MOST CASES.

UW-40 P.W.H.T. PROCEDURES

UW-40 GIVES DETAILS ON P.W.H.T. PROCEDURES IT REFERENCES UCS-56 OR UHA-32, AS APPLICABLE FOR HEAT UP, COOL DOWN AND HOLDING TIMES. THEN IT STATES:

- THE ENTIRE VESSEL SHOULD BE HEATED AT ONE TIME IF PRACTICAL.
- SECTIONS MAY BE HEAT TREATED IF THERE IS A MINIMUM OF A 5 FT. OVERLAP.
- LOCALIZED P.W.H.T. IS ALLOWED ON SHELL SECTIONS IF THE BAND WIDTH IS AT LEAST TWO TIMES THE SHELL THICKNESS ON EACH SIDE OF THE WELD.
- LOCALIZED P.W.H.T. IS ALLOWED ON PIPE OR TUBE CIRCUMFERENTIAL WELDS IF THE WIDTH OF THE BAND IS AT LEAST THREE TIMES THE WIDTH OF THE WELD ON EACH SIDE OF THE WELD.

P.W.H.T. ALTERNATIVE # 3

ANOTHER ALTERNATIVE IS FOUND IN UCS-56 (f). IT MAY BE USED WHEN REPAIRING MATERIALS OR WELD METAL DEFECTS. IT IS LIMITED TO P-1 AND 3 MATERIALS.

- FOR P-1, GROUPS 1, 2 AND 3, THE DEPTH OF REPAIR SHALL NOT EXCEED 1 1/2". FOR P-3, GROUPS 1, 2 AND 3, THE DEPTH OF REPAIR SHALL NOT EXCEED 5/8".**
- AFTER REMOVAL OF THE DEFECT, M.T. OR P.T. THE CAVITY.**
- THE PROCESS USED MUST BE S.M.A.W. USING LOW HYDROGEN ELECTRODES. THE MAXIMUM WELD BEAD SHALL BE FOUR TIMES THE ELECTRODE DIAMETER.**
- FOR P-1 MATERIALS, THE REPAIR AREA SHALL BE PREHEATED AND MAINTAINED AT A TEMPERATURE OF 200 F. DURING WELDING.**
- FOR P-3 MATERIALS, THE "HALF BEAD" TECHNIQUE MUST BE USED. IN THIS CASE, THE REPAIR AREA IS PREHEATED AND MAINTAINED AT 350 F. INTERPASS MAXIMUM SHALL BE 450 F. THE FIRST PASS SHALL BE DEPOSITED USING 1/8" MAXIMUM DIAMETER ELECTRODE. APPROXIMATELY 1/2 OF THIS PASS MUST BE REMOVED BY GRINDING. SUBSEQUENT LAYERS SHALL BE DEPOSITED USING 5/32" MAXIMUM DIAMETER ELECTRODES.**

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