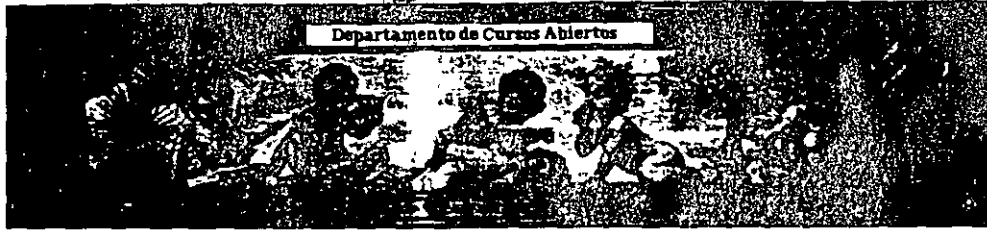




**FACULTAD DE INGENIERÍA UNAM  
DIVISIÓN DE EDUCACIÓN CONTINUA**



# **DIPLOMADO DE RECIPIENTES A PRESIÓN**

**CA 270**

**DISEÑO DE RECIPIENTES A PRESIÓN  
CONFORME A LA SECCIÓN VIII, DIV. 1  
DEL CÓDIGO ASME**

**COORDINADOR: ING. ORLANDO RIVERA MENDÓZA**

**DEL 14 AL 18 DE FEBRERO DE 2005**

**PALACIO DE MINERÍA**



**DIVISIÓN DE  
EDUCACIÓN  
CONTINUA**



**UNIVERSIDAD NACIONAL AUTONOMA DE MÉXICO**

**FACULTAD DE INGENIERIA  
DIVISIÓN DE EDUCACIÓN CONTINUA**

**CURSO / MODULO**

**DISEÑO**

**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

FACULTAD DE INGENIERIA  
DIVISIÓN DE EDUCACIÓN CONTINUA

## DATOS DEL INSTRUCTOR

**ING. ORLANDO R. RIVERA**

Tel. / Fax: (55) 5776-6524 ; E-mail: [orlanriver@hotmail.com](mailto:orlanriver@hotmail.com)

Es Ingeniero Mecánico Titulado egresado de la Escuela Superior de Ingeniería Mecánica y Eléctrica del Instituto Politécnico Nacional. Cuenta con una experiencia profesional de más de 20 años en diseño, fabricación, inspección, prueba, certificación, montaje y reparación de calderas, recipientes a presión, sistemas de tubería y componentes nucleares. Ha calificado ante el Gobierno de Texas, Ohio, Pennsylvania y The National Board of Boiler and Pressure Vessel Inspectors de Norte America como Inspector Autorizado, Supervisor de Inspectores Autorizados e Inspector Nuclear Autorizado de ASME. Ha sido asesor de más de 40 empresas en México, Colombia, Venezuela, Brasil y Argentina en Sistemas y Certificaciones de ASME y National Board. Ha impartido el Diplomado de Ingeniería de Calderas y Recipientes a Presión en la División de Educación Continua de la Facultad de Ingeniería de la Universidad Nacional Autónoma de México, y ha presentado ponencias en Talleres Internacionales de Capacitación en Calderas, Recipientes a Presión y Temas Afines de la Asociación Mexicana de Ingenieros Mecánicos y Electricistas, A.C. (AMIME). Actualmente es Presidente del Comité de Calderas y Recipientes a Presión de AMIME y Consultor de varias compañías nacionales e internacionales.

2004.

# 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
  - Part B — Nonferrous Materials
  - Part C — Welding Rods, Electrodes and Filler Metals
- 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 — Component Supports
  - Subsection NG — Core Support Structures
  - Appendices
- III Division 2 — Code for Concrete Reactor Vessels and Containments
- IV Heating Boilers
- V Nondestructive Examination
- VI Recommended Rules for Care and Operation of Heating Boilers
- VII Recommended Guidelines for the Care of Power Boilers
- VIII Pressure Vessels
  - Division 1
  - Division 2 — Alternative Rules
- IX Welding and Brazing Qualifications
- X Fiberglass-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 1989 Code. The 1986 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 1989 Code. Interpretations of Section III, Divisions 1 and 2, will be included with the update service to Subsection NCA. Interpretations are not part of the Code or the Addenda.

## 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 1986 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 1989 Code.

# 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.

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# 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.

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## 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 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

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# 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



# 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.

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## 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.

# SECTION VIII, DIVISION 1 DESIGN APPROACH

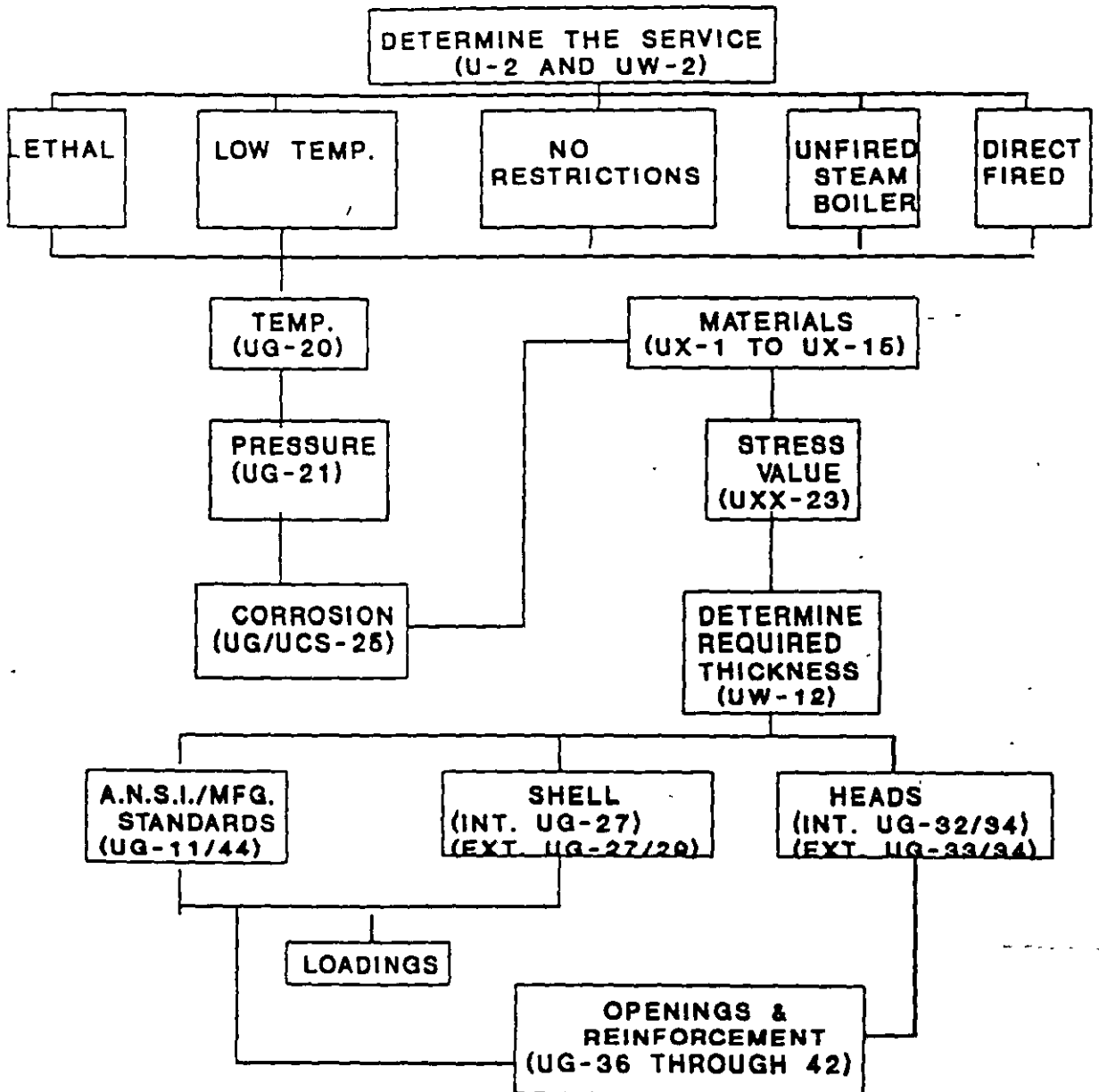
THE DESIGN OF SECTION VIII, DIVISION 1 IS BASED ON:

- THE TYPE OF FABRICATION AND,
- THE TYPE OF MATERIAL USED.

IF A CODE FORMULA IS APPLICABLE TO A PARTICULAR COMPONENT UNDER CONSIDERATION, THE USE OF THAT FORMULA IS MANDATORY.

THE OWNER MUST SPECIFY TYPE OF SERVICE AS WELL AS OTHER PERTINENT INFORMATION OR THE MANUFACTURER MAY NOT BE ABLE TO MEET THE APPLICABLE CODE REQUIREMENTS.

# DESIGN FLOW PER SECTION VIII, DIVISION 1



# TYPES OF SERVICE

THERE ARE BASICALLY FIVE TYPES OF SERVICE FOUND IN SECTION VIII, DIVISION 1. ALL BUT ONE CAN BE FOUND IN UW-2. THESE SERVICES ARE:

- LETHAL SERVICE
- LOW TEMPERATURE SERVICE
- UNFIRED STEAM BOILERS
- DIRECTLY FIRED VESSELS
- NO RESTRICTIONS (NOT FOUND IN UW-2)

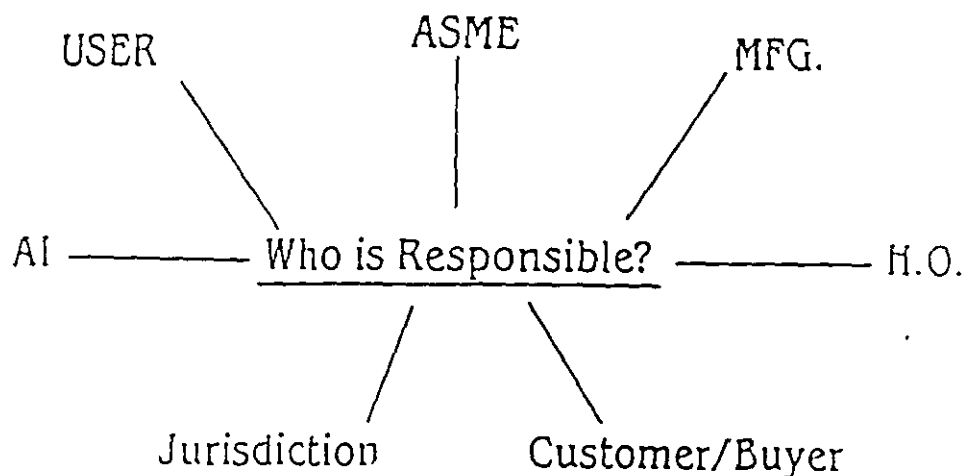
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## DESIGN LOADINGS

THERE ARE SEVERAL TYPES OF DESIGN LOADINGS FOUND IN SECTION VIII, DIVISION 1 THAT MUST BE CONSIDERED. THESE ARE:

- PRESSURE
- TEMPERATURE GRADIENTS
- WEIGHT OF VESSEL AND CONTENTS
- SUPERIMPOSED LOADS (IE. STATIC)
- LOCALIZED STRESSES
- IMPACT LOADINGS
- WIND LOADINGS
- EARTHQUAKE LOADS

NOTE: THERE ARE NO CODE RULES FOR CALCULATING LOADINGS EXCEPT PRESSURE LOADINGS.



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## USER'S RESPONSIBILITIES

THE USER SHOULD SUPPLY THE MANUFACTURER WITH THE FOLLOWING INFORMATION:

- DESIGN PRESSURE AND TEMPERATURE.
- LOADINGS
- CORROSION ALLOWANCE
- SPECIAL SERVICE REQUIREMENTS SUCH AS LETHAL
- P.W.H.T. OR B.T. IF NOT CODE REQUIRED.

## DESIGN MAY BE PERFORMED BY:

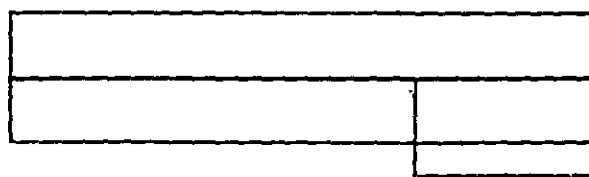
- THE CERTIFICATE HOLDER
- THE USER
- THE USER'S DESIGN AGENT
- CERTIFICATE HOLDER'S DESIGN AGENT.

NOTE: THE CERTIFICATE HOLDER WHO WILL STAMP THE VESSEL IS ALWAYS RESPONSIBLE FOR MEETING ALL CODE REQUIREMENTS, INCLUDING THOSE FOR DESIGN. THERE ARE NO QUALIFICATION REQUIREMENTS FOR ON DESIGNERS IN THE CODE.

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## WELDED JOINTS

TWO TERMS APPLY TO WELDED JOINTS IN THE CODE. ONE OF THESE DESCRIPTIONS IS JOINT CATEGORY. CATEGORY DEFINES THE LOCATION OF A JOINT WITHIN THE VESSEL. FOR EXAMPLE, A CATEGORY A JOINT WOULD BE A LONG SEAM OR A SEAM THAT WOULD SEE THE SAME STRESSES AS A LONG SEAM.



CATEGORY A JOINT

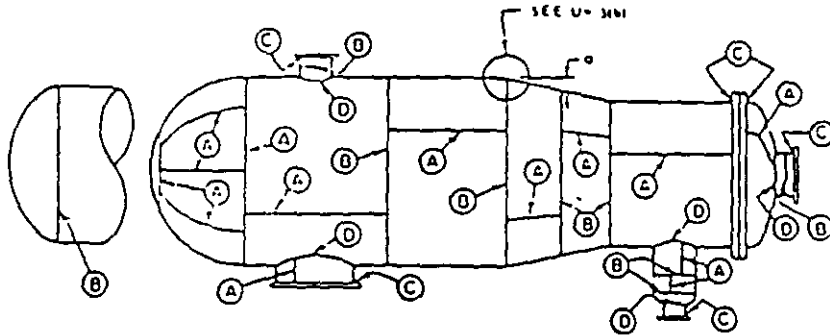
# CATEGORIES OF JOINTS

## UW-3

UW-2-UW-3

SECTION VIII — DIVISION 1

1986 Edition



## WELDED JOINTS

IN ADDITION TO CATEGORY, THE CODE DEFINES JOINTS BY THEIR TYPE. TYPE DEFINES THE CONFIGURATION OF A WELDED JOINT. FOR EXAMPLE, A TYPE TWO JOINT IS A SINGLE BEVEL BUTT JOINT WITH A BACKING STRIP LEFT IN PLACE.



# 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.

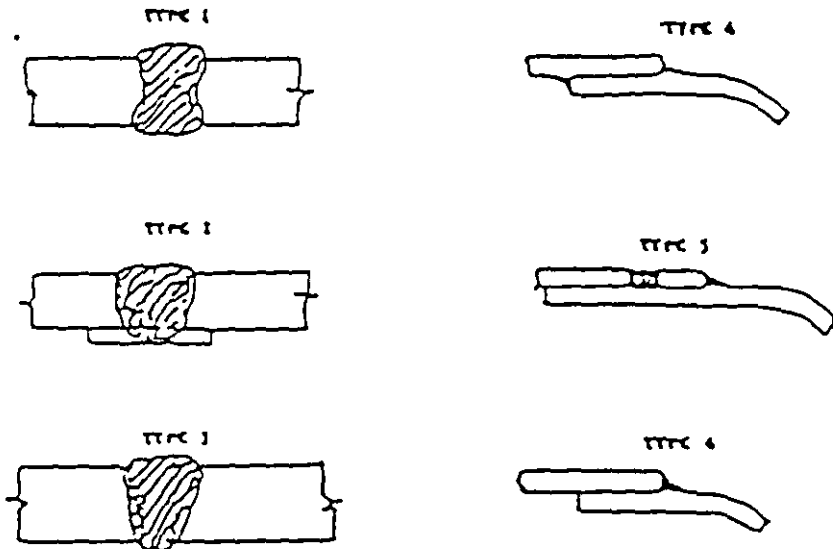
THIS LEFT THREE TYPES OF R.T., FULL, SPOT AND NONE.

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## 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

# 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	$\leq 5/8$ "	$\leq 24$ o.d.		Not Permitted	
4	$\leq 5/8$ "	All		$\leq 3/8$	
5	(1) Head shell $\leq 1/2$ " (2) Shell jacket $\leq 3/4$ "	$\leq 24$ 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 $\leq 24$ o.d.			

# 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.

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## REQUIRED SHELL MINIMUM WALL (CIRCUMFERENTIAL STRESS)

IN TERMS OF INSIDE RADIUS;

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

IN TERMS OF OUTSIDE RADIUS;

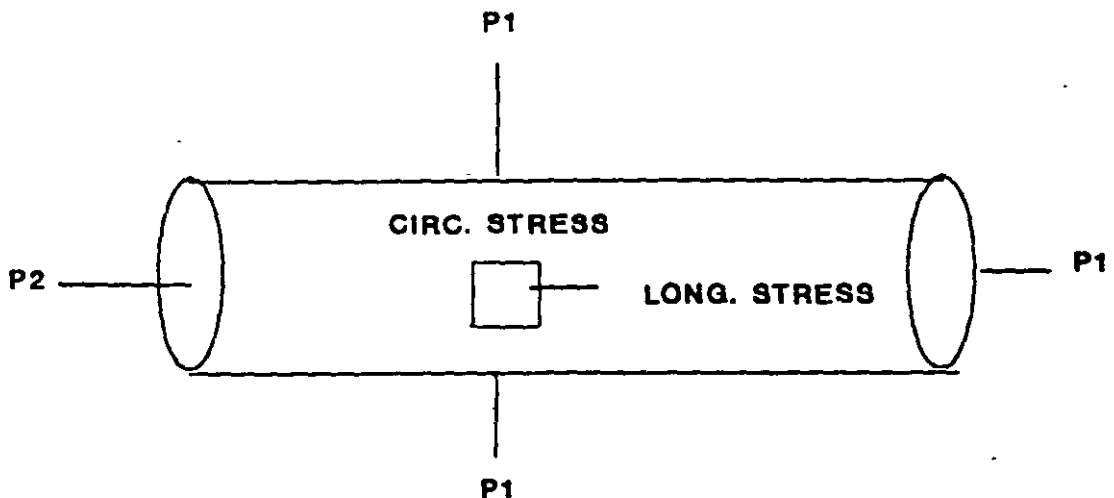
$$t = \frac{PR_o}{SE + 0.4P}$$

# SHELLS MADE FROM PIPE

## UG-31

UG-31 ALLOWS THE FABRICATION OF SHELLS FROM PIPE. IT SIMPLY STATES THAT THE FORMULA IN UG-27 BE USED FOR CALCUALTING THICKNESS. CARE MUST BE TAKEN IN THE COMMUNICATIONS BETWEEN THE DESIGNER AND THE PURCHASER WHEN ORDERING PIPE SUCH AS SA-53(B). THIS MATERIAL COMES IN BOTH SEAMLESS AND E.R.W. AND THEREFORE, HAVE DIFFERENT STRESS VALUES.

## STRESSES



FOR THIN-WALLED, CYLINDRICAL SHELLS, THE CIRCUMFERENTIAL, OR HOOP STRESS, WILL BE APPROXIMATELY TWICE THE LONGITUDINAL.

## UG-16(b)

WITH SOME EXCEPTIONS, THE MINIMUM THICKNESS OF SECTION VIII, DIVISION 1 SHELLS AND HEADS IS  $1/16$  OF AN INCH.

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### TYPE OF HEAD DESIGNS

THERE ARE BASICALLY 5 TYPES OF HEAD DESIGN IN SECTION VIII, DIVISION 1. THEY ARE:

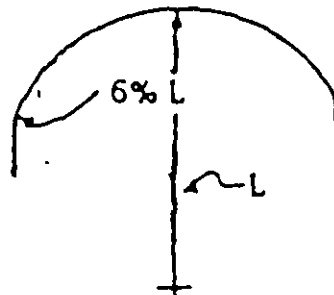
- ELLIPTICAL
- TORISPHERICAL (F & D)
- HEMISPHERICAL
- CONICAL
- FLAT

# TORISPHERICAL HEADS (F & D)

## UG-32(e)

IF THE INSIDE CROWN RADIUS (L) EQUALS THE O.D. OF THE SKIRT, AND THE INSIDE KNUCKLE RADIUS (r) EQUALS 6% OF L, THEN:

$$t = \frac{0.885PL}{SE-0.1P}$$



# TORISPHERICAL HEADS (F & D)

## APP. 1-4(d)

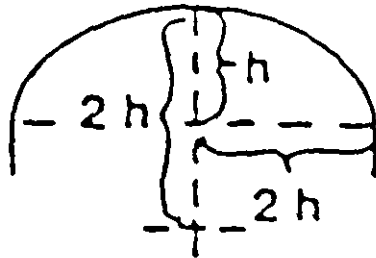
IF THE INSIDE KNUCKLE RADIUS (r) DOES NOT EQUAL 6% OF L, THEN:

$$t = \frac{PLM}{SE-0.2P}$$

WHERE THE M FACTOR IS BASED ON AN L/r RATIO.

NOTE:  $\frac{PLM}{2SE-0.2P} = \frac{0.885PL}{2SE-0.1P}$  WHEN L/r = 16 AND 2/3

## 2:1 ELLIPTICAL HEADS UG-32(d)



$$\frac{\text{MINOR AXIS}}{2} = \frac{\text{I. D. OF THE HEAD}}{4}$$

$$t = \frac{PD}{2SE - 0.2P}$$

## OTHER ELLIPTICAL HEADS APPENDIX 1-4(c)

$$t = \frac{PDK}{2SE - 0.2P} \quad \text{WHERE THE K FACTOR IS BASED ON } \frac{D}{2h}$$

NOTE:  $\frac{PD}{2SE - 0.2P} = \frac{PDK}{2SE - 0.2P}$  WHEN  $\frac{D}{2h} = 2.0$   
21



## UG-32(j)

"THE INSIDE CROWN RADIUS TO WHICH AN UNSTAYED HEAD IS DISHED SHALL BE NOT GREATER THAN THE OUTSIDE DIAMETER OF THE SKIRT OF THE HEAD. THE INSIDE KNUCKLE RADIUS OF A TORISPHERICAL HEAD SHALL NOT BE LESS THAN 6% OF THE OUTSIDE DIAMETER OF THE SKIRT BUT IN NO CASE LESS THAN 3 TIMES THE HEAD THICKNESS". IN OTHER WORDS,

- MAX L = SKIRT O. D.
- MIN. r = 6% SKIRT O.D.  
BUT NOT LESS  
THAN 3 • THE  
HEAD THICKNESS

---

## UG-32(b)

"THE THICKNESS OF AN UNSTAYED ELLIPSOIDAL OR TORISPHERICAL HEAD SHALL IN NO CASE BE LESS THAN THE REQUIRED THICKNESS OF A SEAMLESS HEMISPHERICAL HEAD DIVIDED BY THE EFFICIENCY OF THE HEAD-TO-SHELL JOINT".

## HEMISPHERICAL HEADS UG-32(f)

WHEN  $t \leq .356L$ , OR  $P$  IS  $< 0.665SE$ , THEN:

$$t = \frac{PL}{2SE - 0.2P}$$

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## CONICAL HEADS/REDUCER SECTIONS UG-32(g)

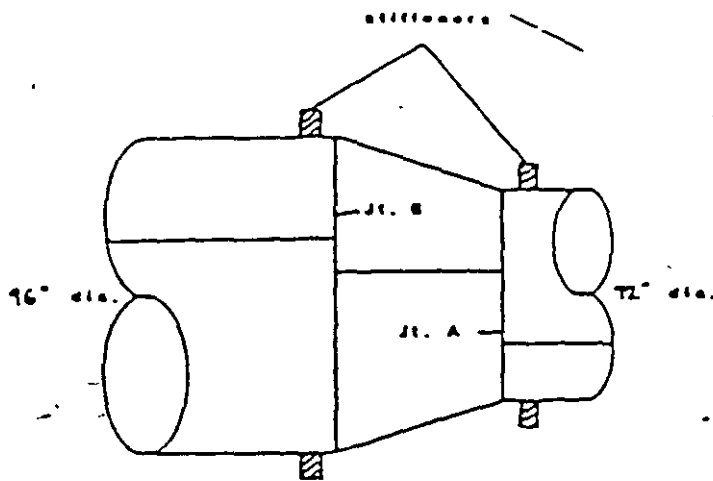
FOR CONICAL HEADS WITHOUT A TRANSITION KNUCKLE THE REQUIRED THICKNESS OF CONICAL HEADS OR CONICAL SHELL SECTIONS THAT HAVE A HALF APEX-ANGLE  $\theta$  NOT GREATER 30 DEG. SHALL BE DETERMINED BY:

$$t = \frac{PD}{2\cos\theta(SE - 0.6P)}$$

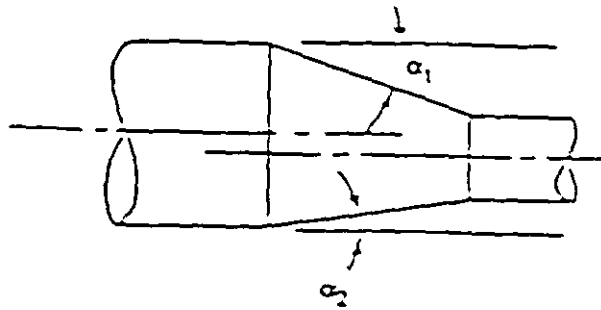
# TORICONICAL HEADS

## UG-32(h)

"TORICONICAL HEADS MAY BE USED WHEN THE ANGLE  $\theta \leq$  TO 30 DEG. AND ARE MANDATORY FOR CONICAL HEAD DESIGNS WHEN THE ANGLE  $\theta$  EXCEEDS 30 DEG., UNLESS THE DESIGN COMPLIES WITH 1-5(g)".



CONICAL REDUCER SECTION  
STIFFENERS



$\alpha_1 > \alpha_2$ . therefore use  $\alpha_1$  in design formulas

UG-36(g)  
OBLIQUE CONICAL SECTIONS  
(Under Internal Pressure)

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## UG-32(i)

"WHEN AN ELLISOIDAL, TORISPHERICAL, HEMISPHERICAL, CONICAL OR TORICONICAL HEAD IS OF A LESSER THICKNESS THAN REQUIRED BY THE RULES OF THIS PARAGRAPH, IT SHALL BE STAYED AS A FLAT SURFACE ACCORDING TO THE RULES OF UG-47 FOR BRACED AND STAYED FLAT PLATES".

# BRACED AND STAYED SURFACES

## UG-47

THE CALCULATIONS FOR BRACED AND STAYED SURFACES SHALL BE:

$$t = p \sqrt{\frac{P}{SC}}$$

- WHERE:  $p$  = THE MAXIMUM PITCH BETWEEN ANY SET OF STAYBOLTS
- $P$  = DESIGN PRESSURE
- $S$  = MAXIMUM ALLOWABLE STRESS PER SUBSECTION C
- $C$  = A FACTOR THAT ADDRESSES THE ATTACHMENT BETWEEN THE STAY/STAYBOLT AND THE FLAT PLATE

# UNSTAYED FLAT HEADS AND COVERS

## UG-34

THE CALCULATIONS FOR UNSTAYED FLAT HEADS AND COVERS ARE:

- WELDED FLAT CIRCULAR HEAD:

$$t = d \sqrt{\frac{CP}{SE}}$$

- BOLTED FLAT CIRCULAR HEAD:

$$t = d \sqrt{\frac{CP}{SE} + \frac{1.9Whg}{SEd}}$$

- WELDED FLAT NON-CIRCULAR HEAD:

$$t = d \sqrt{\frac{ZCP}{SE}}$$

- BOLTED FLAT NON-CIRCULAR HEAD:

$$t = d \sqrt{\frac{ZCP}{SE} + \frac{6Whg}{SELd}}$$