ENGINEERING STANDARD

FOR

PIPING MATERIAL SELECTION

(ON PLOT PIPING)

PART ONE

GENERAL

CONTENTS :

PAGE No.

APPENDICES :

0. INTRODUCTION

This Standards is prepared in three parts, which are separately bindered as follow:

Part I	General (guidance on the application of piping classes).
Part II	Piping class rating: PN 20 (150) and PN 50 (300).
Part III	Piping class rating: PN 100 (600) , PN 150 (900) , PN 250 (1500) and PN 420 (2500).

ENGINEERING STANDARD
FOR
PIPING MATERIAL SELECTION
(ON PLOT PIPING)
PART ONE GENERAL

1. SCOPE

This Standard contains piping classes primarily developed for petroleum refineries and petrochemical plants installed onshore. It is also intended for use in onshore exploration and production facilities as well as booster stations as far as applicable. Facilities covered by this Standard are all within the property limits as defined in ASME B31.3.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to, and shall be considered as a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Executor.

ANSI / ASME (AMERICAN NATIONAL STANDARD INSTITUTE / AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

B 16.5	"Pipe Flanges and Flanged Fittings"
B 31.3	"Chemical Plant and Petroleum Refinery Piping"
B 36.10	"Welded and Seamless Wrought Steel Pipe"
B 36.19	"Stainless Steel Pipe"
BVP Section VIII Div. I	"Un-Fired Pressure Vessels"

API (AMERICAN PETROLEUM INSTITUTE)

Publication 941	"Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-PI-240	"Plant Piping Systems"
IPS-M-PI-110	"Valves"
IPS-M-PI-150	"Flanges and Fittings"
IPS-E-TP-100	"Paints"
IPS-E-TP-270	"Coatings"
IPS-E-TP-740	"Corrosion Consideration in Material Selection"
IPS-C-PI-350	"Hydrotesting"

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

Paper No. 67

3. DEFINITIONS AND TERMINOLOGY

3.1 CA

Corrosion allowance.

3.2 Design Limits

Pressure/temperature limits given in piping classes.

3.3 Piping Class Index

A term which identifies the main characteristics of all piping classes. (e.g. materials for pipe, valve trim and gaskets).

3.4 Service Index

A term which identifies which piping class to select for the service concerned and mentioned in the list (without prefix related to ANSI rating).

3.5 PWHT

Indicates post weld heat treatment.

4. IDENTIFICATION OF PIPING CLASSES

Each piping class is identified from two alphabetical characters which precede a two digit figure, e.g. AN04. The first alphabetical character indicates pressure rating of flange, i.e. ANSI or PN classes as follows:

Character	A	for ANSI rating	PN 20	(150)
Character	C	for ANSI rating	PN 50	(300)
Character	F	for ANSI rating	PN 100	(600)
Character	G	for ANSI rating	PN 150	(900)
Character	H	for ANSI rating	PN 250	(1500)
Character	J	for ANSI rating	PN 420	(2500)

The second alphabetical character indicates material group selected as follows:

Character	N	for Carbon Steel
Character	P	for Low and Intermediate Alloy Steel
Character	S	for Stainless Steel
Character	T	for Aluminum and Aluminum Base Alloy
Character	V	for Copper and Copper Alloys
Character	W	for Nickel and Nickel Base Alloys
Character	X	for Non-Metallic Material
Character	Z	for Carbon Steel with Lining

The two digit figure indicates differing service condition (e.g. process fluid being handled and service temperature limits). The figure has not been selected on the basis of specific purpose and as such is not meaningful. However, piping classes which have identical figure with same material group are for the same service condition.

Example for identification of piping class is given below:

Piping Class AN04 is compiled from:

A	for	ANSI rating	PN 20 (150).
N	for	Material	Group Carbon Steel.
04	for	Service Condition related to this Class.	

Similarly, piping Classes CN07 and FN07 are for ANSI rating 300 and 600 respectively. Also both piping classes indicate same material group and same service.

5. SELECTION OF PIPING CLASSES

To select a piping class, the "Service Index" should be screened to see whether the intended service is listed. If so, the appropriate ANSI rating class shall then be identified by matching the required design pressure and temperature with the design limits given in the piping classes.

For services not listed in the "Service Index", the "Piping Class Index" can be screened to see whether a piping class is available in which the materials are considered suitable for the intended service. Piping class so selected, may be used provided that Company approval is obtained.

6. GENERAL BASES OBSERVED IN PREPARATION OF PIPING CLASS TABLES

6.1 Design Codes

- Piping classes have been designed in accordance with ANSI/ASME B 31.3.

- The design limits specified in the piping classes have been derived from the pressure/temperature ratings for flanges given in ANSI/ASME B 16.5 unless otherwise stated in the piping class notes.

- Where specified by ANSI/ASME B 31.3 bolting calculations have been performed to verify the ability to seat the selected gasket and to maintain a sealed joint under the given P/T range, ASME Section VIII Division I Appendix 2 has been followed for this .

Nominal wall thicknesses and outside diameters of pipe, as specified in the piping classes, are in accordance with ANSI/ASME B 36.10 M and ANSI/ASME B 36.19 M.

6.2 Design Values

Allowable stresses for the materials specifications contained in the piping class have been established in line with ANSI/ASME B 31.3, Paragraph 302.3.

For API 5L Grade B, a distinction has been made between seamless pipe and welded pipe with a weld joint factor E=0.95 (in accordance with ANSI/ASME B 31.3, Table 302.4). For all other materials the selection of pipe wall thickness is based on allowable internal pressure calculations for seamless pipe only. Consequently, where welded pipe is used, a weld joint factor of 1 shall be guaranteed.

In accordance with ANSI/ASME B 31.3, Paragraph 302.2.2, not more than 87.5% of the nominal wall thickness has been used in calculations for butt welding fittings.

6.3 Branch Connections

Reinforcement requirements for 90 degree pipe-to-pipe branch connections have been checked against the design limits of the piping class. The check calculations were performed in accordance with ANSI/ASME B 31.3, Paragraphs 304.3.2 and 304.3.3. The additional reinforcement of the welds is not taken into account.

The branch fitting outlet and the butt welding fittings as listed in Page 4 of each piping class could replace the welded pipe-to-pipe connections.

6.4 Sour Service

The indications on Page 1 of a piping class identify the sour conditions for which the piping class is suitable. This is summarized below:

	Indication on Page 1 of the Piping Class		Condition for which the Piping Class is suitable
PIPING CLASSES	Sour	PWHT	Wet H_2S, High Severity
	Sour		Wet H_2S, Moderate and Low Severity

7. DESIGN CONSIDERATIONS

This Standard shall be used in conjunction with the following considerations:

7.1 General piping design requirements shall be as per IPS-E-PI-240.

7.2 Unless otherwise specified in piping material selection, corrosion considerations shall be as per IPS-E-TP-740.

7.3 Unless otherwise noted, all pressure and temperatures referred to in this Standard are design conditions.

7.4 Buried steel piping is not considered as new classes. These pipings shall be externally protected in accordance with requirements of IPS-E-TP-270.

7.5 Except for parts mentioned in this Standard, valve specification shall conform to IPS-M-PI-110.

7.6 All pipe flanges and fittings shall conform to requirements of IPS-M-PI-150.

7.7 All pipes shall conform to requirements of related ASTM and API Standards.

7.8 Selection of Basic Material

In consultation with the process designer or process engineer, the materials engineer shall establish the preferred materials selection based on the process requirements such as medium, pressure, temperature, flow and the environment of the process facility. Design life and cost considerations shall also be taken into account in this respect.

7.9 Carbon steel piping systems for below-mentioned services shall be designed, and engineered specifically with considering their specific requirements:

a) Caustic soda as per concentration and temperature ranges specified in Appendix C.

b) Sulphuric acid (H_2SO_4) concentration 65% wt. and above, temperature maximum 50°C. Sulphuric acid (sulphuric acid 65-75% wt.) plus hydrocarbons, temperature maximum 65°C. (Appendices D, E)

c) Dry chlorine in either the liquid or gaseous phase at temperature between -50°C and -70°C. Dry chlorine contains less than 150 mg/kg of water. (Appendix F)

d) Dry liquid and gaseous hydrogen flouride at ambient temperature and following conditions and mixtures: (Appendix G)

i) Hydrocarbons, 33% HF and traces of water up to 70°C and 6 bar.
ii) Hydrocarbons, 4% HF and traces of water up to 160°C and 3 bar.
iii) Hydrocarbons, and traces of HF, up to 200°C and 3 bar.

7.10 If approved by company, lap-joint flange may be substituted by ring joint, welding neck or raised face welding neck flanges.

7.11 Slip-on flanges may be considered in hydrogen service, subject to engineering approval. In such case, the enclosed space between the OD of the pipe and the bore of the flange shall be vented by drilling A 3 mm diameter hole in the flange hub.

7.12 Corrosion allowance different from that shown in the line class shall be indicated on the related P & ID drawing.

7.13 Metric/English equivalent of pipe components-nominal size and pipe flanges pressure temperature rating are indicated in Appendices H and I.

7.14 When any carbon steel piping are to be designed and installed with carbon steel steam jacketing, (liquid sulphor, and hot bitumen services), related piping classes for main piping and jacketing shall govern for each system except for main piping corrosion allowance.

The main piping corrosion allowance shall be increased by an amount equal to jacketing corrosion allowance.

Note:

When the Appendices C through G were being reviewed, other relevant Standards Nos. IPS-E-PI-240 and IPS-C-TP-240 were finalized, therefore, these Appendices shall be screened and transferred to the appropriate standard in first revision of the above mentioned Standards.

APPENDICES

APPENDIX A
SUMMERY OF ISSUED PIPING CLASSES

Material	Piping Class	ANS class rating 150 A	300 C	600 F	900 G	1500 H	2500 J
Carbon Steel	N01	*	*	*	*	*	*
	N02	*	*				
	N04	*	*	*	*	*	
	N05	*	*				
	N06	*	*				
	N07	*	*	*	*		
	N09	*					
	N10	*	*	*	*	*	
	N12		*				
	N14		*	*	*	*	
	N16		*				
Alloy Steel	P02		*	*	*	*	
	P04	*	*	*			
	P05						*
	P06			*	*		
Stainless Steel	S02	*	*	*	*		*
	S04	*	*	*			
	S05	*	*				
	S06		*	*	*	*	
	S07		*	*	*		*
Aluminum	T						
Copper-based Alloys	V						
Nickel & Nickel-based Alloys	W						
Non-metallic Materials	X01	*					
Carbon Steel with Lining	Z01	*					
	Z02	*					
	Z03	*					
	Z04	*					
	Z05	*					

APPENDIX B
SERVICE INDEX [1)]

SERVICE		RECOMMENDED		REMARKS	See Note
Medium	Properties	Temp. limits (°C)	Piping Class(es)		
Acetic acid	All concentration	0 - 100	S02		
Acetone		0 - 100	N01		
Acetonitrile		0 - 130	N01		
Air Air	Instrument-Tool Instrument-Tool	0 - 200 0 - 100	N01 Z01		
Allyl chloride	Wet	0 - 20	X01		
Ammonia Ammonia	Aqueous Gas, dry and wet	0 - 165 0 - 100	N02 N02		
Aviation alkylate		0 - 120	N02		
Benzene		0 - 85	N01		
Butane Butane Butane	Gas Liquid	0 - 340 0 - 40 -50 - 50	N01 N02 N07		
Butanol		0 - 200	N01		
Butylene Butylene	Gas	0 - 140 -50 - 100	N01 N07		
Clacium carbonate Clacium chloride Clacium hydroxide	Aqueous Aqueous Aqueous	0 - 50 0 - 50 0 - 50	N02 N02 N02		
Carbon dioxide Carbon dioxide	Dry Wet	0 - 350 0 - 100	N01 S02		
Chlorine Chlorine Chlorine Chlorine	Gas, dry Gas, wet Gas, wet Liquid, dry	-35 - 70 0 - 50 0 - 150 -35 - 70	N16 Z02 Z04 N16		
Condensate	Steam non-aerated	0 - 250	N10		
Coolant	60/40 % H_2O/Methanol	-50 - 50	N07		
Diethanol amine Diethanol amine	Dry Water	0 - 150 0 - 150	N02 S02		
Diethylene glycol Diethylene glycol	All concentrations - Dry	0 - 150 0 - 150	N01 S02	To prevent product contamination	
Dimethylketone	Water	0 - 100	N02		
Diphenyl propane		0 - 140	S02	Final product DPP plant	

(to be continued)

APPENDIX B (continued)

SERVICE		RECOMMENDED		REMARKS	See Note
Medium	Properties	Temp. limits (°C)	Piping class(es)		
Ethane		-90 - 150	S04		
Ethanol		0 - 100	N01		
Ethylene		-140 - 150	S04		
Ethylene oxide Ethylene oxide	CO_2, water	0 - 150 0 - 200	S05 S05		
Foam, fire fighting	Concentrate	0 - 50	S02	DN 15-80	
Formic acids	All concentrations	0 - 30	S02		
Fuel gas	Wet H_2S		N02	Severity category VERY LOW	
Fuel oil	Sulphur compounds	0 - 330	N01		
Gas oil		0 - 200	N01		
Gasoline		0 - 100	N02		
Heat transfer fluid	Downtherm	0 - 390	N03		
Hydrocarbons Hydrocarbons Hydrocarbons Hydrocarbons Hydrocarbons Hydrocarbons Hydrocarbons Hydrocarbons	non-corrosive LPG LPG with mod. sev. H_2S LPG with or withut wet H_2S With mod. sev. wet H_2S With high severity HIC With S and/or NA With S and/or NA	0 - 330 0 - 200 0 - 200 -50 - 150 0 - 200 0 - 200 0 - 240 240 - 450	N01 N02 N04 N07 N04 N06 N01 P04	 Moderate sour Low temp, non-sour or moderate Sour Moderate sour High sour Corrosion rate must be checked	
Hydrochloric acide Hydrochloric acide	All concentrations All concentrations	0 - 30 0 - 150	X01 Z04		
Hydrogen Hydrogen Hydrogen	With or withut wet H_2S no H_2S With H_2S	0 - 230 230 - 450 230 - 538	N14 P06 S07	Moderate sour Check API 1941 for pres./temp. limit	
Hydrogen chloride Hydrogen chloride Hydrogen fluoride Hydrogen peroxide Hydrogen sulphide	Gas, dry Gas wet With or without hydrocarbon Up to 98% Gas, dry	0 - 100 0 - 50 0 - 200	N01 X01 N12 P02 N04	 See App. G Consult corrosion eng.	
Isobutyl alcohol Isopropyl alcohol	Finished product	0 - 100 0 - 100	N01 N01		
Luboil and seal oil		0 - 200	S02	To prevent product contamination	
Methane		-200 - 150	S04		
Methan		0 - 100	N02		
Methanol Methanol		0 - 100 50 - 150	N02 N07		
Methyl ethyl ketone		0 - 100	N01		
Methyl hexanol Methyl mercaptan Naphtha Naphthenic acide		 0 - 30 0 - 340 0 - 95	N02 N02 N01 N02	Consult corrosion engineer	

NA = Naphta

HIC = Hydrogen Induced Cracking

(to be continued)

APPENDIX B (continued)

SERVICE		RECOMMENDED		REMARKS	See Note
Medium	Properties	Temp. limits (°C)	Piping class(es)		
Nitrogen Nitrogen Nitrogen	Liquid	200 - 150 0 - 340 0 - 200	S04 N01 N02		
Phenol Phenol		0 - 200 0 - 150	N01 S02	To prevent product contamination	
Phosphoric acid	All concentration				
Polyols	Acidic or alkaline	0 - 200	S02		
Polypropylene		0 - 200	N01		
Potassium hydroxide				Consult corrosion engineer	
Propylene	Liquid	-100 - 150	S04		
Seal oil			S02		
Secondary butyl alcohol		0 - 200	N01		
Sodium hydroxide (caustic soda)				Consult corrosion engineer	
Steam Steam Steam	Saturated/superheated Superheated	0 - 400 400 - 450 400 - 538	N10 P02 P05		
Sulphur	Dry	0 - 150	N01		
Sulphur trioxide	Dry gas	0 - 340	N01		
Sulphuric acid	> 65% wt	0 - 60	N05		
Water, boiler feed Water, boiler feed Water, boiler feed	Demineralized aerated Treated non-corrosive	0 - 150 0 - 250 0 - 75	S02 N10 Z02	For existing systems only	
Water, cooling Water, cooling	Brackish-/seawater Treated	0 - 50 0 - 60	Z03 N09		
Water, demineralized Water, demineralized	Process use	0 - 80	S02 Z02	For existing systems only	
Water, fire fighting Water, fire fighting Water, fire fighting Water, fire fighting	Brackish-/seawater Brackish-/seawater Fresh Piping normally dry	0 - 45 0 - 50 0 - 50 0 - 50	Z03 Z05 N09 Z01	 For above ground systems only Check oxygen and corrosion rate/life For above ground systems only	
Water, potable	Fresh, treated	0 - 20	Z01		
Water process	Demineralized	0 - 80	Z02		
Xylene		0 - 340	N01		

Notes:

1) Since concern of service index is material group and service conditions, piping class indicated does not bear prefix for pressure rating.

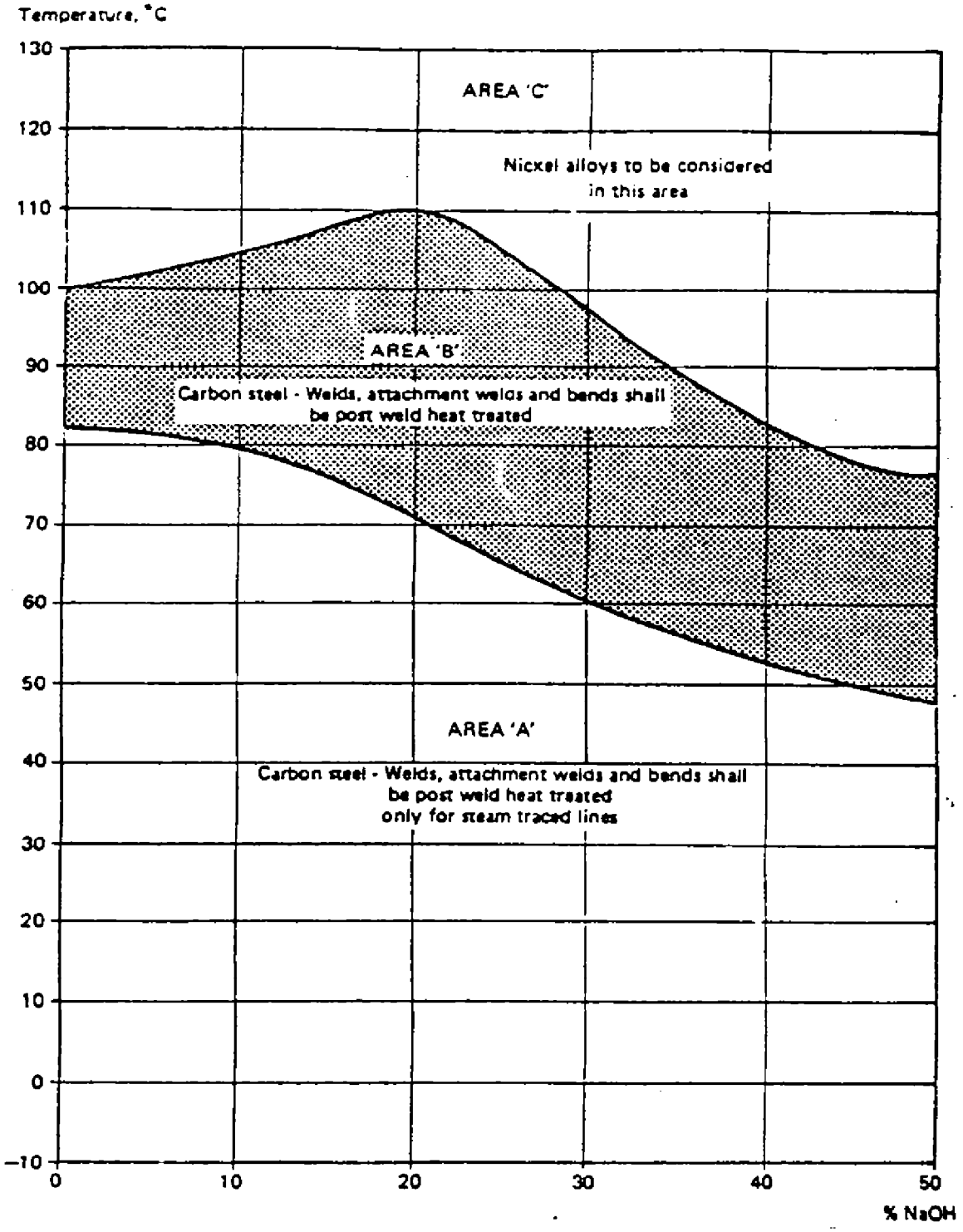
2) At higher temperatures, corrosion due to carbonyl formation may increase significantly; consult materials/corrosion engineer.

3) Design temperature is limited in accordance with API publication 941 (Nelson curve).

4) For steam jacketing (piping class) should be referred to N10.

5) For extended service limit (for temperature up to 540°C) refer to Appendix J.

APPENDIX C
TEMPERATURE AND CAUSTIC SODA CONCENTRATION RANGES FOR METALLIC PIPE, FITTINGS AND VALVES



(to be continued)

APPENDIX C (continued)

GENERAL REQUIREMENTS FOR CARBON STEEL PIPING IN CAUSTIC SODA SERVICE

Requirements to prevent caustic soda embritlement in carbon steel piping are given below:

C.1 Design

C.1.1 For area "A", non-heated lines, no requirements.

C.1.2 For area "A", steam-traced lines, stress-relief for welds, attachment welds and cold-formed bends.

C.1.3 For area "B", all lines, stress-relief for welds, attachment welds and cold-formed bends.

C.1.4 Design piping systems for furnace post-weld heat treatment (pwht) preferably, i.e. with flanges, so as to enable placing in a furnace.

C.1.5 Particularly intricate parts such as valve and pump manifolds should be designed for furnace pwht.

C.1.6 If field pwht is unavoidable, ensure that areas and parts to be heat-treated, are readily accessible.

C.1.7 Restrict the application of cold-formed parts resp. cold forming during fabrication.

C.1.8 Exclude hot spots by direct wall-to-wall contact in the case of steam or electrical traced lines by application of spacers (ceramic, glass fiber or filled phenolic resin).

C.1.9 Include the design of steam or electrical tracers. Fixation points for tracers to be at a distance of 6.5 m max. with special attention at bends and fittings.

C.1.10 Drawings

All drawings for the fabrication of carbon steel piping intended for caustic soda service shall be clearly marked "CAUSTIC SODA SERVICE".

C.2 Fabrication

C.2.1 Welding

Inert gas or CO_2-shielded arc welding shall be used for the root pass. Welds shall be made without excessive penetration (max. 2 mm) and shall be without grooves and/or craters. Pipework shall be inspected after welding.

C.2.2 Installation

Hanger supports shall be clamped around the pipes and bolted. Strips of CAF or glass-fiber material shall be applied between pipe and support. All indications given for the design of traced lines shall be followed closely.

C.2.3 Ensure that all attachment welds are made before pwht is applied.

C.3 Examination

C.3.1 Visual examination of all welded piping parts shall be done during fabrication by an experienced inspector.

C.3.2 A minimum of 10% of all welds shall be checked by radiography before post-weld heat treatment. All defects shall be repaired to fulfill minimum requirements.

(to be continued)

APPENDIX C (continued)

C.4 Heat Treatment

C.4.1 Welds, attachment welds and cold-formed piping parts shall be given a stress relief post-weld heat treatment.

C.4.2 This heat treatment shall be carried out in a furnace or, if required, by electric induction heating.

C.4.3 Heat treatment shall be in the range of 580 to 620°C with a holding time of 3 minutes per mm thickness and a minimum holding time of 1 hour. Cooling shall be controlled at a rate of 100°C per hour down to 350°C.

C.4.4 The complete post-weld heat treatment cycle shall be recorded.

C.5 Testing

C.5.1 All piping parts shall be hydraulically tested after heat treatment.

C.5.2 The hydrostatic test pressure to be used shall be 1.5 times the maximum allowable pressure at ambient temperature, as mentioned in the relevant piping classes.

C.5.3 Ensure that draining and drying after testing is carried out properly.

C.6 Identification

C.6.1 All piping fabricated in accordance with this Standard shall be clearly identified by a suitable marking either by painting or fixing an adhesive tape around the parts.

C.6.2 Pipe class number and line designation shall be painted on each part.

APPENDIX D
GENERAL REQUIREMENTS FOR CARBON STEEL PIPING IN SULPHURIC ACID SERVICE

Carbon steel piping systems in sulphuric acid shall be designed in accordance with the rules given below:

D.1 Design

D.1.1 Flow rate

Piping shall be sized for a nominal velocity of 0.75 m/s in straight ends.

D.1.2 Flow changes

Pipework design shall be studied carefully to avoid sudden changes in the directionflow, turbulences and extreme changes in velocity.

D.1.3 Drainage falls

Horizontal runs of pipework shall be avoided. Generous falls for self-draining purposes shall be provided for, wherever possible. The fall shall be minimum 1 cm/m.

D.1.4 Pipe bends and elbows

Pipe routings shall be studied with the aim to reduce the number of bends and to restrict the number of elbows to the bare minimum.

Pipe bends shall have a radius R = 5 D where D is the nominal pipe diameter. Standard elbows, which shall be used for sweep-in connections, shall be long-radius type R = 1½ D. Short-radius elbows (R = D) shall not be used.

D.1.5 Pipe reducing

Reducers shall be avoided as much as possible. Where a reduction is necessary, the reducer shall be concentric, the reducing part shall be smooth and the reduced diameter bore shall correspond to the connecting part or be tapered to suit that bore.

D.1.6 If reducing is upstream, an eccentric reducer may be considered to ensure the required fall for drainage.

D.1.7 Junctions

Pipework shall be designed to avoid 90° tee junctions, instead 45° laterals; Y-type or sweep-in junctions shall be used.

D.1.8 Spool pieces

Whenever turbulences or considerably higher velocities cannot be avoided, the use of spool pieces shall be considered. These can be made out of solid, fully-resistant alloys or carbon steel, lined with fully-resistant material. Length of spool pieces to be L = 20 D where D is the nominal pipe diameter.

(to be continued)

APPENDIX D (continued)

D.1.9 Post-weld heat treatment

Pipe sections of intricate shapes, which are not accessible for finishing and/or where turbulences and velocity changes are most likely, e.g. valve and pump manifolds, shall be designed as flanged sections, such to enable pwht in a furnace.

D.1.10 Butt welding

Pipework shall be designed to restrict the number of butt welds which are not accessible for finishing and inspection of the inner surface. Misalignment of individual and adjoining pipe bores shall not exceed 0.3 mm.

D.1.11 Flanges

Flanges shall be installed to enable access to welds for finishing and to fabricate flanged pipe sections, junctions, reducers and other special pipe parts. Welding neck flanges shall be used. In exceptional cases the use of slip-on flanges may be considered.

D.1.12 Gaskets

Flat ring gaskets, with ID dimensions exactly equal to the bore of the pipes shall be used. The OD dimensions shall be in accordance with ANSI/ASME B 16.21. Gasket thickness to be 1.5 mm. Gasket material to be specified for sulphuric acid service. Attention shall be given that not all acid-resistant type gaskets are suitable.

D.1.13 Drawings

All drawings for the fabrication of carbon steel piping intended for acid service shall be clearly marked "SULPHURIC ACID SERVICE".

D.2 Welding

Inert gas or CO_2 shielded arc welding shall be used for the root pass. Where the weld metal penetrates to the bore of the pipe and/or fitting, great care shall be taken to ensure full penetration without excess penetration. The internal bore at the location of the welds shall be dressed flush with the inner pipe wall.

Permanent backing rings shall not be used.

D.3 Examination

D.3.1 Visual examination of all welded piping parts shall be done during fabrication by experienced inspectors.

D.3.2 A minimum of 10% of all welds shall be checked by radiography. Radiographing shall be done after the welds have been dressed. All defects shall be repaired to fulfill the minimum requirements.

D.4 Heat Treatment

D.4.1 A normalizing heat treatment shall be applied to sections of intricate shape, e.g. valve and pump manifolds, and sections where high heat input on welding or extreme stresses on forming have been introduced.

(to be continued)

APPENDIX D (continued)

D.4.2 Heat treatment conditions:

- normalizing temperature 900-930°C;
- holding time 3 minutes per mm thickness with a minimum of 1 hour;
- cooling in still air.

Attention shall be paid to adequate support of the piping sections during normalizing to prevent excessive deformation and/or warping.

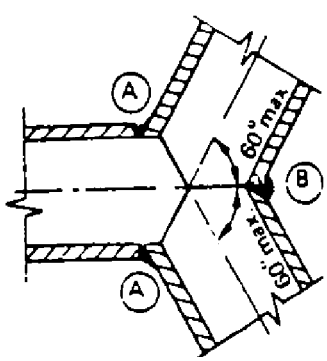
D.5 Testing

D.5.1 All piping parts shall be hydrostatically tested after post-weld heat treatment.

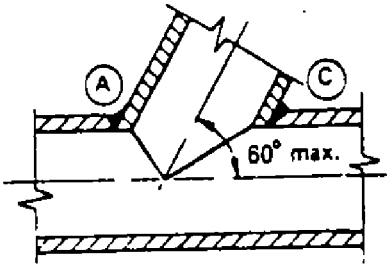
D.5.2 The hydrostatic test pressure to be used shall be 1.5 times the maximum allowable pressure at ambient temperature, as mentioned in the relevant piping classes.

D.5.3 Ensure that draining and drying after testing is carried out properly.

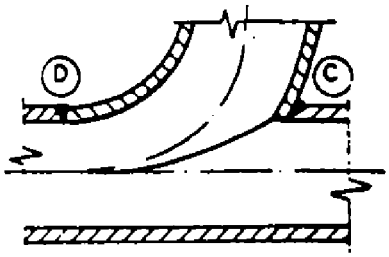
APPENDIX E
CONSTRUCTION AND WELD DETAILS FOR CARBON STEEL PIPING IN SULPHURIC ACID SERVICE



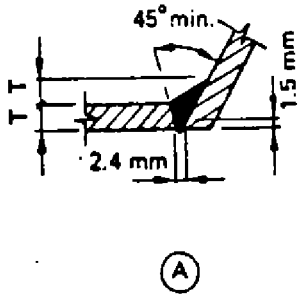
Y Junction

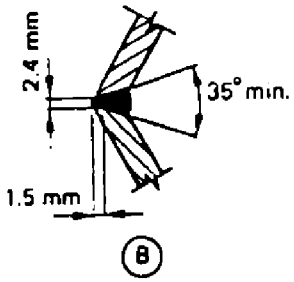


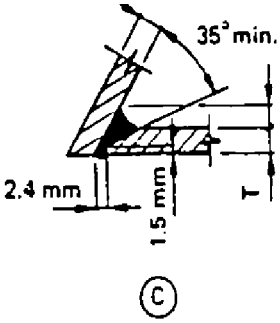
Lateral

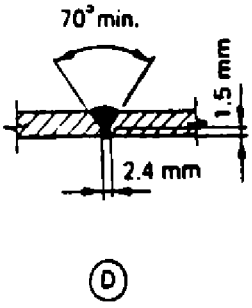


Sweep-in

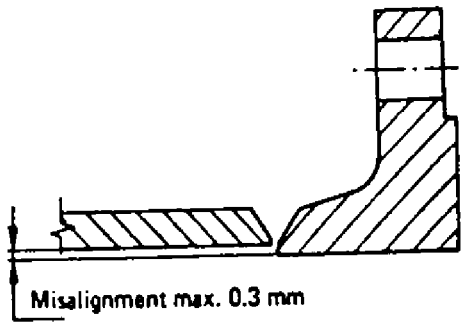




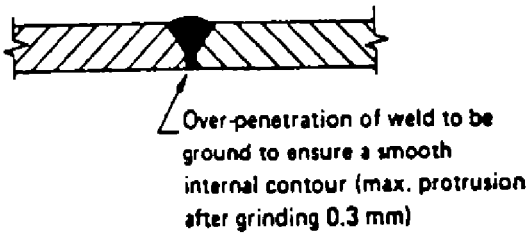




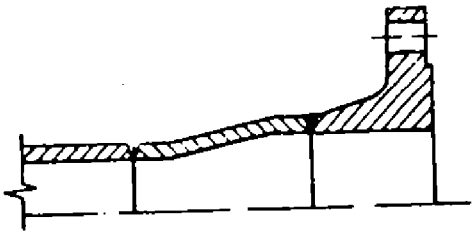
Weld Details



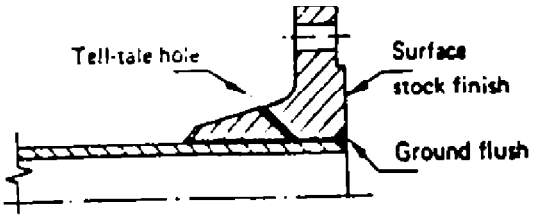
Misalignment of Bore for Butt Jointing



Finishing of Butt Weld



Reducer Assembly



Slip-On Flange Assembly

APPENDIX F
GENERAL REQUIREMENTS FOR CARBON STEEL PIPING IN DRY CHLORINE SERVICE

This Appendix provides requirements for the design, and testing of piping systems for "dry" chlorine, in either the liquid or gaseous phase, at temperatures between -50°C and +70°C. "Dry" chlorine contains less than 150 mg/kg water.

F.1 Design

F.1.1 Materials for process piping in chlorine service, are specified in piping Class CN16. Liquid chlorine shall be considered to be a "(toxic) lethal" substance.

F.1.2 Only schedule 80 seamless pipe of minimum DN 20 (NPS ¾) should be used to ensure rigidity and protection against mechanical damage which may result in leaks.

F.1.3 Piping DN 25 (NPS 1) is adequate for all normal flows.

F.1.4 Piping arrangements shall be as simple as possible, with a minimum of welded or flanged connections. For piping of DN 100 (NPS 4) and smaller, elbows shall preferably be made by bending. Threaded joints shall not be used. All welds shall be butt welds. No socket welding fittings, bosses and weldolets shall be used where a fillet weld will be applied.

F.1.5 Liquid chlorine has a high coefficient of thermal expansion. If liquid chlorine is trapped between two valves, and expands enough pressure is created to burst the pipe. Therefore each line or line section shall have an expansion chamber, a pressure relief valve or rupture disc discharging to a receiver.

The expansion chamber capacity shall have at least 20% of the section volume and be based on a temperature rise of 27°C above the ambient temperature.

F.2 Manufacturing

F.2.1 Assembly of piping components

For the assembly of all piping components, pipe ends, fittings and welding neck flanges to be butt-welded, a uniform root opening, as specified below, is required:

NOMINAL PIPE SIZE	ROOT OPENING
Smaller than DN 50 (2 in.)	1.5 mm
DN 50 - 250 (2-10 in.)	1.5-2.5 mm
DN 300 (12 in.) and larger	2.5-3.5 mm

F.2.2 Alignment

Alignment shall be in accordance with ANSI B 31.3 but with the exception that the internal trimming shall be 1:4, instead of 30°C.

(to be continued)

APPENDIX F (continued)

F.2.3 Bending

1) Pipes may be bent in the hot or cold condition.

2) A normalizing heat treatment shall be applied if the Flattening deformation is more than 5%.

3) No heat treatment is required for hot-formed bends upon which the final forming operation is completed at a temperature above 620°C and below 950°C provided they are cooled in still air.

When hot bending is carried out outside the temperature range given above, a separate normalizing heat treatment at 900-950°C is required.

F.2.4 Welding

- Field welds shall be kept to a minimum and shall be carried out under fair weather conditions only.
- Permanent backing rings shall not be used.
- Post-weld heat treatment is not required.
- Cracked tack welds shall be removed using the same procedure.
- Temporary tack welds should not touch the root gap or the root face.
- For temporary tack welding, the use of "bridge pieces" is recommended to avoid damage to the root face of the gap area.

Welding processes - For pipe sizes DN 50 (2 in.) and smaller, the "gas Tungsten arc welding process" shall be applied.

Larger sizes should be "gas Tungsten are welding", but shielded metal are welding may be used.

Procedures and welders shall be qualified and approved by the principal before actual production welding starts.

Welding consumables - An alternative possibility is the procurement of consumables directly from the manufacturer complete with certificates. These certificates should give information per batch on chemical composition and mechanical properties of the weld deposit.

Final approval of welding consumables for a particular job will follow through meeting the test requirements of the welding procedure qualification.

Inspection of welds - All welds shall be 100% radiographed.

The method of radiography to be employed for inspection should be in accordance with ASME Section V.

Acceptance criteria of welds shall be in accordance with ANSI B 31.3, Table 327.4.1A "Limitation on Imperfections in Welds".

F.3 Hydrostatic Testing

The hydrostatic testing shall be carried out according to IPS-C-PI-350 before the system is cleaned and dried. For piping Class CN16 the hydrostatic test pressure shall be at least 45 bar (1.5 times the pressure of the service limits).

(to be continued)

APPENDIX F (continued)

F.4 Final Cleaning and Drying after Welding and Testing

F.4.1 Chlorine may react with oil. Therefore, in addition to requirements cited in IPS-C-PI-410 cleaning shall be accomplished by pulling through each pipe section a cloth saturated with trichloroethylene or other suitable chlorinated solvent. Hydrocarbons or alcohol shall never be used, because remnants of these solvents react with chlorine.

Cleaning and drying are accomplished by passing steam through the line from the high end until the entire line is hot to the touch (approximately 60°C). Condensate and any foreign particles (such as oil or metal) shall be drained out after the steam supply line has been disconnected and all pockets and low spots have been drained.

While the line is still warm, dry air shall be blown through the line until the dew point of the discharged air is the same as that of the air blown into the system, e.g. minus 40°C or below. When drying is finished, the line shall be kept closed in order to prevent re-entry of atmospheric moisture.

F.4.2 Gas testing

The dried piping system shall be pressurized to 10 bar ga with dry air or nitrogen and tested for leaks by the application of soapy water to the outside of joints. Afterwards, chlorine gas may be introduced and the system re-tested for leaks as described below.

F.4.3 Detection of chlorine leaks

The location of a leak in a chlorine-containing system can be detected by the reaction of ammonia vapor with the escaping chlorine. The reaction gives a dense white cloud.

The most convenient way is to direct the ammonia vapor at the suspect leak employing a plastic squeeze bottle containing aquous ammonia. Do not squirt liquid aquous ammonia on pipe and fittings.

F.4.4 Repairs

Repairing a leak may require welding. Before any welding is started, all piping shall be thoroughly purged and checked for the thoroughness of the purge (inside and around the pipe) with an explosion meter. Carbon steel ignites in chlorine of 250°C, thus welding without purging could start a fire. Purge with dry air and continue a small flow of air during the welding operation.

APPENDIX G
GENERAL REQUIREMENTS FOR PIPING IN HYDROGEN FLUORIDE (HF) SERVICE

G.1 General

Mixtures of hydrogen fluoride, hydrocarbons (and some water) as they occur in the HF alkylation process for the production of iso-octane and detergent alkylates. The following mixtures can be contained in carbon steel:

- Hydrocarbons 33% HF and traces of water up to 70°C and 6 bar,
- Hydrocarbons 4% HF and traces of water up to 160°C and 3 bar.
- Hydrocarbons and traces of HF, up to 200°C and 3 bar.

G.2 Design

Piping Classes:

Class CN12 ASTM A 333 Gr. 6, 3 mm corrosion allowance, temperature limits 0-200°C, specially meant for operation below 45°C.

G.2.1 Hydrogen fluoride is considered a lethal substance, and all piping that operates below 45°C or may reach such low temperatures during any stage in operation shall be made of notch-ductile materials. Classes CN12 fulfill that requirement.

G.2.2 The use of bellows is prohibited. Screwed connections shall not be used, all connections shall be welded or flanged. Flange connections shall be reduced to the least possible number to avoid leakages.

G.2.3 Most bolting materials (Cr-Mo steel, stainless steel, Monel) may be susceptible to stress corrosion cracking if exposed to HF. Therefore flanged connections shall not be permitted to leak and the edge of all flanges shall be painted with one coat of Socony HF Detecting Paint No. 20-Y-15 for the detection of HF leaks. Hence, flanges shall not be insulated.

G.2.4 For safe and easy handling during operation and (downhand) maintenance all valves and instruments shall be located at an elevation of maximum 1 meter above the floor.

G.2.5 To avoid that possible deposition of iron fluoride may hamper the operation, the valve types shall be selected as follows:

- Globe valves with Monel trim and soft seats (PTFE) for valves in normally closed position.
- Ball valves with Monel Ball and seats for valves in normally open position.

G.2.6 All HF service piping shall be installed above grade and shall be self-draining to the necessary low point bleeders. To minimize the number of low point bleeders, piping should drain into equipment if possible (vessels, heat exchangers, pumps, control valves).

G.2.7 Process line size should be minimum DN 25. Drains, vents, bleeders, etc., may be made minimum DN 20. All control vales in HF service shall be installed with block valves and by-pass globe valve and shall have a flush connection on either side of the control valves. Gage glasses shall be provided with a protective cover of KEL-F or PTFE.

G.2.8 Equipment in HF Service is normally post-weld heat treated, this is not required for piping.

(to be continued)

APPENDIX G (continued)

G.3 Identification

All piping fabricated to this Standard shall be identified by a clear and suitable marking, either by painting or fixing an adhesive band around the pipe.

Pipe class number and line designation number shall be painted on each pipe piece.

G.4 Operation and Maintenance

The wearing of protective clothes, gloves, goggles, etc., shall be prescribed and it shall be ensured that all safety instructions are strictly observed.

Before breaking flanges of piping that have been in HF service neutralization by means of ammonia or sodium bicarbonate is required to prevent HF contact with the skin. Even if no severe corrosion is experience fouling and heavy iron fluoride deposits are often present.

Neutralization of such thick fouling layers is rather difficult and upon subsequent mechanical removal acidic conditions may again be encountered underneath due to insufficient neutralization. If the acidity is such that it is unsafe to continue work, a second neutralization is recommended.

APPENDIX H
GENERAL REQUIREMENTS FOR RUBBER LININGS FOR PROCESS EQUIPMENT AND PIPING

H.1 SCOPE

This Appendix covers both the general requirements for the purchase and related testing, inspection transportation and storage of vulcanized and non-vulcanized rubber-lined process equipment and piping, both shop fabricated and in-situ.

H.2 MATERIALS

H.2.1 General

The following rubber types are used for lining purposes (classification in accordance with ASTM D 1418):

- Natural rubber	(NR)
- Synthetic polyisoprene rubber	(IR)
- Styrene-butadiene rubber	(SBR)
- Chloroprene rubber	(CR)
- Butyl rubber	(IIR)
- Nitrile rubber	(NBR)
- Ethylene propylene rubber	(EPM and EPDM)
- Urethane rubber	
- Chlorosulphonated polyethylene	(CSM)*
- Fluoro rubber of the polymethylene type	(FKM)**

* Commercially available under the registered trade mark "Hypalon"
** Commercially available under the registered trade mark "Viton"

Ebonites are rubbers with a hardness value of at least 60° Type D Shore and can be produced from NR, IR, SBR, NBR or blends thereof.

H.2.2 Material Selection

The final selection of the type and thickness of the rubber lining, and the method of application, shall be made in conjunction with the materials specialist and the lining contractor.

The following details shall be included on the requisition of the equipment concerned:

- products to be handled
- temperature
- degree of vacuum or pressure

} minimum, maximum, normal

- cycle of operations
- abrasion and erosion aspects
- immersion conditions.

H.2.3 Quality of Rubber

The grade of rubber shall be specified on the requisition sheet. The lining contractor shall state that the lining will satisfy the chemical and physical conditions specified with respect to the agreed service lifetime.

The manufacturer shall supply the specification for the approved rubber compound and samples of the vulcanized rubber sheet for test and reference purposes. The specification of the rubber compound shall not be changed without prior written approval from the principal.

(to be continued)

APPENDIX H (continued)

H.3 DESIGN AND FABRICATION

H.3.1 General

The fabrication of the equipment shall be in accordance with BS 6374: Part 5 or DIN 28051 and DIN 28055.

The important points are:

- the surface must be accessible for manual working;
- the weld seams must be continuous, smooth and free from pores and, if necessary, machined or ground (H.3.3);
- (steel) reinforcements should, if possible, be situated on the outside.

All branches shall be flanged and the lining shall be taken over the flange face to prevent ingress of the process liquid behind the lining.

For typical flanged connections in equipment see Drawing No. H-7.
For typical flanged connections in piping see Drawing Nos. H-1 and H-6.
For standard lengths and dimensions of piping and piping elements see Drawing Nos. H-4 and H-5.

Sharp changes of contour in the surface to be lined shall be finished to a suitable radius, such that the internal radius of the lining not less than 3 mm. Air vent holes to prevent air trapped in welded joints may sometimes be necessary, see Drawing No. H-2.

H.3.2 Surface Finish of Substrate

The surface to be lined shall be smooth, free from pitting, cavities, porosity, or other surface irregularities in accordance with DIN 28053.

The surface shall also be free from oil, grease and other foreign matter. Metallic surfaces shall be blast-cleaned to a surface finish corresponding to SA 2.5 in accordance with ISO 8501-1. After this operation the surface roughness shall have a peak-to-valley height of 40 μm-100 μm, with an average of 50 μm.

Immediately after the blast cleaning of the metallic substrate the grit, dust etc. shall be removed and a layer of adhesive primer with a dry-film thickness of approximately 30 μm shall be applied.

H.3.3 Welds in Metal Substrate

All metal-to-metal joints shall be made by welding. Welds shall be homogeneous and free of pores. Welds shall be ground smooth and flush with the parent metal on the side to be covered. Wherever possible, they shall be made from the side to be lined. Where this is not possible, the root shall be chipped out and a sealing run shall be applied. Internal corner and tee joints shall be welded with full penetration.

Welds shall be ground smooth and concave to the required radius (H.3.1). Welds shall be examined according to applicable design codes. Drawing No. H-2 shows acceptable welding details.

H.3.4 Joints in Rubber Lining

Overlap joints as shown in Fig. 1 of Drawing No. H-3 shall be used when joining separate sheets of unvulcanized rubber. The total contacting surface between the sheets shall be a minimum of four times the sheet thickness but shall not exceed 32 mm at any point. Where applicable, overlaps shall the direction of the liquid flow.

(to be continued)

APPENDIX H (continued)

When the total lining thickness is built up from more than one layer, only the joints in the top layer shall be of the overlap bevel type, the under layers being flush-jointed as shown in Fig. 2 of Drawing No. H-3. The relatively weak flush joint (Fig. 3 of Drawing No. H-3) is applied when the lining is used as a base for chemical-resistant brick lining. Joints in the different layers shall be staggered.

Joints between rubber pipe linings and the rubber on the flange facing shall not protrude so as to restrict the bore of the pipe or to prevent efficient sealing between the flange faces of adjacent lengths.

H.3.5 Gaskets

The selection and application of the gasket material shall be in accordance with the service conditions. Generally for hard rubber linings a soft rubber gasket is used and for soft rubber linings a CAF gasket is used.

To prevent the gasket and lining bonding together, the rubber flange facing should be lightly rubbed with colloidal graphite.

H.3.6 Painting

Unless otherwise stated, all parts which are not rubber-lined shall be degreased and blast-cleaned and painted with one coat of a suitable epoxy resin-based primer. This shall be carried out after vulcanization of the rubber.

H.3.7 Lining Application

Manufacturer's procedures for the application of the lining shall be adhered to. However, if shop vulcanization is used, the adhesive primer shall be applied immediately after preparation of the substrate. The pre-cut unvulcanized rubber sheets shall be applied without inclusion of air and with specified joints within 96 hours.

If in-situ vulcanization is carried out, the surface to be lined shall have a temperature during the application of the unvulcanized rubber sheets not lower than 10°C and the relative humidity should not be higher than 75%, i.e. water condensation on the surface shall be prevented during application.

The manufacturer shall be responsible for the type of the adhesive system used to bond the rubber lining to the substrate. He shall produce evidence that the adhesive system is suitable for the service conditions and will produce the bond required between rubber and substrate when the rubber is applied under the conditions of vulcanization.

H.4 QUALIFICATION TESTING

H.4.1 General

The principal will indicate at the time of enquiry or order whether qualification testing is required before delivery in order to establish the capabilities of the manufacturer or, for example, because of time elapsed or new developments.

At the request of the manufacturer, and after approval by principal, the tests required may be performed on products from current running stock. The number and size of the samples and the method of sampling shall be established by agreement between the manufacturer and the principal.

Tests may be performed by the manufacturer or by an independent testing organization. In both cases a certificate stating the test results shall be submitted. DIN 50049 3.1 B is acceptable for this purpose.

When the equipment is subject to a test pressure greater than 0.5 barg, the lining shall be carried out after hydrotesting.

(to be continued)

APPENDIX H (continued)

H.4.2 Rubber Lining

H.4.2.1 Rubber quality

It shall be verified that the type of rubber is correct (H.2.3). Test method ASTM D 3677 may be used for identification.

H.4.2.2 Performance of rubber

The manufacturer shall certify that the quality of the rubber will satisfy the chemical and physical conditions to which it will be exposed for the agreed operating life.

H.4.2.3 Physical properties

The physical properties of the vulcanized rubber shall comply with the values given by the manufacturer. The test methods as described in BS 903:part A2 are acceptable. These tests are carried out on separately supplied test samples. All hardness readings shall conform to the specified value within plus/minus 5°. A minimum of three readings shall be taken for each square metre of lining. For large surfaces the maximum number of readings shall be agreed upon by the manufacturer and the principal. In general, it is common to express hardness in Durometer A or Durometer D readings in accordance with ASTM D 2240.

H.4.3 Rubber-Lined Parts

H.4.3.1 Surface defects

Linings shall be free from blisters larger than 10 mm in diameter, cracks or other surface imperfections, porosity, voids or inclusions.

H.4.3.2 Adhesion

For the determination of the adhesion to the metal substrate, samples shall be prepared from the same rubber compound used for the lining and the same metal.

The pretreatment of the metal sample shall be identical to the pretreatment of the surface of the equipment or piping. After the same vulcanization procedure, the adhesion shall be determined according to method A (for ebonites) and to method B (for soft rubbers) as described in ASTM D 429. The adhesion value calculated from the load at failure and the original bonded area shall be as agreed upon in the specification. However, unless otherwise agreed, they shall be at least 10 N/mm^2 (method A) and 4 N/mm^2 (method B) respectively.

H.4.3.3 High-voltage spark

The continuity of the lining on metallic substrates shall be checked with a high-voltage spark test. Sparks shall not be produced when the lining is tested with a direct-current apparatus, using a voltage which is determined by the following formulas:

6 (1 + thickness in mm) kV which shall not exceed 30 kV.

This voltage should be adjusted for high carbon black filled (soft) rubbers to approximately 3 kV per mm thickness (exact voltage to be determined on a test sample). It is not possible to inspect antistatic linings with this test. In this case, after consultation with the Principal, the "wet sponge test", a low-voltage holiday detector shall be used.

(to be continued)

APPENDIX H (continued)

Both the methods describing the continuity testing in BS 6374:Part 5 for high frequency with an AC source and the high-voltage test in DIN 55670 are acceptable to the Principal.

H.4.3.4 Thickness

The thickness of the lining applied on substrates shall be determined with a thickness meter and shall conform to the agreed thickness with a minimum of 90% of that thickness. A minimum of three measurements per square metre shall be made. For large surfaces the maximum number of readings shall be agreed between the manufacturer and the Principal.

H.5 ACCEPTANCE TESTS AND CERTIFICATION

H.5.1 Tests

The inspector representing the Principal shall check at random whether the rubber-lined process equipment and piping meets the requirements mentioned in (H.4). In addition, the following acceptance tests shall be carried out.

if the requirements are not achieved, even after re-vulcanization, the rubber-lined item shall be rejected.

H.5.1.1 Visual inspection

The rubber lining shall be free from cracks or any other imperfections. Blisters smaller than 10 mm diameter are acceptable, unless otherwise specified.

Minor wrinkles and surface markings which will not have a significant effect on the performance of the lining are also acceptable.

The total amount of repairs shall not be more than 100 cm^2 per square metre of lined surface. Lining repairs are not allowed in piping, on flange facings or on nozzle necks of equipment.

Repair of damaged rubber linings shall only be carried out by the contractor after consultation with and the agreement of the Principal.

H.5.1.2 Adhesion

The adhesion between the rubber lining and the substrate shall be homogeneous and without any defect. This may be investigated by lightly tapping the rubber lining with an appropriate wooden hammer. At areas where the adhesion is broken, a hollow sound will occur.

H.5.1.3 Thickness

The thickness of the rubber lining applied on carbon steel substrates shall be determined and shall conform to the thickness as mentioned on the requisition form with a minimum of 90% of that thickness. A minimum of three measurements per square metre shall be made.

H.5.1.4 Hardness

The hardness shall conform to the value specified on the requisition within a tolerance of plus/minus 5°. A minimum of three readings per square metre shall be taken.

(to be continued)

APPENDIX H (continued)

H.5.1.5 Continuity of the lining

The continuity of the lining shall be checked according to (H.4.3.3); however, using a reduced voltage determined by the following formula:

4 (1 + thickness in mm) kV.

H.5.1.6 Hydraulic testing

If applicable, equipment and piping shall be tested hydraulically at a pressure equal to the test pressure mentioned in the appropriate design code, and at the maximum allowable service temperature for the particular lining. These conditions shall be maintained for a period of 1 hour. At the end of the test, the lining shall be visually inspected. Blisters, cracks or other surface irregularities are not permitted. Thereafter the lining shall pass the high-voltage spark test.

H.5.1.7 Vacuum testing

If applicable, the equipment and piping shall be tested at a vacuum of 130 mbar absolute at ambient temperature for a period of 1 hour. After this test no visible defects shall be permitted in the lining.

H.5.1.8 Flange alignment

The flatness of the lining applied on the gasket contact surfaces shall be determined with a stretcher and shall be within a tolerance of plus/minus 0.3 mm.

H.5.2 Certification

The manufacturer shall keep complete qualitycontrol and test reports. He shall submit a certified record of inspection and testing, together with a statement of compliance with these requirements. These shall include the certificates of the steel parts.

H.6 TRANSPORT AND STORAGE

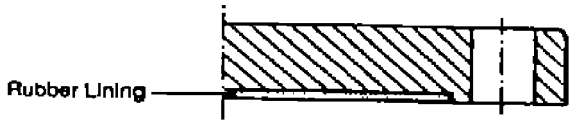
Lined piping shall be packed in a manner which will ensure that no damage to the lining, including its edges, can occur. Rubber-lined equipment and piping shall not be transported or assembled if ambient temperature is below, or is likely to drop below, 0.°C. The objects shall be handled with care: hoisting shall be carried out using non-metallic slings. In particular branches, openings and flange facings are vulnerable and shall be protected adequately, e.g. by wood.

All rubber-lined items shall be clearly and permanently marked on the outside "RUBBER-LINED, HANDLE WITH CARE".

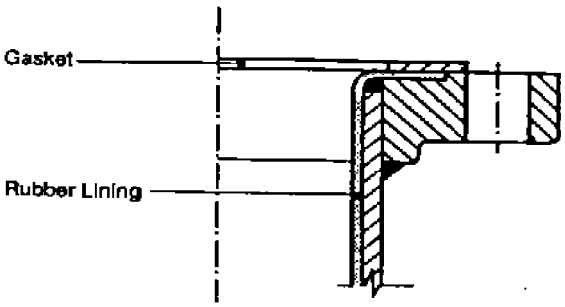
Rubber-lined equipment and piping shall be stored indoors or under cover. Allowance shall be made for free air circulation. Soft supporting material shall be used, e.g. wood or rubber. The objects shall not be exposed to direct heat or UV radiation. If this cannot be avoided owing to prevailing conditions, the items shall be kept filled with water until taken into use. Freezing of this water shall be prevented.

(to be continued)

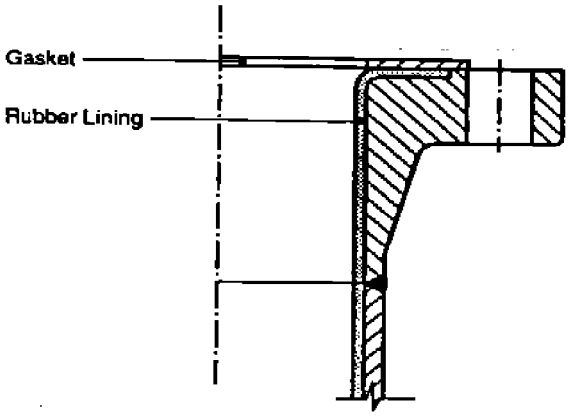
APPENDIX H (continued)



BLIND FLANGE - SPECIAL FACING



SLIP ON FLANGE - SPECIAL FACING

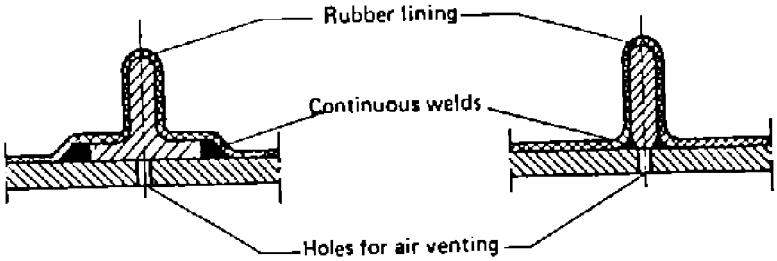


WELDING NECK FLANGE - SPECIAL FACING

FLANGED CONNECTIONS FOR HARD RUBBER-LINNED PIPING
DRAWING No. H-1

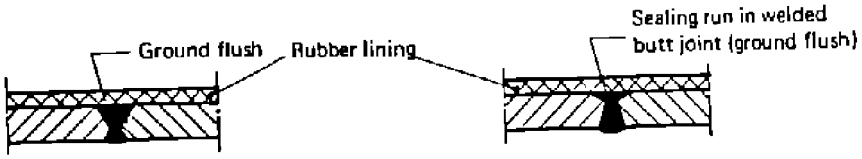
(to be continued)

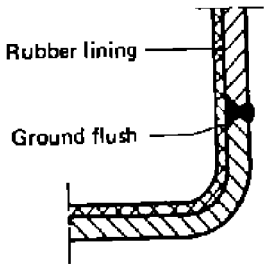
APPENDIX H (continued)



NOTE: Air vent holes to be drilled at regular distances. Diameter of holes depends on dimensions of vessel, but is generally 5 mm

WELDING DETAILS





AIR VENT HOLES AND WELDING DETAILS
DRAWING No. H-2

(to be continued)

APPENDIX H (continued)

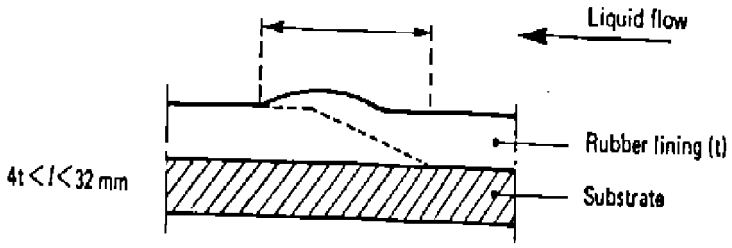


Fig. 1
OVERLAP BEVEL JOINT
(1 layer)

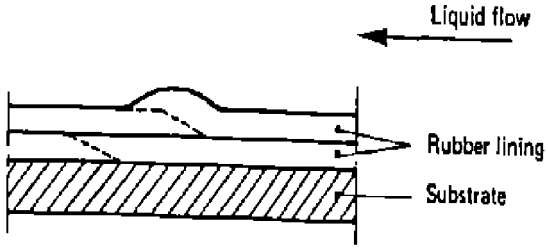


Fig. 2
OVERLAP BEVEL JOINT
(2 layers)

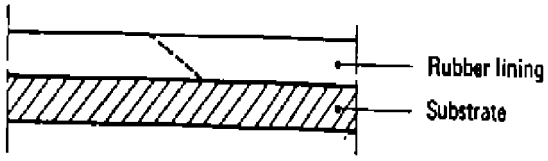
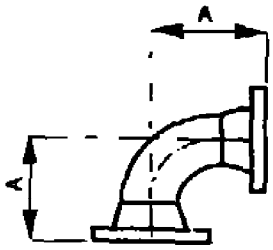


Fig. 3
FLUSH JOINT
(Brick lining not shown)

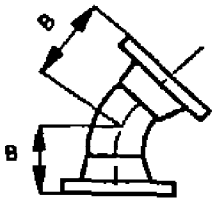
JOINTS IN RUBBER LINING
DRAWING No. H-3

(to be continued)

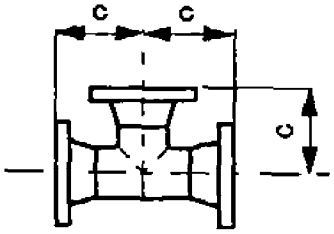
APPENDIX H (continued)



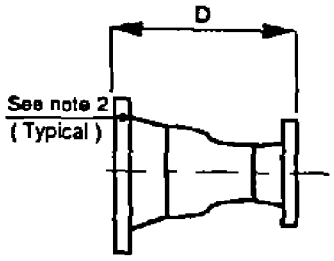
90 DEG. ELBOW



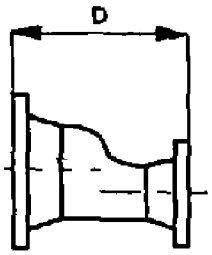
45 DEG. ELBOW



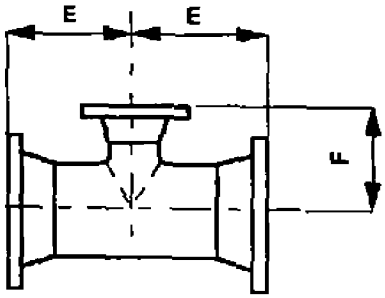
TEE STRAIGHT SIZE



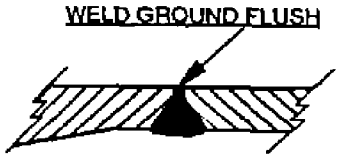
REDUCER



ECCENTRIC REDUCER



TEE REDUCING SIZE



TYPICAL WELD DETAIL

NOM SIZE (DN)	A 1) mm	B 1) mm	C 1) mm
25	93	77	93
40	118	90	118
50	139	99	127
80	183	120	155
100	227	139	180
150	317	183	231
200	406	228	279
250	482	260	317
300	570	303	367

NOMINAL SIZE (DN)	D 1) mm	E 1) mm	F 1) mm
40 x 25	180	118	112
50 x 25	194	127	106
50 x 40	200	127	121
80 x 40	219	155	134
80 x 50	221	155	139
100 x 40	238	180	147
100 x 50	240	180	151
100 x 80	246	180	167
150 x 80	297	231	193
150 x 100	303	231	205
200 x 100	328	279	231
200 x 150	341	279	256
250 x 100	354	317	259
250 x 150	367	317	282
250 x 200	380	317	304
300 x 150	404	367	307
300 x 200	417	367	330
300 x 250	417	367	342

Notes:

1) Tolerance (mm) : + 4.0 / - 4.0

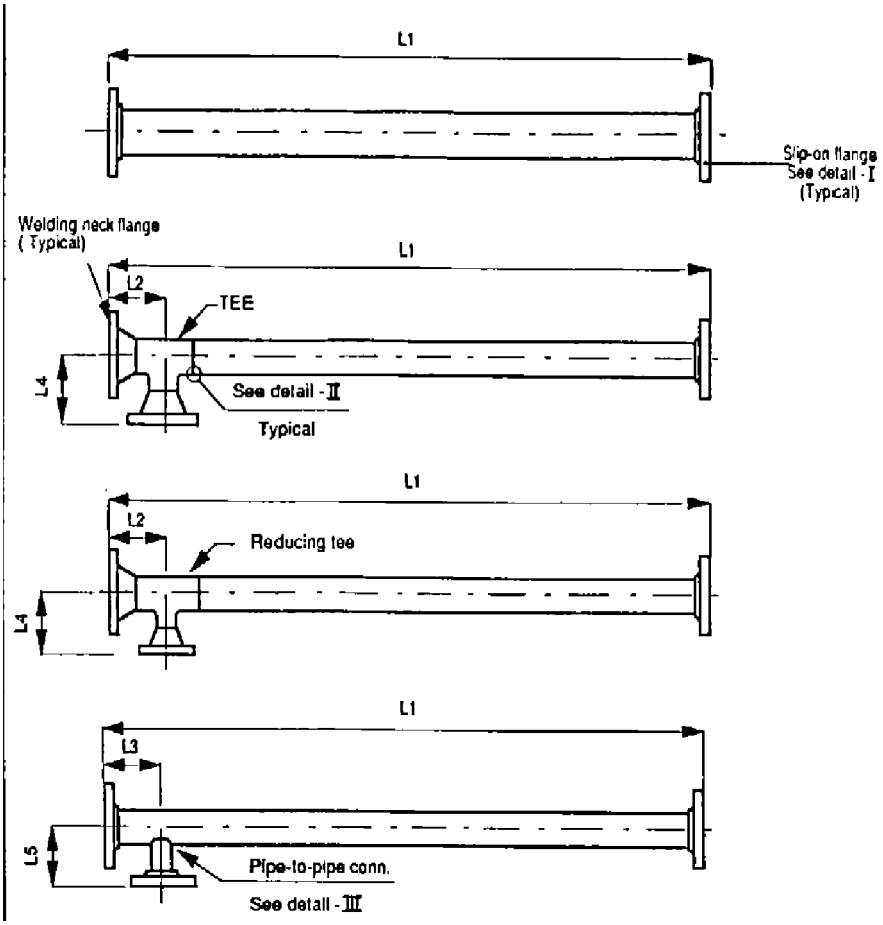
2) Flange, welding neck : Flat face with recess see Drawing No. H-6

3) *Flange & fitting mat.* : In accordance with Piping Class 1804.

OVERALL DIMENSIONS OF FLANGED FITTINGS FOR RUBBER LINING DRAWING No. H-4

(to be continued)

APPENDIX H (continued)

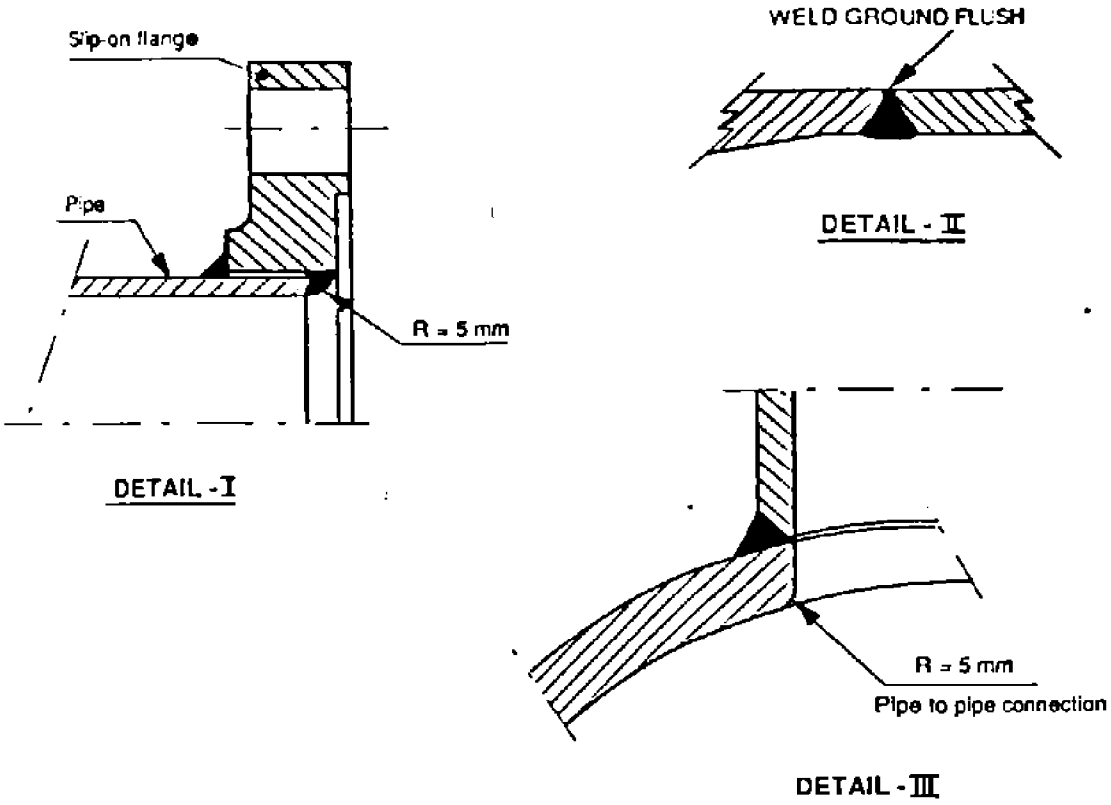


Run pipe Nom. size (DN)	1), 2) L1 - mm	2) L2 - mm	2) L3 - mm	Outlet - Tee Nominal Size (DN) 25	40	50	80	100	150	200	250	300	Outlet - pipe to pipe connection Nominal Size (DN) 25	40	50	80	100
				2) L4 - mm									2) L5 - mm				
25	1000	93	—	93	—	—	—	—	—	—	—	—	—	—	—	—	—
40	3000	118	—	112	118	—	—	—	—	—	—	—	—	—	—	—	—
50	4000	127	—	106	121	127	—	—	—	—	—	—	—	—	—	—	—
80	5000	155	120	—	134	139	155	—	—	—	—	—	150	—	—	—	—
100	6000	180	120	—	147	151	167	180	—	—	—	—	165	—	—	—	—
150	6000	231	140	—	—	—	193	205	231	—	—	—	200	200	200	—	—
200	6000	279	150	—	—	—	—	231	256	279	—	—	225	225	225	225	—
250	6000	317	150	—	—	—	—	259	282	304	317	—	250	250	250	250	—
300	6000	367	175	—	—	—	—	—	307	330	342	367	275	275	275	275	275

OVERALL DIMENSIONS OF FLANGED PIPING FOR RUBBER LINING DRAWING No. H-5 (Page 1)

(to be continued)

APPENDIX H (continued)



Notes:

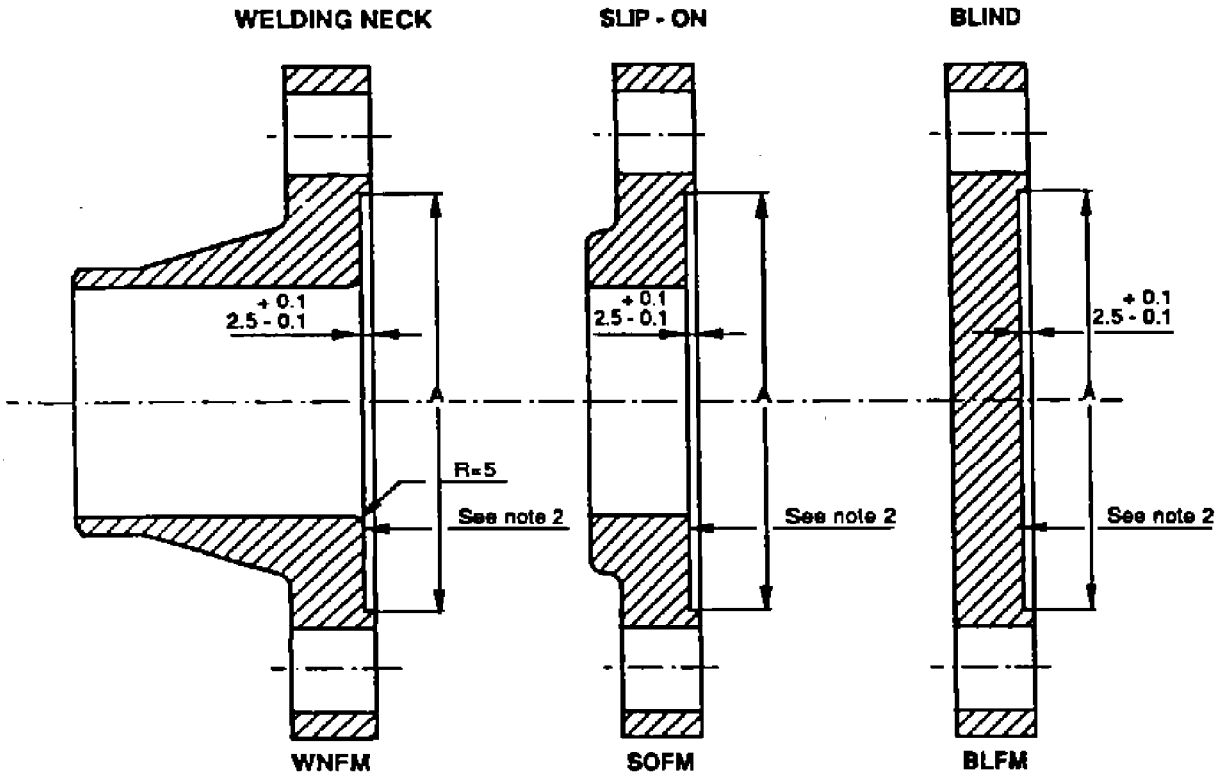
1) Length	**:**	**Based on max. allowable length for ruber-lined pipe.**
2) Tolerace (mm)	**:**	**+ 4.0** **- 4.0**
3) Flanges	**:**	**Flat face with recess see Drawing No. H-6.**
4) Material	**:**	**In accordance with piping class 1804.**

OVERALL DIMENSIONS OF FLANGED PIPING
FOR RUBBER LINING
DRAWING No. H-5 (Page 2)

(to be continued)

APPENDIX H (continued)

MODIFIED FLANGES FOR



NOM. SIZE (DN)	A 1) mm
25	58
40	78
50	98
80	132
100	166
150	218
200	274
250	330
300	396

NOTES :

1) Tolerance (mm) : $^{+0.5}_{-0.5}$

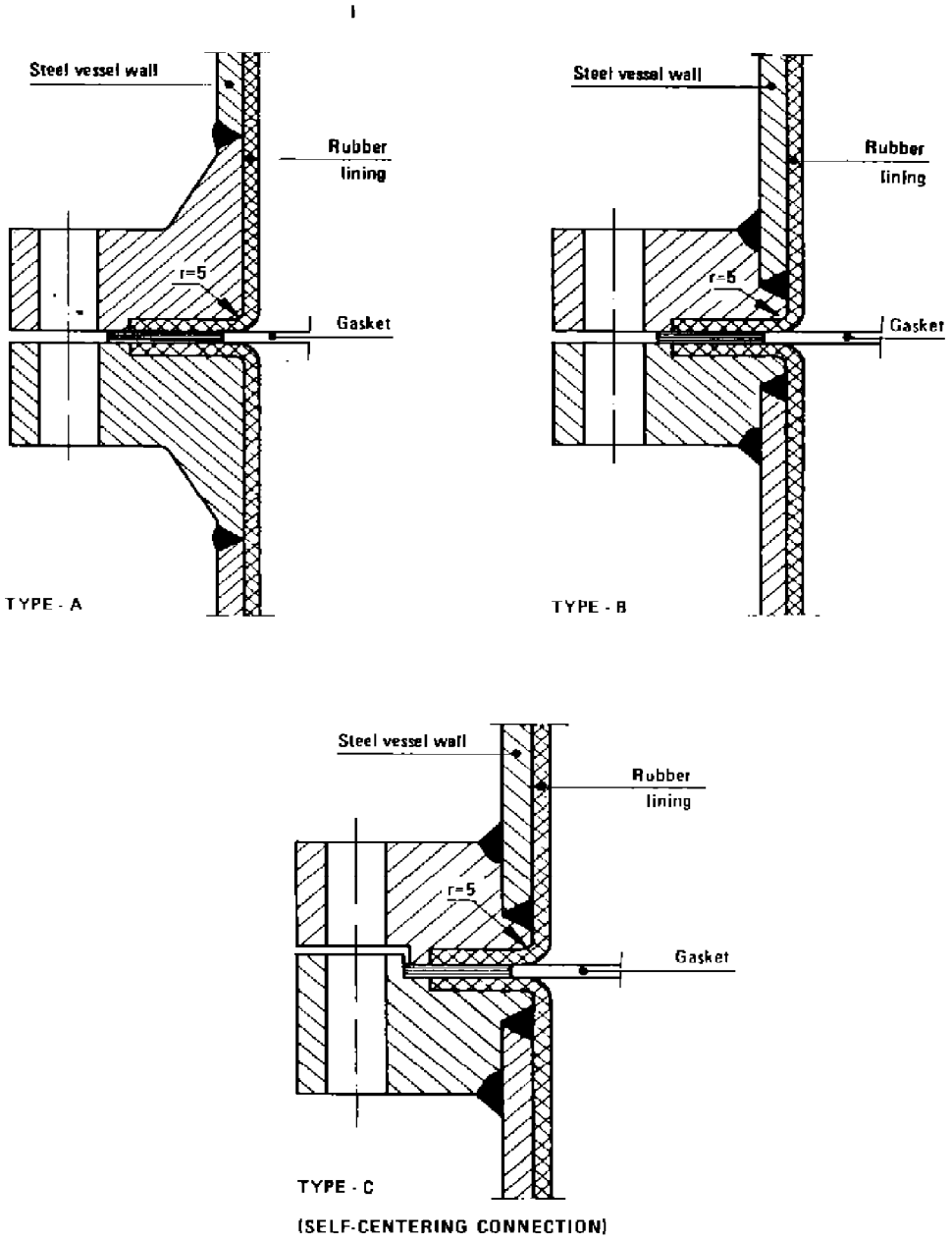
2) Facing finish : Ra 3.2 micrometer max. as per ANSI / ASME B46.1

3) Dimensions : Millimeters

FLANGES, FLAT FACE WITH RECESS
FOR RUBBER-LINED PIPING SYSTEM
DRAWING No. H-6

(to be continued)

APPENDIX H (continued)



TYPICAL DETAILS OF
RUBBER LINED FLANGES
DRAWING No. H-7

APPENDIX I

GENERAL REQUIREMENTS FOR CEMENT LINING OF NEW PIPELINES

I.1 SCOPE

This technical specification gives the minimum requirements for the design, application, inspection, installation and testing of pipes from nominal size DN 100 (4 inch) up to and including nominal size DN 900 (36 inch) to be lined with cement mortar in the shop and the jointing of these lined pipes in situ, including the hand-applied lining of the field butt-joints.

The in situ lining of piping systems, other than the above mentioned joints, is outside the scope of this specification.

Internal cement lining of pipelines is usually required for carbon steel cooling water or fire-fighting water piping systems containing/carrying sea-water or brackisch water at ambient temperatures to prevent internal corrosion. These systems can be installed above ground as well as underground. If an above ground lined piping system is drained for a longer period, special precautions are required to prevent cracking of the lining due to extreme high or low temperatures, and temperature or humidity variations. The special precautions to be taken are outside the scope of this specification.

I.2 CONTRACT STRATEGY

I.2.1 Contractor Involvement

The contractor shall prepare for the manufacturer a detailed specification. In addition detailed Drawings shall be prepared if the details are not covered by the Drawings. Forementioned documents shall be approved by the Principal.

I.2.2 Selection of Cement Lining Contractor

The manufacture selected shall be able to design and install complete systems, including the procurement of all required piping materials together with technical services related to the products. In addition the manufacturer shall be responsible for the proper application of the cement lining to the field-joints. The manufacturer shall have provided systems to at least one Group Operating Company or prequalification tests shall be performed in accordance with section I.8. In both cases the final selection is subject to the Principals approval.

Damage to the lining may occur during the application of the shop painting, handling, transport and storage of the pipes. Therefore the manufacturer of the cement lining should also apply the shop-painting and/or wrapping to the outside of the pipe.

I.3 DESIGN OF CEMENT LINED PIPING SYSTEMS

I.3.1 General

Pressure design of pipes and fittings shall be in accordance with ASME/ANSI B31.3.

I.3.2 Service Condition

In general the fluid to be conveyed through cement lined pipes is sea-water or brackish water at ambient temperatures. However, the contractor shall obtain from the Principal a chemical analysis of the fluid to be conveyed.

(to be continued)

APPENDIX I (continued)

The temperature of the fluid to be transported shall not exceed 45°C.

The composition of the lining shall be determined taking into account the nature, operating temperature and velocity of the fluid to be handled. The composition of the lining shall be agreed with the Principal.

The lining applied shall have a design life of minimum 25 years.

I.3.3 Sizing Criteria

The diameter of the cement lined piping systems shall be sized so that the maximum water-velocity inside the lined piping shall not exceed 3 meters per second.

The minimum outside diameter for piping and fittings to be cement lined is DN 100 (4 inch). The maximum diameter shall be DN 900 (36 inch). The straight length of the pipes shall be between 6 and 13 meters.

Where carrying capacity is of importance, calculations shall be made to determine the maximum friction and loss of waterhead.

Unless an increased thickness has been specified, the recommended lining thickness after curing, shall be as follows:

Nominal pipe size, inches	Minimum lining thickness, mm	Tolerance in mm
4	5.0	+3
6	5.0	+3
8	6.0	+3
10	6.0	+3
12	8.0	+3
14	8.0	+3
16 up to 36	10.0	+3

I.3.4 Limitations on Pipe

I.3.4.1 Wall thickness

The wall thickness of pipe (schedule No.) shall be as per piping class No. AZ03 of IPS-E-PI-221/2.

I.3.4.2 Tolerances

Tolerances on dimensions of pipe ends shall be in accordance with API 5L (including the ends of fabricated fittings).

I.3.5 Fittings, Flanges, Gaskets and Valves

I.3.5.1 Fittings

For the selection and overall dimensions of fabricated fittings see Drawings No. I-3 and I-4. For typical details of a set-on branch (for cement lined fittings) see Drawing No. I-7. For dimensions of sleeves see Drawing No. I-5. Factory-made butt welding fittings shall be in accordance with ASME/ANSI B16.9.

All sleeve-Joint connections of the piping shall be prefabricated prior to installing the lining. All pipes, T-pieces, and other fittings shall be prepared with bevelled ends. When sleeve couplings shall be applied, for piping with a diameter of DN 600 (24 inch) or less, the pipes shall be prepared with one end plain and the other end with a sleeve coupling, externally welded to the pipe. T-pieces, valves and other fittings shall be prepared with sleeve couplings welded to both ends. In this case one of the straight pipes connected to the forementioned shall be provided without sleeves.

(to be continued)

APPENDIX I (continued)

Joints for piping with diameters DN 650 (26 inch) up to and including DN 900 (36 inch) shall be butt-welded.

For shop-welding, welding procedures and welders shall be qualified in accordance with ASME Section IX. The procedures shall be submitted to the Principal for approval.

I.3.5.2 Flanges

All flanges shall be class 150, raised face, except those connected to flat face flanges of glass-fibre reinforced epoxy or equipment with cast iron flanges etc. In these cases a suitable matching flange should be used.

Slip-on flanges should be installed in pipe sizes from DN 100 through DN 600. For pipe sizes DN 650 and larger welding neck flanges shall be used. Flanges from DN 100 through DN 600 shall be in accordance with ASME/ANSI B16.5 and flanges from DN 650 and larger shall be in accordance with MSS SP-44.

Flange facing shall be smooth finish between Ra 3.2 and 6.3 micrometers.

For flanged ends (slip-on) for cement-lined pipe and fittings see Drawing No. I-6.

For shop-welding, refer I.3.5.1.

I.3.5.3 Gaskets

For design pressures up to and including 10 bar ga the gaskets shall be 3 mm thick, reinforced chloroprene rubber with a Shore A hardness of 70.

For design pressures above 10 bar ga, CAF gaskets 3 mm thick shall be used.

The inside diameter of the gasket shall be equal to the inside diameter of the cement lining.

Note that on some pipe-to-pipe valve (e.g. butterfly) connections the cement lining I.D. is tapered to equal the pipe I.D. at the gasket position to prevent possible inferference of the valve disc with the cement lining (see Drawing No. I-2).

I.3.5.4 Valves

The valves shall be as per piping class No. AZ03 of IPS-E-PI-221/2.

I.3.6 Selection of Materials

I.3.6.1 Pipes

Seamless : DN 100 through DN 400-API 5L GR.B - [1) 2) 3) 4)]
Welded : DN 450 through DN 900-API 5L GR.B - [1) 2) 4) 5)]
(Submerged-arc weld)

Notes:

1) Carbon content 0.23% max.
2) Rimming steel not permissible
3) Non-expanded pipe
4) Jointers not acceptable
5) Cold expansion is acceptable up to a maximum of 1.70%

(to be continued)

APPENDIX I (continued)

I.3.6.2 Fittings

Fittings: ASTM A234-WPB shall have the following restriction: Carbon content of 0.23% max. and the Manganese content may be increased to 1.3% max.

Base material:

DN 100 through DN 400: seamless pipe - ASTM A106 GR. B
DN 450 through DN 900: plate - ASTM A515 GR. 65 (or seamless pipe)

I.3.6.3 Flanges

Flanges: - ASTM A105 with the following requirements:
- Normalized
- Marking to A105-S9
- Carbon content 0.25% max.
- Manganese content may be increased to 1.20% max.

I.3.7 Compatibility of Materials

The possibility of galvanic corrosion shall be taken into account when different metals are coupled together. The coupling shall be broken by flange insulation made from non-conducting material.

I.4 APPLICATION OF CEMENT LINING

I.4.1 Surface Preparation

The inside of the pipe shall be cleaned of all grease, mill scale, loose rust or other foreign materials, by blast cleaning to Sa2 in accordance with ISO 8501-1 or by power tool cleaning to St3.

I.4.2 Composition of the Cement Mortar

I.4.2.1 Sand

Sand shall be natural sand, manufactured sand or a combination thereof and shall conform to ASTM C-33 or BS 882/1201 within the following limits:

SIEVE	PERCENT PASSING
No. 8 (2.36 mm)	100
No. 16 (1.18 mm)	50 - 95
No. 30 (0.6 mm)	25 - 65
No. 50 (0.3 mm)	10 - 35
No. 100 (0.15 mm)	2 - 15

(to be continued)

APPENDIX I (continued)

Deleterious substances shall not exceed the following limits:

SUBSTANCES	% BY MASS	STANDARD
Clay lumps and friable particles	3.0	ASTM C 142
Material finer than No. 200 sieve	5.0	ASTM C 117
No. 1 and No. 2 combined	6.0	
Acid soluble chloride (CI)	0.06	Analytic
Acid soluble sulphate (SO_3)	0.4	Analytic
Magnesium sulphate soundness	15	ASTM C 88

The maximum size of sand-grain shall not exceed one third of the thickness of the lining.

The fineness modulus of the sand shall be not less than 2.3 or more than 3.1.

The sieve analysis shall be performed in accordance with ASTM C-136.

I.4.2.2 Cement

For general application, the cement shall be Ordinary Portland Cement in accordance with BS 12 or ASTM C 150 or equivalent.

When high sulphate resistance is required, Portland Cement type V in accordance with ASTM C 150 or Sulphate Resisting Portland Cement in accordance BS 4027 with a maximum tricalcium-aluminate content of 3% shall be used.

When moderate sulphate resistance or moderate heat of hydration is required, other types of cement can be used e.g. Portland Cement type II in accordance with ASTM C 150 or tricalcium-aluminate-free Portland Cement.

Fly-ash and raw or calcined natural pozzolan according to ASTM C 618 can be used as a mineral admixture in Portland Cement.

Blast furnace slag shall conform to the applicable parts of ASTM C 595.

The type of cement including all admixtures or chemical additives shall be approved by the Principal.

The source of cement shall not be changed without prior written approval of the Principal. If bagged cement is used, all bags shall be marked with the name of the manufacturer, type of cement and volume. Similar information shall be provided on the bills of lading accompanying each shipment of bulk cement.

A manufacturer's test certificate, showing results of the laboratory chemical tests and physical tests, shall be submitted by the supplier to the Principal not later than the day of delivery of the cement.

I.4.2.3 Water

Water shall be potable and not contain chlorides (CI) in excess of 500 mg/kg nor sulphates (SO_3) in excess of 500 mg/kg.

The water shall not contain dissolved solids in excess of 2000 mg/kg or sugars, phosphates and harmful impurities (e.g. oil).

The pH of the water shall be between 5.0-8.0.

Testing shall be carried out in accordance with BS 2690 and BS 3148 or equivalent.

(to be continued)

APPENDIX I (continued)

I.4.2.4 Cement mortar mix

Unless otherwise agreed the cement/sand ratio and the water/cement ratio shall be as follows:

- The cement/sand ratio shall be one part by weight of cement and one and a half part by weight of dry sand (1:1.5) for linings not exceeding 6 mm.
- For linings with a thickness > 6 mm, the cement/sand ratio shall be 1:1 (parts by weight).
- The water/cement ratio shall be between 0.3 and 0.4.

I.4.3 Installation of Shop Cement Lining

I.4.3.1 General

Straight sections of pipes, diameters from DN 100 (4 inch) up to and including DN 900 (36 inch), length 6 to 13 meters, shall be lined with the spinning method. The interior surface shall be smooth, straight and true and the sand/cement particles shall be equally distributed throughout the lining thickness, after completion of the lining process.

I.4.3.2 Spinning method

The lining shall be applied by a spinning machine specifically designed and built for the purpose of applying cement mortar linings to the interior of steel pipe by means of centrifugal forces and rotation of the pipe. To prevent distortion or vibration during spinning, each section of pipe shall if required, be braced with external or internal supports. The entire quantity of mortar required for the lining of one section of pipe shall be placed without interruption. The pipe shall be rotated slowly until the mortar has been equally distributed along the inside periphery of the pipe.

Thereafter the rotation speed shall be increased to produce a dense lining with a smooth surface and a minimum of shrinkage. Provisions shall be made for removal of surplus of water.

I.4.3.3 Bends and fittings

Bends and fittings which cannot be machine lined in accordance with (I.4.3.2) may receive a hand-applied mortar lining. Hand-applied mortar shall have a uniform surface. Cement mortar for hand work shall be of the same consistency and material as the mortar for machine method. Surfaces to be lined shall be cleaned in accordance with (I.4.1) and damped with water immediately prior to placing the hand-applied mortar. Steel finishing trowels shall be used for the hand application of cement mortar.

I.4.4 Curing

I.4.4.1 General

After application of the lining, the pipe and/or fittings shall be sealed with plastic caps and left to cure in situ, or they may be transferred carefully to a curing yard.

The curing area shall be sheltered, so that lined pipes and fittings are protected from harmful climatic conditions (e.g. exposure to direct sun, frost, etc.). Within 24 hours after application of the cement lining the bores shall be inspected and water added to aid curing if required. After the inspection, the ends of the pipes and fittings shall be re-capped with the plastic caps. These covers shall not be removed within 14 days after cement lining in order to protect the lining form drying out.

(to be continued)

APPENDIX I (continued)

Pipes or fittings shall not be removed from the curing yard until the curing procedure is completed and the mortar has reached its specified strength.

Water to be used for curing shall be in accordance with (I.4.2.3).

I.4.4.2 Normal curing

The lining shall be protected form drying out as specified above for the whole period of the hardening process of the mortar in order to minimize shrinkage cracks. The minimum period of hardening shall be 28 days.

I.4.4.3 Water curing

The lining shall be kept totally submerged for the total period of the hardening process of the mortar in order to minimize shrinkage cracks. The minimum period of hardening shall be 4 days.

I.4.4.4 Steam curing

Steam curing shall only be applied if required and approved by the Principal. Recording thermometers shall be installed.

I.4.4.5 Membrane curing

Membrane curing by application of any moisture-retaining liquid is not permitted.

I.4.5 Lining Repair

Dummy, spalled and excessively cracked areas, etc. in fully accessible pipes shall be removed and repaired by hand to the required thickness of the lining.

Cracks with a width less than 0.8 mm can be left, providing they will not impair the stability of the lining, as the self-healing effect will set them tight as soon as the pipes are in operation. Cracks with a width greater than 0.8 mm can be washed in by means of soft brush with a liquid sand/cement mixture consisting of one part cement and one part fine sand (0.1 mm). The mixture should be liquid similar to heavy paint.

Larger local damages, other than cracks, shall be repaired by removing all loose particles, old mortar, grease and dirt by brushing with a stiff/wire brush. All traces of oil and grease shall be removed with a suitable de-greasing agent. The sides of the existing cement lining shall be primed with a multi-purpose adhesive, based on synthetic resin.

The damaged area shall be filled with a ready mixed mortar. The repaired lining shall be finished by means of a trowel or a spatula and brushed flush with the original cement, it shall be kept moist for at least three days. Minor damage can be repaired by means of a multi-purpose adhesive.

I.5 COATING OF CEMENT-LINED PIPES

The faces of all flanges to be used in cement lined piping systems shall be coated with Shell Ensis Fluid SDC, after which they shall be provided with protective covers.

The shop-painting of the outside surface of the pipe, shall be carried out after installing and curing of the cement lining, while the wrapping of the outside surface of the pipe (if required) shall be done before the installation and curing of the lining.

(to be continued)

APPENDIX I (continued)

I.6 HANDLING OF CEMENT-LINED PIPE

Lined pipes and fittings shall be handled carefully to avoid internal damage to the cement lining.

The end caps shall be kept in place during transport and storage in order to prevent dust, dirt, foreign matter etc. entering the pipe.

For loading and unloading of very heavy pipes, it is recommended to use slings with cushion pads or a suitable fork-arrangement placed at the centre of the joints. Hooks or other devices which insert into the ends of the pipe shall not be used. A flat-bed trailer provides the best support for the lined pipes during transport. During loading or unloading lined pipes shall not be dropped onto or off the transporting vehicle.

To prevent bending of the pipes which can cause damage to the lining, supports shall be used during storage and shipping. The distance between the supports shall not exceed 3 m.

Pipes shall be stored in supported tiers. The height of the tiers depends on the diameter of the pipes and shall not be more than 10 pipes for diameters < DN 150 (6 inch), 6 pipes for diameters between DN 200 to DN 400 (8 inch to 16 inch), 4 pipes for diameters between DN 500 to DN 900 (20 inch to 36 inch).

I.7 FIELD-JOINTING

I.7.1 General

The pipes and fittings shall be assembled in situ by means of field welds or flanged connections. The field welds shall be butt-joints for pipe diameters of 26 inch and above and sleeve-joints for diameters below 26 inch. However, butt-joints shall be internally lined in situ.

The Contractor and Principal shall agree upon the type of multi-purpose adhesive and the ready mixed mortar to be used for the assembling of the pipes.

Alternative methods for field jointing of cement lined pipes and fittings (for instance with impregnated gaskets etc.) are subject to approval of the Principal.

I.7.2 Butt-Jointing

The bevelled ends of the cement lined pipes shall be thoroughly cleaned, see (I.4.1), and all loose particles of the cement lining shall be removed over 20 mm at both ends of the pipe, i.e. 20 mm at either side of the joint, see also Fig. 4 of Drawing No. I-1. After the welding (see section I.7.5) has been completed, a hand-applied mortar shall be used to finish the cement lining at the inside surface of the steel pipe at the location of field weld, see Fig. 5 of Drawing No. I-1.

Unless another method has been agreed upon, the sides of the existing cement lining shall be sealed with a priming coat consisting of one part of a multi-purpose adhesive, based on synthetic resin (e.g. Conline "CEBOND", X-PANDO COMPOUND No. 2, SINMAST 121 or approved, equivalent bonding agent) and one part of potable water. After this priming coat has become tacky (20-30 minutes), the ready mixed mortar shall be applied.

The application of the adhesive and ready mixed mortar shall be in accordance with manufacturer's specifications. The hand applied mortar shall be finished by means of a trowel or spatula and shall be brushed flush after which a curing compound shall be applied. Pressure testing of a pipe section with site applied cement lining shall be delayed until 28 days after application or until such time that the minimum compression strength has been reached (this will require an earlier compressive strength test in addition to the 28 day test, I.9.1.6).

(to be continued)

APPENDIX I (continued)

I.7.3 Sleeve-Jointing

The free access-length of the female part shall be determined prior to the jointing and shall be marked on the male part over the full circumference, see Fig. 2A and 2B of Drawing No. I-1. The cut-end of the pipe inside the sleeve coupling shall be thoroughly cleaned, dry and free of dust and shall be provided with a concrete glue. This type of glue shall be based on a two component solvent free epoxy-resin (e.g. "SINMAST UW" or approved equivalent) suitable for application on moist mortar surfaces. Before installation of the male pipe end part, the concrete glue shall be tapered with a minimum thickness at the cement lining edge of 3 mm and with an angle of 75°, see also Fig. 2 of Drawing No. I-1.

Immediately after the application of the concrete glue, the male part shall be carefully pulled into the female part, without distorting the alignment (i.e. center-line) of the pipe and shall be tack-welded in accordance with section (I.7.5).

I.7.4 Cutting to Size in Situ

When cutting in situ is unavoidable, this shall be carried out at the required position by means of cutting-disk of 3 mm. Flame cutting is not allowed. The end of the steel pipe shall be cut perpendicular to the pipe and bevelled (if required) depending on the type of the field-joint. For a sleeve-joint, the cut pipe end shall be used as the female part. For a butt-weld joint the cement lining shall be cut over a length of at least 20 m/m at the end of the pipe. In both cases the cement lining shall be cut perpendicular to the pipe. Typical details of the pipe ends are shown on Drawing No. I-1.

I.7.5 Field Welding

The pipes shall be tack-welded in three equidistant positions.

The pipe shall be joined by the shielded metal arc welding process. The arc shall not come in direct contact with the cement lining or seal material.

Starts and stops shall be staggered so as not to start or stop more than once in the same place. Welding slag shall be cleaned from all weld passed.

Welding procedures and welders shall be qualified in accordance with ASME Section IX, the procedures shall be submitted to the Principal for approval.

Welding materials used shall be in accordance with the current list of approved welding consumables published by Lloyds Register of Shipping, Controlas or other internationally acknowledged bodies.

I.8 QUALITY CONTROL

I.8.1 General

Before the start of the actual cement lining production the manufacturer shall make arrangements to execute line-up tests in order to demonstrate the suitability of the equipment for an uninterrupted production process. All required materials shall be supplied by the manufacturer. The testing shall reflect the actual application conditions.

The entire process of applying cement mortar lining, at the manufacturer's works and at the construction site, shall be subject to continuous inspection by a QC inspector appointed by the contractor, but such inspections shall not relieve the manufacturer of his responsibility to furnish material and perform the work in accordance with this specification.

(to be continued)

APPENDIX I (continued)

I.8.2 Procedure Qualification Test

Prior to the installation of the shop cement lining, or in case of any variation in the process or composition of the mortar or change in any components the manufacturer shall perform procedure tests to demonstrate that he is able to produce a lining system in accordance with the design requirements. The constituents, mortar and finished pipe shall be tested, the samples shall be taken from one of the first finished test pipes or fittings, and testing shall be carried out as indicated below:

Individual constituents of the mix
- cement/admixture
- sand
- water

Cement mortar test specimen
- density
- compressive strength
- flexural tensile strength
- water absorbtion

Finished product
- visual inspection

The acceptance criteria for the tests shall be in accordance with section (I.9). Successful tests qualifies the procedure for the installation of the actual lining.

A record shall be made of the complete test procedure, including:

- details of test piece,
- batch identification of cement mortar.
- test data and results.
- acceptance by principal's inspector.

I.8.3 Quality Control During Shop Application

During preparation of the cement mortar and subsequent application, a regular production sampling program shall be established and maintained.

A logbook shall be kept showing the portion of the completed lining which is represented by the sample and all information regarding the sample preparation and the operating parameters at the time of sample collection such as ambient temperatures, water content, cement/sand ratio, mixing times. Preparation of the samples shall be witnessed by the QC inspector.

Immediately after the final spin an inspection of the cement lining shall be carried out by looking through the pipe from each end, using a strong light. Defects in lining including but not restricted to sand pockets, voids, sags, oversanded areas, blisters, excessively cracked and dummy areas, and unsatisfactory thin spots shall be removed before the initial set of the mortar.

Defective areas encompassing the full diameter of the pipe shall be repaired by machine. Small defects in pipes > DN 600 (24 inch) shall be repaired by hand to the full required thickness of the cement lining. In pipes less than DN 600 (24 inch), defective lining shall be removed before the initial set of the mortar. Defective linings rejected after initial set shall be replaced or repaired by the most practical method to be determined by the manufacturer in accordance with a procedure approved by the Principal.

(to be continued)

APPENDIX I (continued)

Most cracking occurs when the lining is allowed to dry out during curing, transportation and storage. The inspector shall ensure that the lining is still moist after inspection and that air-tight end caps are placed and maintained on the pipe.

I.8.4 Quality Control During Field-Jointing

Before assembling the pipes and fittings shall be inspected for possible cracks and damage. If required any cracks and damage shall be repaired prior to the assembling of the piping system see (I.4.5).

The cement shall be the same as applied for the shop cement lining. Both sand and cement and quality shall meet the requirements as described in section (I.4.2.1) and (I.4.2.2).

The lengths of pipe shall be butted together and checked for alignment and good contact of the cement lining and pipe ends.

A ready mixed mortar shall be used for the butt-joints and to repair linings of butt-joints.

It is recommended to inspect the piping system 8 days after completion of the cement lining.

I.8.5 Production Tests

Production testing shall be performed during manufacturing of the pipe lining and tests and inspection shall be carried out in accordance with the table below. All test results shall be reported and submitted to the Principal.

Test or inspection	Frequency
cement/admixture	once per batch delivered
sand/additives	once per week
water/cement ratio	twice a day
mixing ratio/times	twice a day
density	twice a day
compressive strength	twice a day
flexural strength	twice a day
ambient temperature	once a day
visual inspection	continuously
lining thickness	20% of pipes and fittings
pipe and fitting ends	each pipe and fitting
surface condition	each pipe and fitting
lining structure	once per week

The acceptance criteria for the tests shall be in accordance with section (I.9).

I.9 TESTS AND INSPECTION CRITERIA

I.9.1 General

All bare pipes shall be inspected before cleaning and lining. The surface on which the cement lining is to be installed shall be free from all grease, mill scale, loose rust or other foreign materials prior to the installation of the cement lining.

Test samples of the cement lining mortar shall be prepared by the manufacturer. Each sample shall be clearly marked with the contractor's code numbers for that day/shift/crew and for sequence of production. The manufacturer shall be responsible for regular transport of samples to an independent qualified laboratory, subject to Principal's approval.

If samples or completed lining do not meet the specified criteria, the installed cement lining represented by the failing sample(s), shall be removed and replaced.

Completed lining not meeting the specified criteria under I.9.1.10 / I.9.1.11 / I.9.1.12 / I.9.1.13 shall be rejected.

(to be continued)

APPENDIX I (continued)

I.9.1.1 Sand

For test criteria refer (I.4.2.1) of this specification.

I.9.1.2 Cement

For test criteria refer (I.4.2.2) of this specification.

I.9.1.3 Water

For test criteria refer (I.4.2.3) of this specification.

I.9.1.4 Water/Cement ratio

The Water/Cement ratio determined in accordance with DIN 1048, "Drying to constant weight", shall be between 0.30 and 0.40.

I.9.1.5 Mixing ratio

The dry-mix of lining materials shall not contain less than 40% nor more than 50% of cement by weight.

I.9.1.6 Compressive strength

The compressive strength after a curing period of 28 days, tested in accordance with ASTM C 349, shall not be less than 55 N/mm^2.

I.9.1.7 Flexural strength

The flexural strength after a curing period of 28 days, tested in accordance with ASTM C 348, shall not be less than 6.5 N/mm^2.

I.9.1.8 Density

The density, measured in a saturated, surface dry condition, shall not be less than 2160 kg/m^3.

I.9.1.9 Water absorbtion

The water absorbtion of the sample, tested in accordance with ASTM C 642 shall not exceed 10%.

I.9.1.10 Lining thickness

The thickness of the lining shall be measured on the vertical and horizontal diameters of the cut faces at both pipe ends, that is at clock positions 3, 6, 9 and 12, by direct measurement or by means of suitable electric instrument e.g. a cover-meter, calibrated before use. The values of lining thickness shall be given with an accuracy of 0.10 mm. For tolerances of lining thicknesses see (I.3.3) of this specification.

(to be continued)

APPENDIX I (continued)

I.9.1.11 Pipe and fitting ends

Pipe and fitting ends of pipes and fittings with a diameter of 26 inch and above assembled in situ by means of field welding shall have the cement lining removed over a length of 20 mm at either side of the pipe.

The ends of the lined pipes are considered to be defective if the lining end is:

a) not located as specified,
b) not perpendicular to the longitudinal axis of the pipe,
c) not square,
d) chipped or cracked,
e) separated from the steel pipe surface,
f) not to the specified thickness.

In addition to the above the welding bevel shall be free of cement.

I.9.1.12 Surface condition

The surface condition of the finished cement lining shall be smooth and even, not be flattened at individual spots, not have loose sand, not have dummy, spalled or excessively cracked areas or show waves or grooves. Single waves or grooves are acceptable providing the minimum specified lining thickness is maintained. However, the maximum peak to trough height shall not exceed 1.0 mm. Aggregate grains may only protrude at the surface sporadically. Hairline cracks and sporadically occurring surface cracks up to 0.8 mm are allowed.

Voids, being a place in the pipe where the cement lining is not continuous, are not acceptable. Voids occur during the spinning process when the cement does not distribute evenly.

Sags, appearing as large smooth lumps in the lining at the top of the pipe, are not acceptable.

I.9.1.13 Lining structure

The polished section of a cement lined pipe sample shall not have visible pores and the individual grains of the sand shall be surrounded on all sides with the cementing agent.

I.10 FABRICATION REPORT

After finishing the work as defined in the purchase order, the contractor shall provide a fabrication report with the following contents:

- project references such as: location, project number, piping system
- bill of materials including lining
- reference drawings and specifications
- registration of date and time of application of all phases
- registration of the produced samples and tests results
- final inspection results
- welding procedures used

This report shall also include certificates for the following materials:

- piping, fittings, flanges, gaskets and valves,
- welding consumables,
- sand,

(to be continued)

APPENDIX I (continued)

Cement mill test certificates shall be provided for each shipment of:

- cement
- admixtures and additives,
- adhesives, concrete glue and ready-mixed mortar.

I.11 GUARANTEE

If an inspection by the Principal of the cement lining work within a period of five year after final completion and acceptance of the contract work gives evidence of defective materials or workmanship as defined in this specification, then the Principal may order such remedies as described in section (I.4.5) of this specification. The manufacturer shall perform the repairs at his own expence in a manner acceptable to the Principal.

(to be continued)

APPENDIX I (continued)

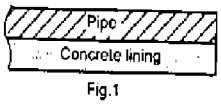


Fig.1

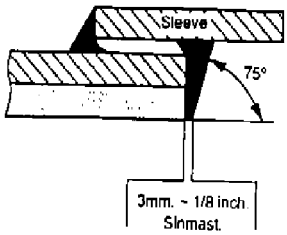


Fig. 2

S.R. = SLEEVE RECESS

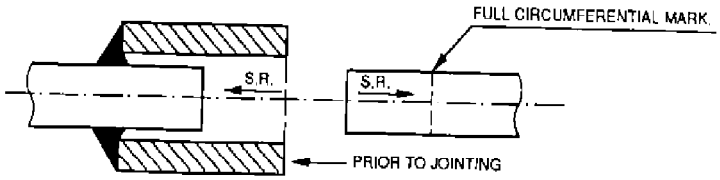


Fig. 2A

Fig. 2B

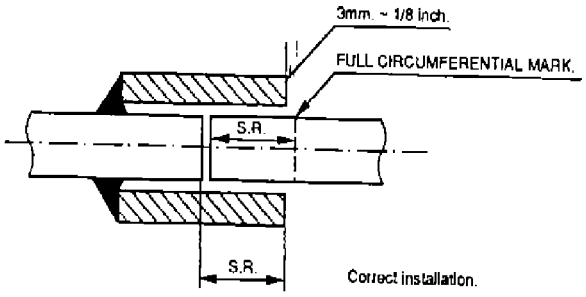


Fig. 2C

PIPE JOINTING-SLEEVE JOINTS
DRAWING No. I-1
(PAGE 1)

(to be continued)

APPENDIX I (continued)

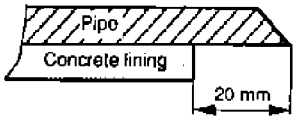


Fig. 4

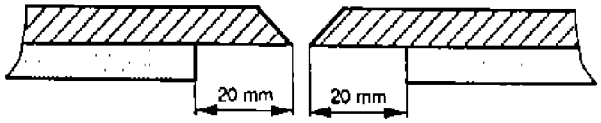


Fig. 4A

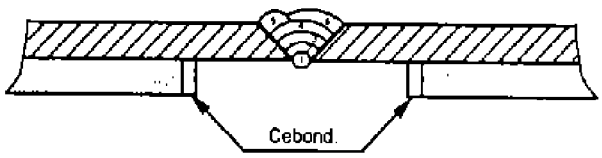


Fig. 4B

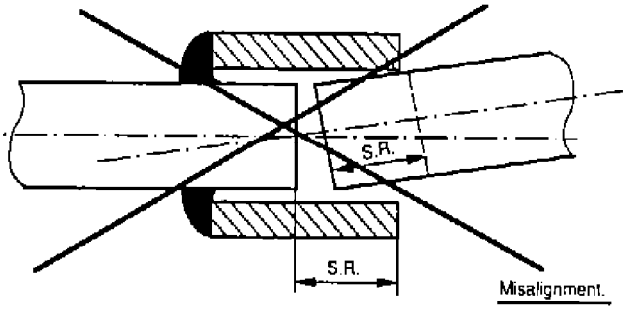
Fig. 5

PIPE JOINTING-BUTT JOINTS
DRAWING No. I-1
(PAGE 2)

(to be continued)

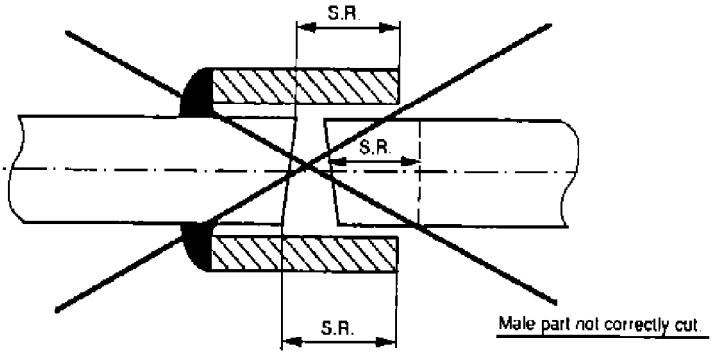
APPENDIX I (continued)

Fig. 2D



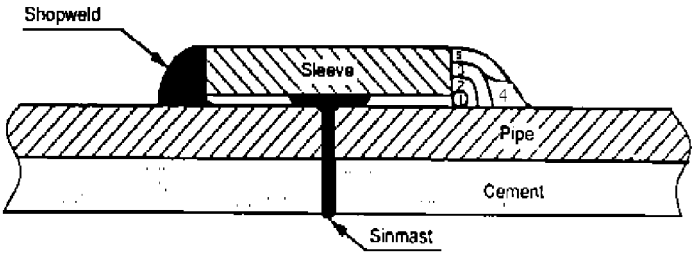
Incorrect Installation.

FIG. 2E



Incorrect installation.

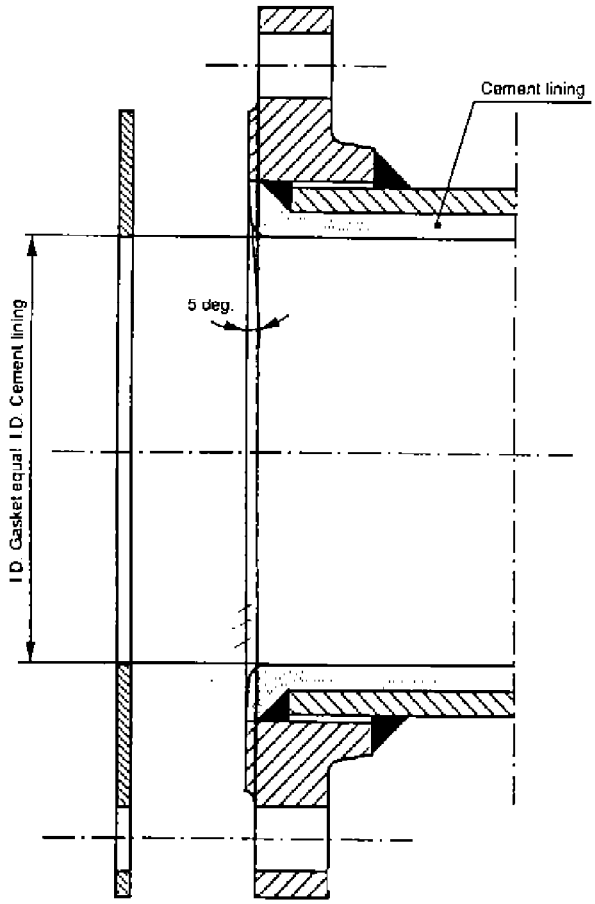
Fig. 3



PIPE JOINTING-SLEEVE JOINTS
DRAWING No. I-1
(PAGE 3)

(to be continued)

APPENDIX I (continued)

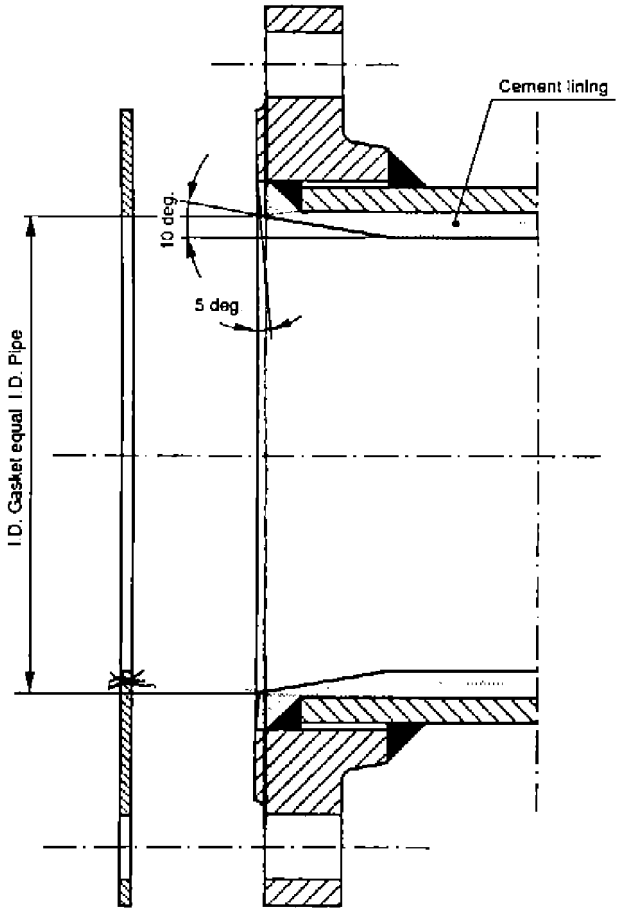


Flange is flat-face not raised-face
for gasket material see (I-3.5.3)

TYPICAL DETAILS OF FLANGED PIPE-TO-PIPE CONNECTION
DRAWING No. I-2
(PAGE 1)

(to be continued)

APPENDIX I (continued)

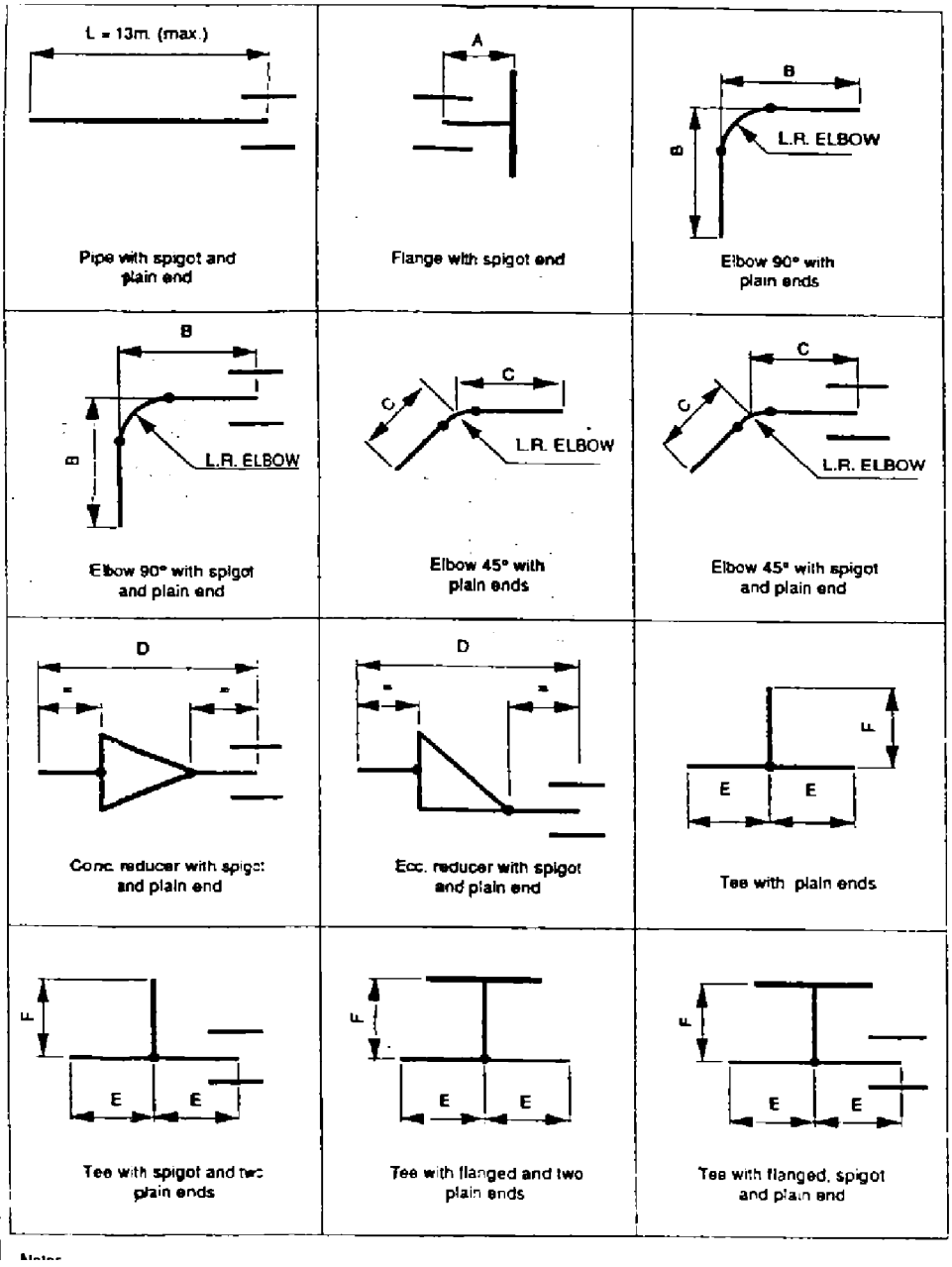


Flange should be flat-face not raised-face
for gasket material see (I-3.5.3)

TYPICAL DETAILS OF FLANGED PIPE-TO-PIPE CONNECTION
DRAWING No. I-2
(PAGE 2)

(to be continued)

APPENDIX I (continued)



Notes:

1. Butt welding elbows and reducers to ASME/ANSI B 16.9.

2. Flanges (slip-on) raised face or flat face to ANSI B 16.5.

3. For dimensions of sleeves and to lerances of pipe ends see Drawing No. I-5.

4. For flanged ends see Drawing No. I-6.

5. For typical detail of set-on branch see Drawing No. I-7.

DIMENSIONS OF CEMENT-LINED FITTINGS
NOM. SIZE DN 100 THROUGH DN 600
DRAWING No. I-3
(PAGE 1)

(to be continued)

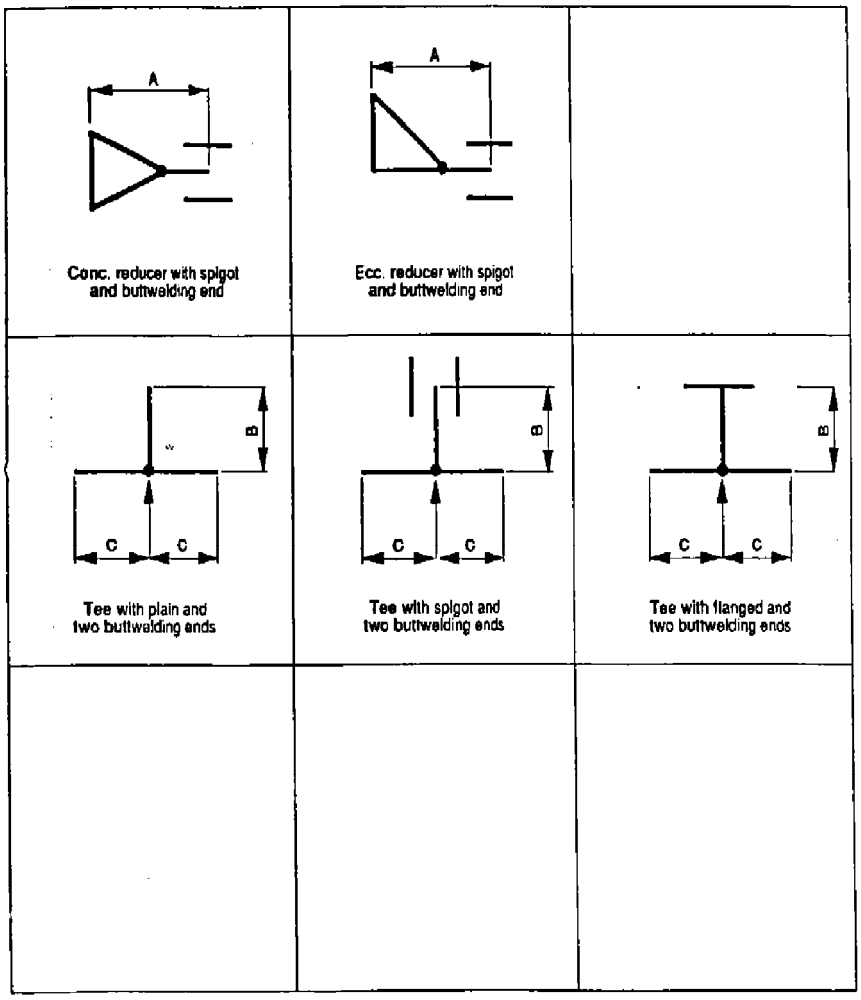
APPENDIX I (continued)

Nom. size (DN) mm	A mm	B mm	C mm	D mm	E mm	F mm
100	135	254	164	—	165	165
150 × 100	—	—	—	440	200	200
150	145	379	245	—	200	200
200 × 100	—	—	—	452	230	230
200 × 150	—	—	—	452	230	230
200	150	455	277	—	230	230
250 × 100	—	—	—	478	230	280
250 × 150	—	—	—	478	230	280
250 × 200	—	—	—	478	280	280
250	165	531	309	—	280	280
300 × 100	—	—	—	—	230	305
300 × 150	—	—	—	503	230	305
300 × 200	—	—	—	503	280	305
300 × 250	—	—	—	503	305	305
300	180	607	340	—	305	305
350 × 100	—	—	—	—	230	355
350 × 150	—	—	—	630	230	355
350 × 200	—	—	—	630	280	355
350 × 250	—	—	—	630	305	355
350 × 300	—	—	—	630	355	355
350	180	683	372	—	355	355
400 × 100	—	—	—	—	230	380
400 × 150	—	—	—	—	230	380
400 × 200	—	—	—	656	280	380
400 × 250	—	—	—	656	305	380
400 × 300	—	—	—	656	355	380
400 × 350	—	—	—	656	380	380
400	190	760	404	—	380	380

Nom. size (DN) mm	A mm	B mm	C mm	D mm	E mm	F mm
450 × 100	—	—	—	—	230	420
450 × 150	—	—	—	—	230	420
450 × 200	—	—	—	—	280	420
450 × 250	—	—	—	681	305	420
450 × 300	—	—	—	681	355	420
450 × 350	—	—	—	681	380	420
450 × 400	—	—	—	681	420	420
450	205	836	436	—	420	420
500 × 100	—	—	—	—	230	455
500 × 150	—	—	—	—	230	455
500 × 200	—	—	—	—	280	455
500 × 250	—	—	—	—	305	455
500 × 300	—	—	—	808	355	455
500 × 350	—	—	—	808	380	455
500 × 400	—	—	—	808	420	455
500 × 450	—	—	—	808	455	455
500	215	912	468	—	455	455
600 × 100	—	—	—	—	230	560
600 × 150	—	—	—	—	230	560
600 × 200	—	—	—	—	280	560
600 × 250	—	—	—	—	305	560
600 × 300	—	—	—	—	355	560
600 × 350	—	—	—	—	380	560
600 × 400	—	—	—	808	420	560
600 × 450	—	—	—	808	455	560
600 × 500	—	—	—	808	560	560
600	230	1064	531	—	560	560

(to be continued)

APPENDIX I (continued)



Nom. size (DN) mm	A mm	C mm	B mm
650 × 300	—	495	536
650 × 350	—	495	559
650 × 400	—	495	559
650 × 450	760	495	584
650 × 500	760	495	602
650 × 600	760	495	635
700 × 300	—	521	562
700 × 350	—	521	584
700 × 400	—	521	584
700 × 450	760	521	610
700 × 500	760	521	628
700 × 600	760	521	660
750 × 300	—	559	587
750 × 350	—	559	610
750 × 400	—	559	610
750 × 450	—	559	635
750 × 500	760	559	653
750 × 600	760	559	685
800 × 350	—	597	635
800 × 400	—	597	635
800 × 450	—	597	661
800 × 500	—	597	678
800 × 600	760	597	711
850 × 400	—	635	660
850 × 450	—	635	686
850 × 500	—	635	704
850 × 600	760	635	736
900 × 400	—	673	686
900 × 450	—	673	712
900 × 500	—	673	729
900 × 600	760	673	762

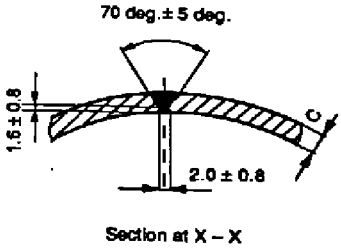
Notes:

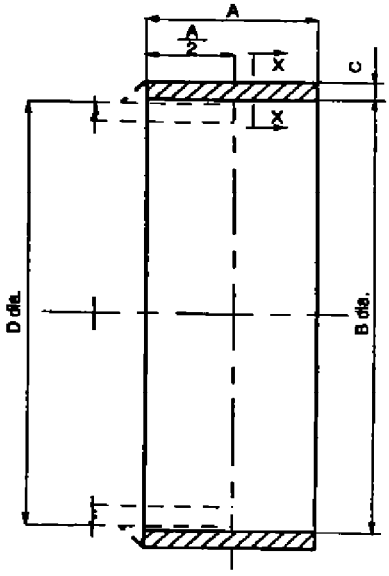
1. Butt welding reducers to ASME/ANSI B 16.9, or may be made from plate.
2. Flanges (slip-on)raised face or flat face to ANSI B 16.5.
3. For dimensions of sleeves and tolerances of pipe ends see Drawing No. I-5.
4. For flanged ends see Drawing No. I-6.
5. For typical detail of set-on branch see Drawing No. I-7.

DIMENSIONS OF CEMENT-LINED FITTINGS
NOM. SIZE DN 650 THROUGH DN 900
DRAWING No. I-4

(to be continued)

APPENDIX I (continued)





Nom. size (DN) mm	A mm	B Min. mm	B Max. mm	C Min. mm	D Min. mm	D Max. mm
100	100	120	122	6	113.9	115.9
150	150	174	176	8	167.9	169.9
200	150	225	227	8	218.7	220.7
250	150	279	281	8	272.7	274.7
300	150	329	331	8	323.1	326.3
350	150	361	363	8	354.8	358.0
400	150	412	414	8	405.6	408.8
450	150	462	464	10	456.2	459.4
500	150	513	515	10	507.2	510.4
600	150	616	618	10	609.2	612.4

Notes:

- Pipe ends must have the tolerance shown in the table for a distance of 100 mm.

- Sleeves can also be manufactured from sized pipe.

SLEEVES
FOR CEMENT-LINED PIPE AND FITTINGS
DRAWING No. I-5

(to be continued)

APPENDIX I (continued)

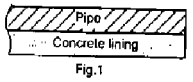


Fig.1

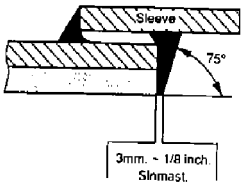


Fig. 2

S.R. = SLEEVE RECESS

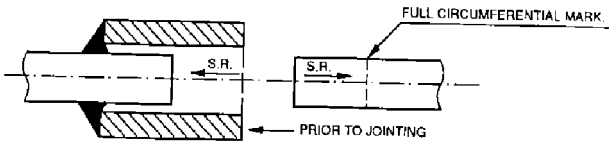


Fig. 2A Fig. 2B

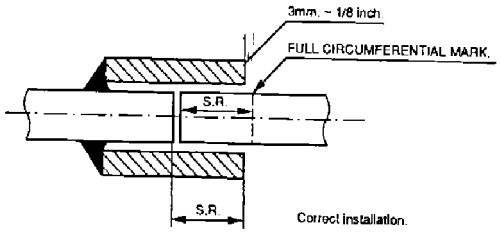


Fig. 2C

FLANGED ENDS
FOR CEMENT-LIND PIPE AND FITTINGS
DRAWING No. I-6

(to be continued)

APPENDIX I (continued)

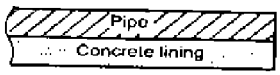


Fig.1

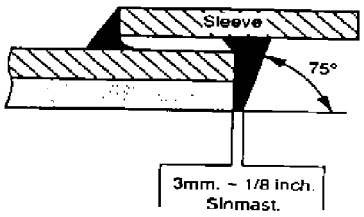


Fig. 2

S.R. = SLEEVE RECESS

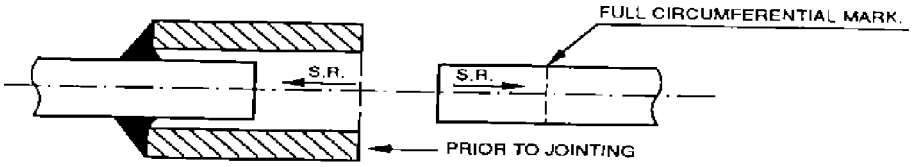


Fig. 2A

Fig. 2B

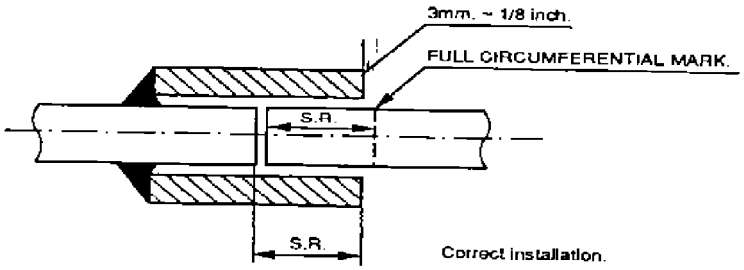


Fig. 2C

TYPICAL DETAIL OF SET-ON BRANCH
FOR CEMENT-LINED FITTINGS
DRAWING No. I-7

APPENDIX J
REQUIREMENTS FOR GLASS-FIBRE REINFORCED EPOXY PIPES AND FITTINGS

J.1 INTRODUCTION

J.1.1 General

This specification covers the general requirements for the purchase, inspection and transportation of pipes, fittings and flanges made from glass-fibre reinforced epoxy (GRE) which belongs to glass-fibre reinforced thermosetting plastics (GRP).

Described are pipes, fittings and flanges made by the filament-winding, centrifugal casting or pressed-sheet moulding process.

Section J.5 describes the qualification testing program to which a manufacturer is subjected before his first delivery of GRP pipes and fittings.

Section J.6 describes the minimum number of production tests to be carried out for each subsequent delivery of GRP pipes and fittings by a manufacturer whose products have been qualified successfully.

Section J.7 describes the qualification testing procedure.

A number of requirements in this specification are comparable to those of API Specification 15 LR.

This specification does not cover high-pressure piping, as defined by API Spec. 15 LR (approx. 70 bar, (1000 PSI)), casing and tubing and reinforced plastic mortar piping. The Company shall be contacted for those applications.

The requirements of this specification shall be adhered to, except where national and/or local regulations exist in which specific requirements are more stringent.

The contractor shall determine by careful scrutiny which of these requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economics and legal aspects.

In all cases the contractor shall inform the Company of any deviation from the requirements of this specification considered to be necessary to comply with national and/or local regulations. The Company may then negotiate with the authorities concerned with the object of obtaining agreement to follow this specification as closely as possible.

J.2 BASE MATERIALS

All base materials shall be new and unused, and shall be free from all contaminations and imperfections. The base materials, e.g. resins, glass-fibre reinforcing materials, pigments and other materials, when combined as a composite structure, shall produce pipe, fittings and flanges which meet the requirements of this specification. All base materials shall be specified in writing by the pipe manufacturer and certified by the raw materials supplier(s) per delivery.

J.2.1 Epoxy resins

Unless otherwise agreed, the pipes, fittings and flanges shall be made from a bisphenol A epichlorohydrin epoxy resin e.g. "EPIKOTE" 828 and an aromatic or cyclo-aliphatic amine-type curing agent. The manufacturer shall describe the type of resin and curing system chosen.

J.2.2 Glass-Fibre Reinforcement, Fillers and Pigments

Glass-fibre reinforcement for the reinforced wall shall be made of E-glass (i.e. low-alkali glass) meeting an internationally accepted standards such as BS 3691, BS 3396 and shall have a finish (coupling agent) which is compatible with the epoxy resin.

Fillers are not acceptable. Thixotropic additives added to the resin/curing agent mixture for viscosity control shall not exceed 2% by weight.

Pigments are only acceptable as long as they do not affect the performance of the components as defined in section (J.5) or if agreed with the Company in order to fulfil special application requirements.

J.2.3 Lining Materials

Unless otherwise agreed (J.3.1), flange surfaces and all pipes and fittings which are to be exposed to the fluid, shall have a smooth uniform resin-rich lining consisting of:

- a surfacing mat (tissue) or a veil, which may be either a C-glass (i.e. chemical-resistant glass) or a synthetic fibre, e.g. linear polyester fibres of polyacrylonitrile fibres;

- the same resin which is used for the fabrication of the pipe, fitting or flange.

J.2.4 Adhesives

Adhesive for adhesive-bonded connections shall be of an epoxy type, formulated to be resistant to the product to be conveyed, and for the service temperatures and pressures. It shall be of the type and quality regularly supplied by the pipe manufacturer for the duty intended, and as used for the qualification test (J.5.3.1) and shall have a proven record of good service.

The adhesives shall be provided in a kit containing at least epoxy resin and curing agent (separately in the recommended proportions) and mixing stick, joint cleaner, sandpaper and brush, together with instructions.

The adhesive kit shall have been date stamped at the time of the packaging and shall indicate the required storage conditions and date of expiration of shelf life.

The adhesive kit shelf life at 40°C shall not be less than six months from the date of shipment or 12 months from the date of production.

J.2.5 Rubber Sealing Rings

The sealing rings for the spigot and socket connections shall be made of a rubber type resistant to the product to be conveyed and for the service temperatures and pressures. The manufacturer shall state the type of rubber, providing evidence for its suitability in the proposed application.

J.2.6 Fixation Rod

The fixation rod for thrust-resistant spigot and socket connections with rubber sealing rings shall be made of a flexible thermoplastic material, resistant to the particular service conditions, such as temperature, surrounding environment, ultra-violet exposure etc. The manufacturer shall state the type of thermoplastic material, providing evidence for its suitability in the proposed application.

J.3 DESIGN AND DIMENSIONS

J.3.1 General

The manufacturer shall submit a piping stress analysis based on data for his specific brand and in accordance with ANSI/ASME B 31.3.

The components shall also be designed and manufactured to ANSI/ASME B 31.3.

If the influence of chemicals is to be taken into account, the manufacturer should state the maximum allowable operating conditions for continuous chemical service.

The Company shall specify those applications where the presence of a lining is not mandatory, as in cases where less severe chemical resistance is required or for electrically conductive piping.

The manufacturer shall provide proper installation instructions and, if requested by the Company, adequate supervision at all stages of installation.

J.3.2 Dimensions

J.3.2.1 Pipes

Diameter

The pipe standard for filament-wound pipe may be based on either the inside diameter (Type A) or the outside diameter (Type B). Standard diameters for both types of pipes are given in Table J-1.

Centrifugally cast pipe is based on the outside diameter (Type B).

The inside diameter (Di) of type A1 pipes is equal to the nominal diameter.

The A2 and B1 series are based on a commercial need for pipes with the outside diameters equal to those of pipes made from other materials, e.g. cast iron and steel so as to enable joints to be made to existing pipes without special jointing adapters.

The dimensions of the B1 series are equal to those of Spec. 15 LR.

The B2 series have their outside diameter (Do) related to the nominal diameter (DN) by the equation Do = 1.02 DN + 4 mm.

Wall thickness

The reinforced wall thickness of the pipe shall be sufficient to withstand the temperatures, pressures and service conditions of the particular application. It shall be at least 1.8 mm.

Liner/Top coat

If a lining is specified, its thickness for filament-wound pipe shall be at least 0.5 mm. For centrifugally cast pipe the thickness of this lining shall be at least 1 mm. Pressed-sheet moulding compound (SMC) fittings have no liner but a press skin which shall be at least 0.2 mm thick.

All piping shall have a smooth resin rich top coat.

Ovality

The difference between the largest and smallest diameter (ovality) in each cross section, shall be not more than 0.007 Di (Type A) or 0.007 Do (Type B).

Ends

The pipe shall be supplied with plain ends, with shaved ends, with spigot ends, or with one spigot end and one (integral) socket end or with flanged ends as stated by the Company.

If pipe is to be furnished with threaded ends, threading shall be to API Std. 5B, unless otherwise agreed.

J.3.2.2 Fittings

Fittings shall be supplied with plain ends, spigot ends, integral socket ends, threaded adaptors or flanges as stated by the Company.

The reinforced wall thickness of the fittings shall be sufficient to withstand the temperatures, pressures and service conditions of the particular application. It shall be at least 2.2 mm.

The difference between the largest and smallest measured inside diameter (ovality) shall not be more than 0.007 Di (Type A) or 0.007 Do (Type B).

J.3.2.3 Flanges

The outside diameter and drilling template of flanges shall be in accordance with ANSI B 16.5 class 150. The flange face shall be flat-type.

J.3.3 Prefabricated Piping Systems

Prefabricated piping systems may have adhesive-bonded socket/ spigot connections or hand-laminated butt and strap joints or integral spigots and/or sockets for connections with rubber sealing rings.

The surfaces without a liner at adhesive-bonded connections exposed to the product shall be covered by the adhesive.

The butt and strap joints shall be laminated over a length of at least the pipe diameter on the outside, and if the diameter allows, also on the inside.

All machined or cut surfaces, except the spigot ends, shall receive a coat of resin type, formulated to be resistant to the product to be conveyed and for use at the service temperatures and pressures.

J.4 FABRICATION

Unless otherwise agreed by the Company, the following fabrication/construction methods shall be adhered to.

Filament-wound pipe

Filament-wound pipe shall be manufactured by winding resin-impregnated continuous fibrous glass strand roving or woven glass roving tape on to the outside of a mandrel in a predetermined pattern under controlled tension.

Centrifugal cast pipe

Centrifugal cast pipe shall be manufactured by applying resin and reinforcement to the inside of a mould that is rotated and heated, subsequently polymerizing the resin system.

Fittings and flanges

Fittings shall be of a filament-wound construction. Flanges shall be of a filament-wound construction or a pressed-sheet moulded compound (SMC) construction. In the latter case the length of the reinforcing fibres shall be at least 12 mm.

The application of fittings and flanges of another design shall be specifically agreed upon between Company and manufacturer.

J.5 TECHNICAL REQUIREMENTS

J.5.1 General

Pipes and fittings purchased to this specification shall meet the requirements as stated in (J.2), (J.3) and (J.4) and shall further be in accordance with the technical requirements specified in this section.

The raw materials shall be checked against the sales specification as given by the manufacturer of these materials.

The manufacturer shall check for each production batch per shift of eight hours the mixing ratio of resin and curing agent. He shall also record permanently the mixing ratios.

J.5.2 Finished Products

The following qualification requirements apply to the finished products. Manufacturers complying to this Spec. 15 LR shall contact the Company upon the acceptability of tests carried out and as indicated in this section by means of an asterisk (*).

All tests to be carried out at room temperature, unless otherwise indicated.

J.5.2.1* Appearance

Unless otherwise agreed, the inside of pipe and fittings shall have a smooth and uniform lining and be in accordance with ASTM D 2563 level I.

The other parts of pipes and fittings shall be classified according to level II of ASTM D 2563, with the following exceptions:

- air bubble : maximum 2 mm; 3 bubbles/1000 mm^2
- pimple : level III
- pit : level III, but depth less than 10% of the wall thickness

Pipes and fittings shall be uniform in composition and structure, density and other physical properties.

All ends of pipes and fittings shall be cut at right angles to the axis and any sharp edges shall be removed.

J.5.2.2 Curing

The degree of curing of GRE pipe and fittings shall be determined by boiling samples in acetone (dimethyl ethyl ketone) for 3 hours. After boiling and drying to constant weight the samples shall not show more than 2% loss of weight.

The degree of curing may also be assessed by determination of the transition temperature by differential scanning calorimetry (DSC) or differential thermal analysis (DTA) in accordance with ASTM D 3418. The glass-transition temperature shall be at least 110°C.

J.5.2.3 Glass content

J.5.2.3.1 Filament-wound pipe

The glass/resin ratio shall be tested in accordance with EN 60 or ASTM D 2584. The glass content of the filament-wound pipe shall be at least 65% by weight, whereas for filamentwound fittings the glass content shall be at least 55% by weight.

J.5.2.3.2 Centrifugally cast pipes

For the structural wall of centrifugally cast pipes and moulded fittings, the figures shall be at least 45% by weight and 30% by weight respectively.

The maximum glass content shall in all cases be 77% by weight.

J.5.2.4 Consistency of the pipe material

Three samples shall be taken from three places situated 120° apart in the same cross section. The glass content of each sample shall be determined in accordance with EN 60 or ASTM D 2584. The difference in the glass content between two samples shall be not more than 5% by weight.

J.5.2.5 Water absorption

Pipes and fittings shall not show evidence of delamination of other impairment when tested in accordance with ISO 62 or ASTM D 570.

J.5.2.6* Hydrostatic design stress, Pressure ratings and Hydrostatic pressure test

The long-term hydrostatic strength of pipe, fittings, and joints shall be determined in accordance with Procedure A or B of ASTM D 2992. The manufacturer shall select the procedure and the size for these tests. Adhesive joints, if any, shall be included utilizing both the factory and field adhesives and their respective joining and curing procedures, if different. The samples tested shall carry the full end load due to pressure.

Testing shall be conducted at at least 20°C.

The hydrostatic design stress determined in accordance with Procedure A of ASTM D 2992 shall utilize a service (design) factor of 1.0.

The hydrostatic design stress determined in accordance with Procedure B of ASTM D 2992 shall utilize a service (design) factor of 0.5.

Pressure ratings for pipe shall be calculated using the hydrostatic design stress for the specific pipe material and the ISO formula for hoop stress in section 3.2.1 of ASTM D 2992. The minimum reinforced wall thickness shall be identified.

Flanges shall be pressure rated and hydrostatic pressure tested in accordance with ASTM D 4024.

The pipe, pipe spools or pipe joints shall be subjected to a bi-axial loaded hydrostatic pressure test as described in ASTM D 1599.

The GRE pipe, pipe spool or pipe joints shall not display a weeping effect below a hoop stress value of 150 MN/m^2.

The test pressure shall subsequently be increased to 3 times the design pressure and be maintained for at least 5 minutes.

During this pressure test the test specimens shall not show any sign of breakage.

Note:

This test will cause irreversible deformations in the material, so that the test specimens shall be discarded.

J.5.2.7* Stiffness of pipe

The minimum specific tangential initial stiffness (STIS) shall be not less than:

2,500 N/m^2 for 10 bar piping,

Alternatively the pipe stiffness at 5% deflection in accordance with ASTM D 2412 can be determined. In that case the pipe shall be free from cracks or delaminations at a minimum stiffness of:

20 lb/in^2 for 10 bar piping.

J.5.2.8* Beam deflection

The modulus of elasticity of the GRE pipe shall have a minimum of 7,000 MN/m^2 at 90°C when tested in accordance with ASTM D 2925.

J.5.2.9* Impact resistance

A steel ball 50 mm in diameter and weighing approximately 550 g shall be dropped perpendicularly on to the surface of the test pipe with a free fall (which may be guided) of 300 mm.

The ball shall be caught or deflected after the hit so that the rebound does not strike the pipe again. The pipe shall be filled with water containing, if possible, a soluble fluo-rescent dye. The test shall be made at room temperature and the pipe shall be supported on its bottom axis on a solid flat support. Four drops shall be made on randomly selected areas which are separated by a minimum length of one pipe diameter from each other. The test shall be repeated on the same pipe but with the pipe pressurized at the pressure class of the pipe. Four drops shall be made on different areas from those previously used. The pipe shall then be pressurized to 2 times the pressure class rating at 25°C for 5 minutes.

Fittings shall be tested in the same manner except that the drops shall be reduced from four to one in each test.

The pipe or fitting shall not show any porosity or visual delamination when examined, e.g. with an ultra-violet or normal lamp.

J.5.2.10 Linear thermal expansion

The manufacturer shall state in his qualification testing report the coefficient of thermal expansion of a pipe length as determined in accordance with ASTM D 696.

J.5.3 Piping Systems

Upon request of the Company the pipe manufacturer shall provide the following certified documentation for mutually agreed piping diameter(s).

J.5.3.1 Adhesive bonded piping systems

The relevant requirements for the specific component shall also apply for the adhesive bonded piping system.

It is not allowed to apply an additional overlap laminate to the joint to obtain the necessary strength.

J.5.3.2 Spigot and socket with rubber sealing rings joint piping systems

A spigot and socket with rubber sealing rings joint piping assembly shall meet the following requirements:

- No leakages shall occur during hydrostatic pressure testing at 1.5 times the design pressure during 10 minutes, whilst the test sections are deflected angularly in such a way that the center-line of one section of the assembled specimen makes an angle*) of 1.5 degrees with the center-line of the other section.

- The joint assembly shall withstand a combination of a bending force and an internal hydrostatic pressure of 1.5 times the design pressure.

***) Indicated angles not to be used for actual design calculations**

The bending force shall be applied in the middle of the joint and shall be calculated depending on the length of the specimens and the support distance. The applied bending force shall be such that the sum of the occurring axial stresses due to the internal hydrostatic pressure of 1.5 times design pressure plus the occurring axial stress due to the bending force shall be two times the nominal axial stress.

After having applied the calculated bending force, 10 cycles of 0 to 1.5 times design pressure shall be performed.

The pressure cycle time shall be 10 minutes (5 minutes without pressure, 5 minutes at design pressure).

- The joint assembly shall withstand a combination of a shear force (in N) of 20 times the inside diameter (in mm) and an internal hydrostatic test pressure of two times the design pressure. The test pressure shall be cycled from 0 to the test pressure, 10 times, while holding the shear force. The time for one pressure cycle shall be 10 minutes (5 minutes without pressure, 5 minutes at design pressure).

The test sections shall be deflected while the pipe units are in horizontal position, by applying a load vertically at the spigot end of the joint. The shear force shall be uniformly applied over an arc of not more than 180 degrees along a longitudinal distance of one pipe diameter or 300 mm, whichever is the smaller, from the sealing of the assembled joint, at the unsupported spigot end of the pipe. The specimens in the test shall be supported on blocks, placed immediately behind the bell. Instead of the applied load by external force, the use of own weight of the filled specimen can be chosen.

- The joint assembly shall withstand an internal vacuum of 0.74 bar absolute during 10 minutes when

= deflected angularly in such a way that the center-line of one section of the assembled specimen makes an angle*) of 1.5 degrees with the center-line of the other section, and when

= deflected in a horizontal position by a shear force vertically applied at the spigot end of the joint over an arc of not more than 180 degrees along a longitudinal distance of one pipe diameter or 300 mm, whichever is the smaller, from the sealing of the assembled joint, at the unsupported spigot end of the pipe.

Note:

Pressure stabilizing for 30 minutes is allowed.

J.5.3.3 Flanged piping systems

Flanges shall withstand, without any visible sign of damage, a bolt torque of at least 1.5 times that recommended by the manufacturer at the design pressure.

For this test a flanged section shall be bolted against a flat face steel flange. The bolts shall be tightened in 7 N.m increments according to the recommended practice.

Two flanged sections shall be bolted together using the gasket and bolt torque for standard field installation as recommended by the manufacturer. This assembly shall meet the following requirements:

- No leakages shall occur during hydrostatic pressure- testing at 1.5 times the design pressure during 168 hours.

Retorquing to the manufacturers specified level after initial pressurization is permitted.

- No rupture of the flanged connection shall occur during hydrostatic pressure testing at 2 times the design pressure for 10 minutes. Leaking past the gasket interface is permissible during this test. Bolt torque may be increased if necessary during the test in order to minimize gasket leaking and to achieve the pressure necessary to cause flange failure.

J.5.3.4 Threaded piping systems

The qualification testing of threaded piping systems shall be in accordance with the requirements given by the Company.

***) Indicated angles not to be used for actual design calculations**

J.6 INSPECTION AND TESTING

J.6.1 General

This section describes the minimum number of acceptance tests required for each delivery of GRP pipes and fittings purchased to this specification from a manufacturer whose products have been qualified successfully (J.5).

Additional tests may be established by mutual agreement between the manufacturer/contractor and the Company prior to any contract award.

If the material fails to pass any of these tests, this may constitute sufficient cause for rejection.

J.6.2 Acceptance Tests

J.6.2.1 Visual inspection

All pipes and fittings shall be visually inspected in accordance with (J.5.2.1).

J.6.2.2 Dimensions

The dimensions of all pipes and fittings (J.3.2) shall be checked in accordance with ASTM D 3567.

J.6.2.3 Curing

The degree of curing of each lot[1)] of pipe and fittings (J.5.2.2) shall be checked at random by means of a Barcol impressor (ASTM D 2583 or EN 59) and shall have a minimum value of 40.

J.6.2.4 Glass content[2)]

The glass content of each lot[1)] of pipe and fittings shall be checked, see (J.5.2.3).

J.6.2.5 Hydrostatic pressure test

All pipes furnished under this specification shall be subjected to a hydrostatic pressure test at room temperature. The test pressure shall be equal to 1.5 times the pressure class rating and be maintained for at least 5 minutes.

During the pressure test the pipes and/or fittings shall not show any sign of leakage.

Unless otherwise agreed all fittings, pipe spools and prefabricated piping shall be hydrostatic-pressure-tested at 1.5 times the pressure class rating of the pipe.

The Company shall be contacted for those cases where testing of pipe spools would result in damage of the pipe ends caused by the end caps.

J.6.2.6 Impact resistance[2)]

The impact resistance of each lot[1)] of pipe and fittings shall be checked (J.5.2.9).

Notes:

1) Unless otherwise agreed, a lot of pipe shall consist of 900 meters or a fraction thereof and a lot of fittings of one fitting, both of one size, wall thickness and grade.

2) These tests are destructive tests; if appropriate a deviation of test frequency shall be established by agreement between the manufacturer and the Company.

J.7 QUALIFICATION TESTING

The full program of qualification testing is required before a manufacturer will be allowed to deliver for the first time. The Company may require to repeat, completely or in part, the qualification testing of a certain make, for example because of time elapsed or new developments.

Changes in the design and/or method of manufacture of pipes and/or fittings will in any case require new or additional qualification tests.

The qualification testing shall be carried out on products with representative diameters. The type of product, its pressure and temperature rating and number etc. shall be mutually agreed with the Company.

Representative diameters and products:

Representive products	Pipe, elbow 90°, equal lateral and reducer			
Representive diameter (mm)	50	150	300	600
Diameter range (mm)	25 40 50	80 100 150	200 250 300	350 400 450 500 600

Qualification testing as described in (J.5) shall be carried out by the manufacturer and witnessed and certified by an independent authority recognized by SIPM. Alternatively, testing and certification may be carried out by an independent testing organization. This shall be confirmed by submitting a certificate stating the test results.

The Company shall be contacted for those cases where the material will be accepted and released pending some time consuming qualification tests (e.g. the beam deflection test). Such tests may be accepted on their satisfactory completion and the material will then receive the final clearance.

The manufacturer shall state in his qualification testing report, the coefficient of thermal expansion of a pipe length as determined in accordance with ASTM D 696.

J.8 DOCUMENTATION

J.8.1 Quality Control

The manufacturer will be evaluated for ability to perform adequate and sufficient quality control (including inspections and tests performed at sufficient intervals before and during production) to ensure that proper and correct base materials are being used, that the finished material meets physical and chemical specifications and that the finished product meets all dimensional and performance requirements.

BS 5750 will be used as a guideline in this respect.

In order to assure traceability of materials and products, the manufacturer shall keep a record of all quality control tests performed and shall maintain this record for a minimum period of five years from the date of manufacture.

J.8.2 Manufacturers Drawings

J.8.2.1 Pipes

The following pipe dimensions and tolerances, when applicable, shall be stated by the manufacturer and shall be in accordance with the certified manufacturers drawings:

- pipe inside/outside diameter
- minimum total wall thickness
- overall pipe length
- effective pipe length
- outside/inside diameter of the end
- length of joint
- conical form of spigot/socket
- spigot or socket chamber for rubber sealing rings and for fixation rod
- shear length, i.e. distance between chamber for rubber sealing rings and fixation rod.

J.8.2.2 Fittings

The following fitting dimensions and tolerances, where applicable, shall be stated by the manufacturer and shall be in accordance with the certified manufacturers drawings:

- fitting inside/outside diameter
- minimum total wall thickness
- overall fitting length
- effective fitting length
- conical form of spigot/socket taper
- length of joint
- spigot or socket chamber for rubber sealing ring and for fixation rod
- shear length, i.e. distance between chamber for rubber sealing ring and fixation rod.

J.8.2.3 Flanges

The following flange dimensions, where applicable shall be stated by the manufacturer and shall be in accordance with the certified manufacturers drawings:

- thickness of the flange
- rating
- bolt hole circle and diameter.

J.8.2.4 Prefabricated piping systems

The following flange dimensions, where applicable, shall be stated by the manufacturer and shall be in accordance with the certified manufacturers drawings:

- items as indicated in (J.8.2.1), (J.8.2.2) and (J.8.2.3)
- face-to-face, center-line-to-face and center-line-to-center-line
- lateral off-set of flanges
- flange face alignment.

J.8.3 Certification

The manufacturer shall keep complete quality control and test reports. He shall submit a certified record of inspection and testing together with a statement of compliance with the requirements. These shall also include the certificates of the steel parts, if any.

If appropriate, he shall issue a list, showing each deviation from the purchase order.

J.9 MARKING AND PACKAGING

J.9.1 Marking

All pipes and fittings shall be permanently marked with the manufacturer's name or trade name, the pressure class, the nominal diameter and vendor's identification code.

The marking shall remain legible under normal handling and installation practices.

Markings for identification purposes shall be made in such a manner as not to impair the integrity of the pipe/fittings material.

J.9.2 Packaging

The pipes and fittings shall be packed in a manner which will ensure arrival at destination in a satisfactory condition and which will be acceptable to the Company. Pipe ends shall be protected with suitable protective covers. The covers shall be securely attached.

Fastening is necessary where container transportation is used, to ensure immobilization of pipe joints.

The bottom of crates shall be provided with skids to facilitate handling by forklift truck.

TABLE J-1 STANDARD DIAMETERS OF GRP PIPES[1)]

Nominal pipe size DN		Type A (based on inside diameter)		Type B (based on outside diameter)	
in mm	in inch	Type A1 Di in mm	Type A2 Di in mm	Type B1[2)] Do in mm	Type B2 Do in mm
25	1	25	27	33.7	30
40	1.5	40	40	48.3	45
50	2	50	53.1	60.3	55
80	3	80	81.8	88.9	86
100	4	100	105.2	114.3	106
150	6	150	159	168.3	157
200	8	200	208.8	219.1	208
250	10	250	262.9	273	259
300	12	300	313.7	323.9	310
350	14	350	344.4		
400	16	400	393.7	429	412
450	18	450	433.8		
500	20	500	482.1	532	514
600	24	600	578.6	635	616
700	28	700		738	718
750	30	750	723.1		
800	32	800		842	820
900	36	900	867.9	945	922
1000	40	1000		1048	1024
1200		1200		1255	1228
1400		1400		1462	1432
1600		1600		1668	1636
1800		1800		1875	1840
2000		2000			2044
2400		2400			2452
2800		2800			2860
3200		3200			3268
3600		3600			3676
4000		4000			4084

Notes:

1) These dimensions are not yet accepted and approved by the ISO Council. Some manufacturers fabricate pipes with outside diameters which completely differ from those mentioned in the table.

2) These dimensions are equal to the dimensions given in API Spec. 15 LR.

APPENDIX K
PIPE COMPONENTS - NOMINAL SIZE

The purpose of this Appendix is to establish an equivalent identity for the piping components-nominal sizes in Imperial System and SI System.

TABLE K - 1

NOMINAL SIZE	
DN [1]	NPS [2]
15	½
20	3/4
25	1
32	1¼
40	1½
50	2
65	2½
80	3
90	3½
100	4
125	5
150	6
200	8
250	10
300	12
350	14
400	16
450	18
500	20
600	24

1) Diameter nominal, mm

2) Nominal pipe size, inch

APPENDIX L
PIPE FLANGES PRESSURE TEMPERATURE RATING

The purpose of this Appendix is to establish an equivalent identity for the pipe flange nominal pressure temperature ratings in Imperial system and SI System.

TABLE L - 1

PN [1)]	ANSI RATING (CLASS) [2)]
20	150
50	300
100	600
150	900
250	1500
420	2500

1) Pressure Nominal, bar

2) Pounds per square inch, gage

APPENDIX M
EXTENDED SERVICE LIMITS FOR PIPING CLASSES AT ELEVATED TEMPERATURE

- In piping classes, the use of bolting material to ASTM A193-B7 and ASTM A194-Gr.2H is limited to a maximum temperature of 450°C. However, for a number of applications the temperature limit can be as high as 538°C because of service experience in the given situations. For those higher temperatures, the flanged connections and bolting shall be uninsulated.

- For piping classes with a temperature allowance to 538°C, the extended service limits should be as hereunder:

Piping class CP04 - extended service limits:

Temperature, °C	475	500	525	538
Pressure, bar ga	31	27	20	12

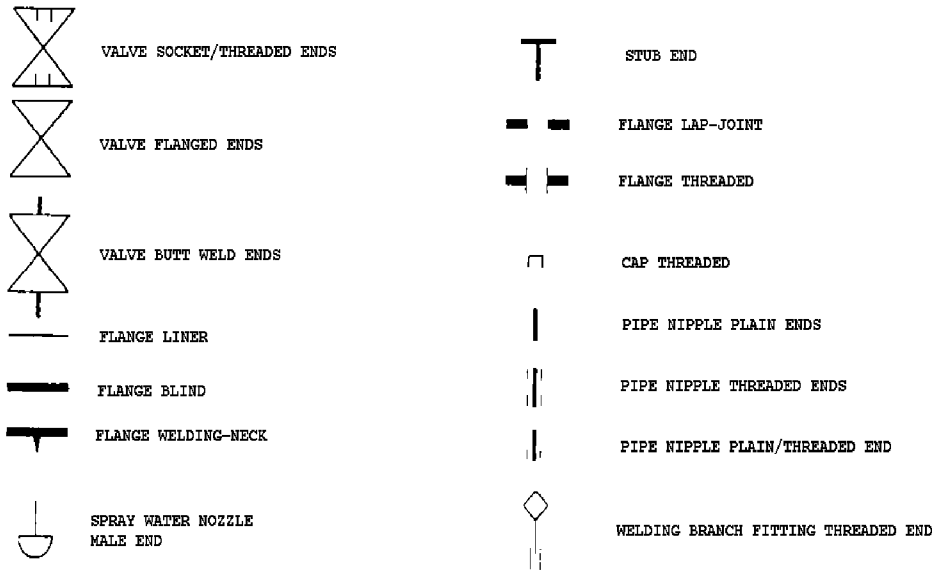
Piping class FP04 - extended service limits:

Temperature, °C	475	500	525	538
Pressure, bar ga	63	55	40	25

APPENDIX N
VENT, DRAIN, AND PRESSURE INSTRUMENTS CONNECTIONS ASSEMBLIES

This appendix contains sketches of assembly configurations. The figure number used in the assembly, appears on page 5 of the piping class, consists of a two digit code. The first digit identifies the type of valves and the second digit identifies the type of connection.

SYMBOL LEGEND



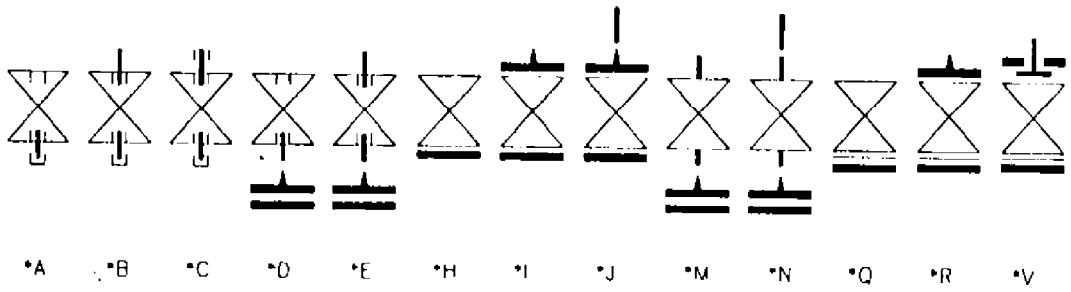
Note:

The above symbols, exclusively are used for this Appendix.

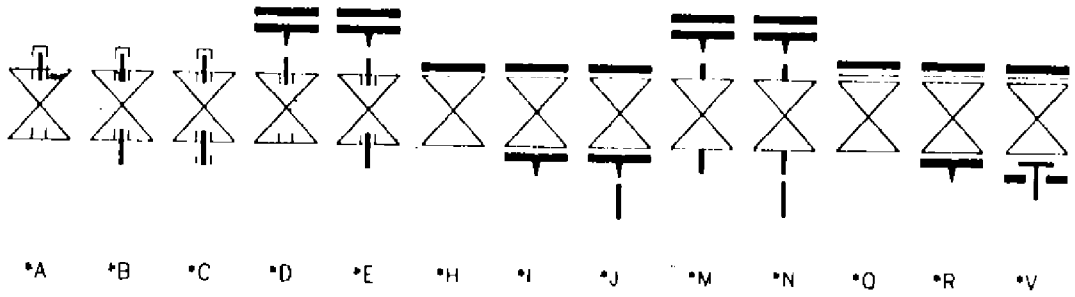
VALVE TYPE IDENTIFICATION LEGEND

0: GATE VALVE (except threaded ends)
1: GLOBE VALVE (except threaded ends)
2: REDUCED BORE BALL VALVE
3: FULL BORE BALL VALVE
4: PLUG VALVE
5: BALL VALVE (in combination with o-ring groove in counter flange)
6: THREADED GLOBE / GATE VALVE
7: DIAPHRAGM VALVE

DRAIN CONNECTION SKETCHES



VENT CONNECTION SKETCHES



FOR PRESSURE INSTRUMENT CONNECTION REFERENCE IS MADE TO IPS-D-IN-104