WATER SUPPLY (Infrastructure)

CC Pressure Pipe Systems

CHRYSOTILE CEMENT

50 years
1959 - 2009

DADEX

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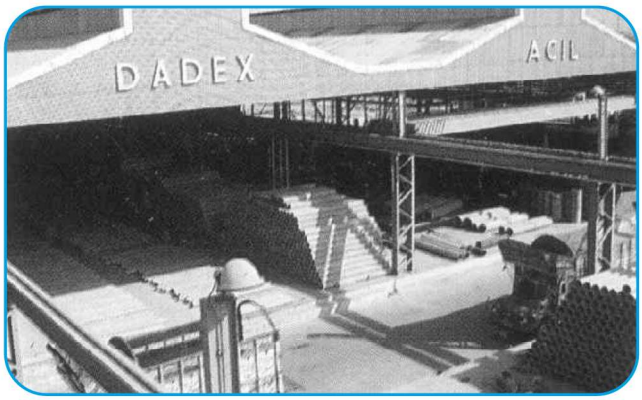
1. INTRODUCTION

Dadex is a public limited company manufacturing and marketing various AC/FC products since 1959. The Company has two factories, one at Karachi and the other at Hyderabad.

Rubber seal rings are an integral part of CC piping system therefore Dadex manufactures high quality rubber rings at its own rubber plant.



Karachi Factory

1.1 COMPOSITION OF AC/FC PRESSURE PIPE SYSTEMS

The material used in AC/FC pressure pipe is Chrysotile fibre and Cement. The reinforcing chrysotile fibre is bound in cement matrix. Chrysotile is a natural hydrous magnesium silicate fibre.

Tensile strength of Chrysotile fibre is 3 to 4 times greater than steel. Hence, these fibres when encapsulated in cement impart strength to pipes and couplings.

Chrysotile Fibre

Binder

For the manufacturing of Dadex AC/FC Pressure Pipes, ordinary portland cement is normally used. For special applications Sulphate Resistant Cement is also used.

1.2 MANUFACTURING PROCESS

Dadex AC/FC pipes are manufactured using the Mazza Process. This involves building up a number of thin laminations of a slurried mix of cement, Chrysotile fibre, and water, onto a steel mandrel under high pressure. The use of a steel mandrel ensures a very smooth pipe bore and a consistent internal diameter across the length of the pipe.

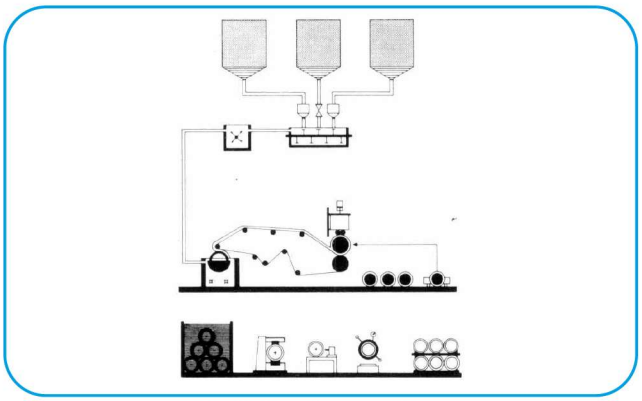
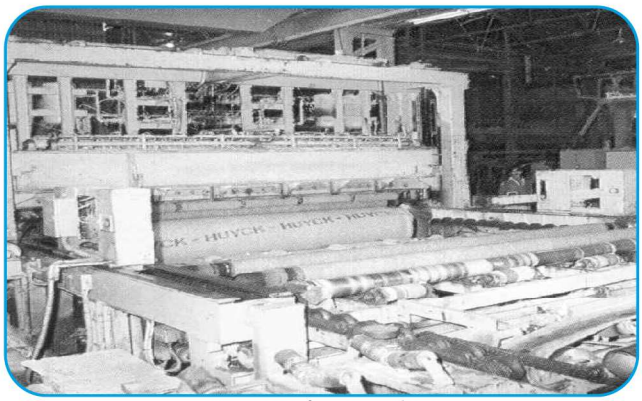


Fig. 1. The flow diagram of process


Pipe Manufacturing Plant

When the desired wall thickness is achieved, the mandrel is removed and the pipe is initially cured in a high humidity environment. The final curing is carried out in water tanks, changing the chemical structure of the cement fibre matrix producing a more chemically resistant and stronger material. The pipe ends are then machined on a lathe to produce the joint profiles.

Quality Control and Testing

Raw material control

Fibre: Quality of each shipment of fibre is certified by the suppliers with regard to type and quality.

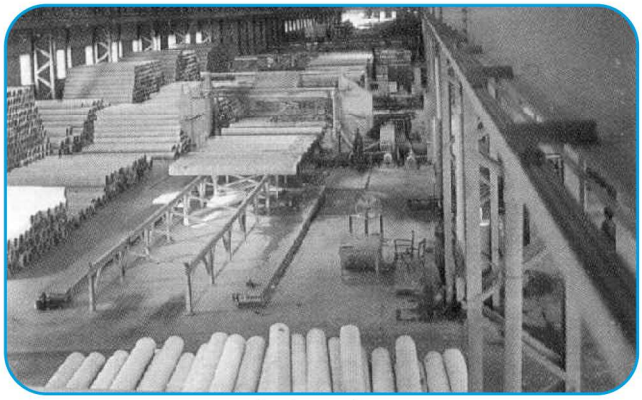
Cement: Cement conforming to Pakistan and International Standards Specifications is used. Periodically samples are sent for testing to the laboratory.

Control During Manufacturing

The Company's Quality Assurance Department takes material samples at every stage of the manufacturing process. The results of various tests like density, percentage of water, etc. are sent to production engineers to guide them for adjusting the process in light of these results.

Random samples of pipes are taken by the Quality Assurance Department from each batch and shift for conducting following tests as per PS 428:

1) Internal Hydraulic Pressure Bursting Test.
2) Transverse Crushing Test.
3) Bending Test (limited up to 150mm dia.).



Production Line

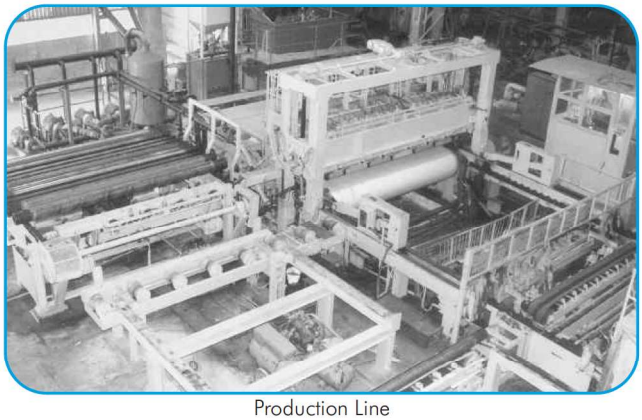
1.3 ECONOMICAL & TECHNICAL ADVANTAGES

Durability

Resistant to corrosion without the application of additional coatings.

Minimum effect of following types of water and soil corrosion due to non-metallic character: Galvanic, Bimetallic, Chemical Reaction, Biological, Hydrogenation, Direct Oxidation, Electrolytic.

High tensile strength fibres give Dadex AC/FC pressure pipes high strength to resist external and internal forces.



Production Line

Flexibility and Easy Jointing

The Comete joint method of jointing Dadex AC/FC pressure pipes, couplings, and rubber rings provides optimum joint flexibility, resistance to shock, vibration and line stress, and suitability for earth quake zones.

The Comete joint design provides self-aligning push-on-coupling for rapid assembly and automatically separates pipe ends allowing for pipe expansion and deflection.

Efficiency

Dadex AC/FC pressure pipes have low coefficient of friction. Bore smoothness is virtually permanent and free from incrustation and tuberculation due to non-metallic nature of pipes, hence there is no change in the hydraulic efficiency of the pipes with aging.

Versatility

Dadex AC/FC pressure pipes are highly compatible with metallic and non-metallic pipes and fittings as they are available in widely recognized standards, pressure classes, diameters, and lengths.

Dadex AC/FC pressure pipes can be tapped easily by using saddles and are conveniently cut and machined in the field with the use of simple tools.

Cost Competitive

Initial laid cost of cast-iron and ductile-iron pipes is 3 to 4 times higher than that of Dadex AC/FC pipes.

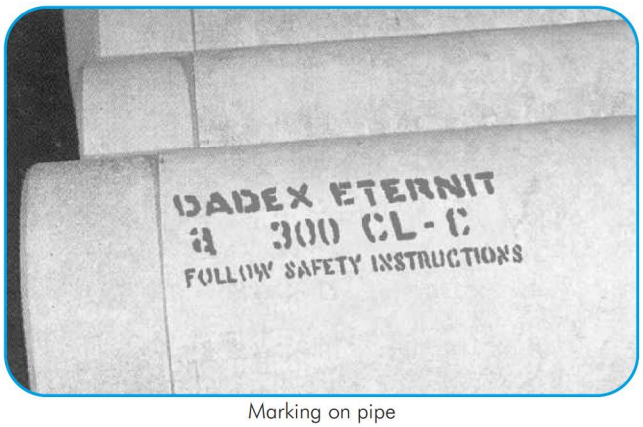
Lighter than cast-iron and ductile-iron pipes, therefore, enables easier handling and economical transportation.

Due to low frictional losses in Dadex AC/FC pressure pipes pumping costs are upto 3 times less compared to other pipes.

Lower maintenance costs as there is no corrosion, incrustation or tuberculation.

Water Hammer

There is a lower effect of water hammer on Dadex AC/FC pipes as they are less rigid and more resilient.



Marking on pipe

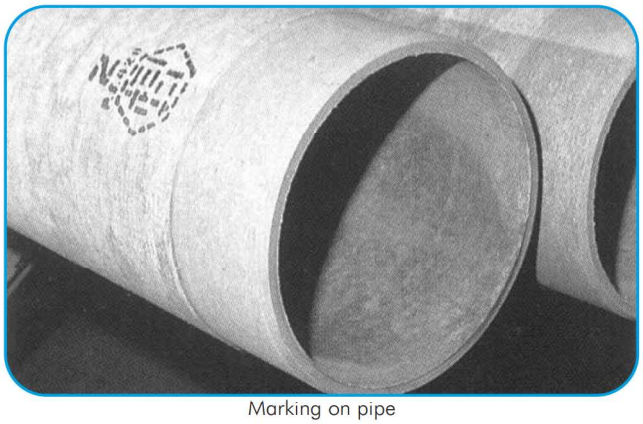
1.4 ISO AND PS SPECIFICATIONS AND MARKINGS

Dadex AC/FC pressure pipes and couplings are manufactured to conform to **PS 428.**

The PSQCA logo marking is done at one end of each pipe as shown below:

PS 428

PSQCA logo


Marking on pipe

The following information is moulded into the Rubber Rings.

DADEX ETERNIT LTD., PAKISTAN

Year of manufacture

_____ (dia in mm)

PS 1915

Comete couplings also have the size and class stenciled on them.

1.5 APPLICATIONS

Dadex AC/FC pressure pipes and rubber rings are suitable for many applications and are widely used throughout Pakistan.

- Water supply schemes - for pressure mains and distribution lines.
- Sewage disposal - although the requirement for pumping head is comparatively low, but the buried pipeline must withstand particularly high crushing loads.
- Supply of raw water for irrigation.
- Conveyance of brine/salt water.
- Pumping mains for conveying fly ash suspended in sea water or fresh water.

1.6 SPECIAL APPLICATIONS

Due to certain mechanical characteristics, fibre cement pipes are highly suitable for many useful applications.

Disposal of Industrial Effluents

Dadex AC/FC pressure pipes can be used for disposal of industrial effuents after protection of internal surface by protective coatings.

Permanent False Work / Form Work

Dadex AC/FC pressure pipes have been used on regular basis as permanent form work for the construction of RCC columns. For this purpose Dadex AC/FC pressure pipes are used without turned ends.

Gutters

Dadex AC/FC pressure pipes can be cut in longitudinal direction so as to manufacture drain gutters of various radii and segments. Similarly for inclined outlets, these pipes can be cut in transverse direction under any given angle.

Above around installation

Inspection Pits and Large Dia Manholes

Inspection pits and manholes can be fabricated in AC/FC pressure pipes of large diameters.

Perforated Pipes

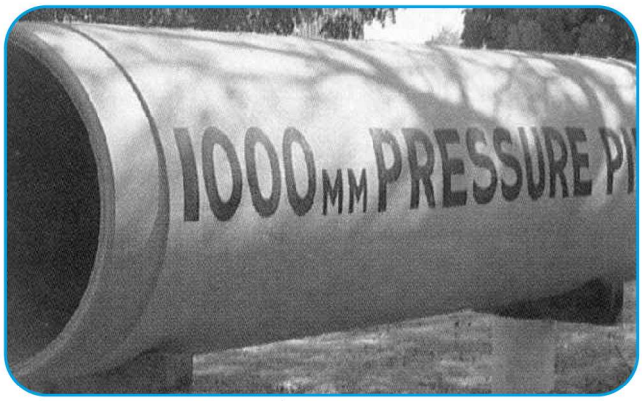
Perforated pipes can be used for protective lining of wells or bore hole and for sub surface drainage systems. The perforations depend upon purchaser specifications.

2. PRESSURE PIPE RANGE

2.1 SIZES, CLASSIFICATIONS AND DIMENSIONS OF DADEX AC/FC PRESSURE PIPES, COMETE COUPLINGS AND RUBBER RINGS

Pressure Pipes

Detailed dimensions of Dadex AC/FC pressure pipes of nominal length = 4 meter [13 ft. 1 1/2 in.] are given in Table 1.



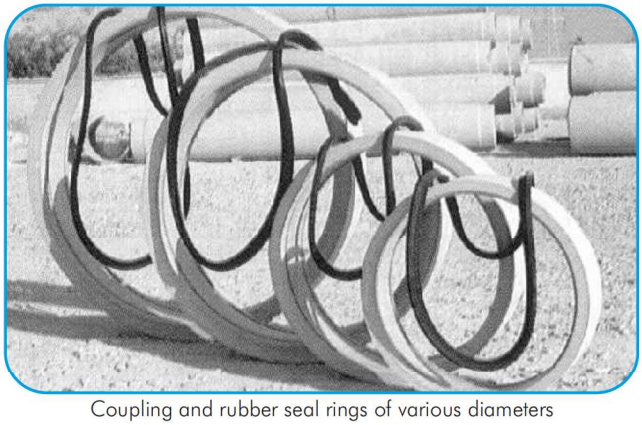
1000mm dia CC Pressure pipe

Comete Couplings

Dadex Comete couplings are manufactured by cutting especially manufactured AC/FC pressure pipes to required lengths. These are then machined internally to make two semi-circular grooves to accomodate Comete Rubber Rings. For dimensions refer Table 2.

Rubber Rings

Dadex Rubber Rings are manufactured at the rubber plant, located at the Karachi factory. These rings conform to PS 1915 "Rubber seals - Joint Rings for water supply, drainage and sewerage pipelines - Specifications for materials". Detailed dimensions are given in Table 2.



Coupling and rubber seal rings of various diameters

TABLE 1 - DIMENSIONS OF DADEX CC PRESSURE PIPE

Class (B) MAXIMUM WORKING PRESSURE 6.0 BAR

PIPE						COMETE JOINTS									RUBBER RING	
Dia	Outside Diameter	OD Tol.	WT T. End	WT Tol.	TE Width	Internal D2	Internal D1	GO	NO GO	Groove Depth	D4 D2+2 [G.D]	OD of C/J	Min. OD of C/J	Socket Width	Outside Diameter	Chord Thick
80	98	±0.6	9	-1.5	120	104	100	103.2	104.5	7	118.0	136	133.0	110	121	12
100	118	±0.6	9	-1.5	140	124	120	123.2	124.5	9	142.0	160	157.0	130	148	14
150	171	±0.6	10.5	-2.0	140	177	173	176.2	177.5	9	195.0	216	212.0	130	198	14
200	226	±0.6	13	-2.0	140	232	228	231.2	232.5	9	250.0	276	272.0	130	258	14
250	280	±0.6	15	-2.0	140	286	282	285.2	286.5	9	304.0	334	330.0	130	316	14
300	334	±0.6	17	-2.0	140	340	336	339.2	340.5	9	358.0	392	388.0	130	365	14
350	388	±0.8	19	-2.0	170	394	390	393.2	394.5	9.5	413.0	451	447.0	160	429	16
400	442	±0.8	21	-2.5	170	449	444	448.2	449.5	10	469.0	511	506.0	160	481	16
450	494	±0.8	22	-2.5	170	501	498	500.2	501.5	10	521.0	565	560.0	160	537	16
500	546	±0.8	23	-2.5	170	553	550	552.2	553.5	10	573.0	619	614.0	160	594	16
600	654	±1.0	27	-2.5	200	662	658	661.2	663	12	686.0	740	735.0	190	700	19
700	764	±1.0	32	-3.0	200	772	768	771.2	773	12	796.0	860	854.0	190	821	19
800	872	±1.2	36	-3.0	200	880	876	879.2	881	14.5	909.0	981	975.0	230	939	22
1000	1090	±1.2	45	-3.0	200	1098	1094	1097.2	1099	14.5	1127.0	1217	1211.0	230	1169	22

[a] Tolerance in pipe length = +5mm & -20mm

Tolerance on D1 from 80 to 300 mm (+1.0 ~ -0.5)
Tolerance on D1 from 350 to 500 mm (+1.5 ~ -0.6)
Tolerance on D1 from 600 to 1000 mm (+2.0 ~ -0.8)

TABLE 2 - DIMENSIONS OF DADEX CC PRESSURE PIPE

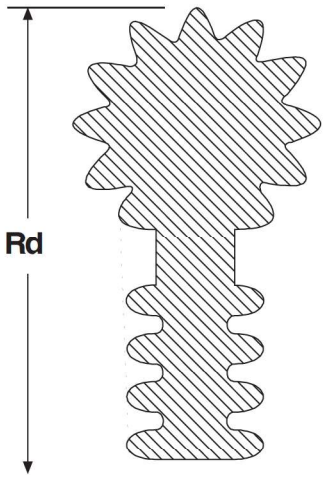
Class (C) MAXIMUM WORKING PRESSURE 9.0 BAR

PIPE						COMETE JOINTS									RUBBER RING	
Dia	Outside Diameter	OD Tol.	WT T. End	WT Tol.	TE Width	Internal D2	Internal D1	GO	NO GO	Groove Depth	D4 D2+2 [G.D]	OD of C/J	Min. OD of C/J	Socket Width	Outside Diameter	Chord Thick
80	98	±0.6	9	-1.5	120	104	100	103.2	104.5	7	118.0	136	133.0	110	121	12
100	120	±0.6	10	-1.5	140	126	122	125.2	126.5	9	144.0	164	161.0	130	148	14
150	174	±0.6	12	-2.0	140	180	176	179.2	180.5	9	198.0	222	218.0	130	204	14
200	228	±0.6	14	-2.0	140	234	230	233.2	234.5	9	252.0	280	276.0	130	258	14
250	284	±0.6	17	-2.0	140	290	286	289.2	290.5	9	308.0	342	338.0	130	316	14
300	340	±0.6	20	-2.0	140	346	342	345.2	346.5	9	364.0	404	400.0	130	374	14
350	398	±0.8	24	-2.5	170	404	400	403.2	404.5	9.5	423.0	471	466.0	160	439	16
400	456	±0.8	28	-2.5	170	463	458	462.2	463.5	10	483.0	539	534.0	160	497	16
450	512	±0.8	31	-3.0	170	519	516	518.2	519.5	10	539.0	601	595.0	160	555	16
500	568	±0.8	34	-3.0	170	575	572	574.2	575.5	10	595.0	663	657.0	160	612	16
600	680	±1.0	40	-3.0	200	688	684	687.2	689.0	12	712.0	792	786.0	190	733	19
700	794	±1.0	47	-3.0	200	802	798	801.2	803.0	12	826.0	920	914.0	190	847	19
800	908	±1.2	54	-3.0	200	916	912	915.2	917.0	14.5	945.0	1053	1047.0	230	973	22

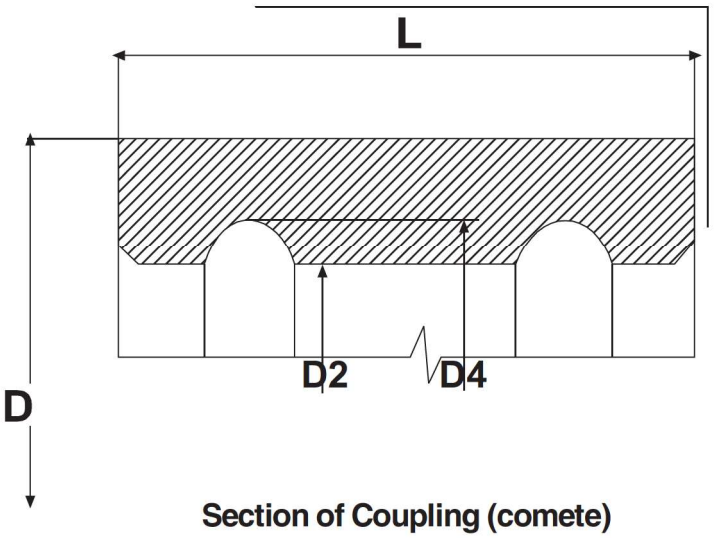
[a] Tolerance in pipe length = +5mm & -20mm

Tolerance on D1 from 80 to 300 mm (+1.0 ~ -0.5)
Tolerance on D1 from 350 to 500 mm (+1.5 ~ -0.6)
Tolerance on D1 from 600 to 1000 mm (+2.0 ~ -0.8)

DIMENSIONS OF DADEX COMETE COUPLING & RUBBER RINGS



Section of Rubber Ring



Section of Coupling (comete)

TABLE 3 - DIMENSIONS OF DADEX CC PRESSURE PIPE

Class (D) MAXIMUM WORKING PRESSURE 12.0 BAR

PIPE						COMETE JOINTS									RUBBER RING	
Dia	Outside Diameter	OD Tol.	WT T. End	WT Tol.	TE Width	Internal D2	Internal D1	GO	NO GO	Groove Depth	D4 D2+2 [G.D]	OD of C/J	Min. OD of C/J	Socket Width	Outside Diameter	Chord Thick
80	98	±0.6	9	-1.5	120	104	100	103.2	104.5	7	118	136	133	110	121	12
100	122	±0.6	11	-2.0	140	128	124	127.2	128.5	9	146	168	164	130	152	14
150	180	±0.6	15	-2.0	140	186	182	185.2	186.5	9	204	234	230	130	208	14
200	240	±0.6	20	-2.0	140	246	242	245.2	246.5	9	264	304	300	130	270	14
250	300	±0.6	25	-2.5	140	306	302	305.2	306.5	9	324	374	369	130	330	14
300	360	±0.6	30	-2.5	140	366	362	365.2	366.5	9	384	444	439	130	392	14
350	420	±0.8	35	-3.0	170	427	422	426.2	427.5	9.5	446	516	510	160	455	16
400	480	±0.8	40	-3.0	170	487	482	486.2	487.5	10	507	587	581	160	519	16
450	540	±0.8	45	-3.0	170	547	544	546.2	547.5	10	567	657	651	160	586	16
500	600	±0.8	50	-3.0	170	607	604	606.2	607.5	10	627	727	721	160	643	16
600	720	±1.0	60	-3.0	200	728	724	727.2	729.0	12	752	872	866	190	779	19

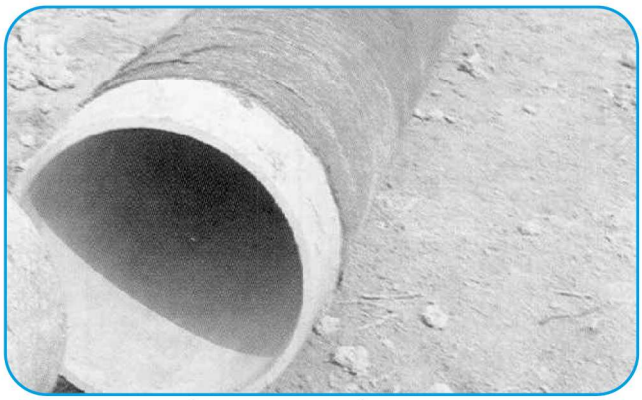
[a] Tolerance in pipe length = +5mm & -20mm

Tolerance on D1 from 80 to 300 mm (+1.0 ~ -0.5)
Tolerance on D1 from 350 to 500 mm (+1.5 ~ -0.6)
Tolerance on D1 from 600 to 1000 mm (+2.0 ~ -0.8)

2.2 PIPES FOR AGGRESSIVE EFFLUENTS

Dadex AC/FC pressure pipes can be used for disposal of effluent and industrial sewage without any internal/external protective coating upto certain limits. However these pipes need extra internal and external protection if the effluent is corrosive enough to impair the pipes.

Special epoxy coated Dadex AC/FC pressure pipes for aggressive chemical discharges, from process plants such as fertilizer factories, textile, tanneries, etc., are also available on request. The customer needs to provide details about the nature of effluent in order to obtain the right coating material.



Dadex Bitumen Coated Pressure Pipe

3. DESIGN DATA

3.1 PLANNING AND PROPER SURVEY OF PIPELINE ROUTE

Initial survey of pipeline route, drawing up plan and longitudinal section will help in determining the requirements of various accessories. In the absence of proper planning the work can be held up due to non-availability of required accessories.

3.2 PHYSICAL PROPERTIES AND STRENGTHS OF DADEX AC/FC PRESSURE PIPES

The physical properties of Dadex AC/FC pressure pipes can be described in detail as follows:

Resistance to Corrosion

Due to their high density (1.75 gms/cm^3) and very low water cement ratio.

Resistance Against Abrasion

Due to tenacious elastic behavior of fibres, resistance to abrasion is very high which has resulted from various stringent tests during which the pipes are subjected to extremely abrasive conditions.

TABLE 4 - LIMITS UP TO WHICH PROTECTION IS NOT REQUIRED

DESCRIPTION	LIMITS
pH	≥ 6
Titration acidity ml NaOH N/10 per 100 gm of soil	< 20
NH_4 mg/l	< 80
Alkaline solution in %	< 10%
Vegetable oil, fats mg/l	< 300
SO_4 in mg/l in function of Cl in mg/l (sea water)	Cl SO_4 0 < 500 300 < 800 5000 < 1430
MgO in mg/l in function of SO_4 in mg/l	SO_4 mgO 0 < 2000 200 < 700
Sugars	No limit if pipe is fully hardened

Hydraulic Characteristics

The coefficient of absolute roughness according to Prandtl-Colebrook formula is 0.025 mm for uncoated water mains. For sewage disposal mains, the coefficient for absolute roughness has to be increased to 0.25 mm or more, depending on viscosity of the effluent and design of sewer lines.

The formula which is commonly used in many countries is that of Hazen-William in which the coefficient for AC/FC pressure pipe has been established between 145 and 150. These roughness coefficients apply to present as well as old fibre cement pipes as the walls of these pipes do not show any incrustation even after very long periods.

Mechanical Characteristics

The minimum material strength for wet pipes according to **PS 428**

Bursting stress (internal pressure)	224 kgf/cm^2(22 N/mm^2)
Crushing stress (external vertical load)	450 kgf/cm^2(44 N/mm^2)
Longitudinal bending stress (external load)	250 kgf/cm^2(24.5 N/mm^2)

These values represent only minimum standard requirements.
As a general guideline, the other physical properties of Dadex AC/FC pressure pipes are given below:

Density	(1.70 ~ 1.75 gms /cm^3)
Free moisture	3%
Coefficient of elongation	0.00001 (m/m°C)
Thermal conductivity coefficient	0.04 K. Cal/m.h. °C
Specific heat	0.23 Cal/gm°C
Modulus of elasticity	200,000-300,000 kg/cm^2
Electrical conductivity (dry condition)	550 x 10 ohms cm^6

3.3 HYDRAULIC GRADIENT ACCORDING TO COLEBROOK RATIONAL FORMULA

The COLEBROOK-WHITE Rational Formula is recommended for calculation of flow velocity by **ISO 7336**

$$V = -2\sqrt{2gdj}\ \log\left[\left(\frac{k}{3.71d}\right) + \left(\frac{2.51Ø}{d\sqrt{2gdj}}\right)\right]$$

Where:

1. V = Velocity in m/sec
2. Ø = Kinematic viscosity of water (at 18°C) = 1.01 x 10^{-6} m^2/sec
3. g = 9.81 m/sec^2
4. d = pipe dia in M
5. j = Hydraulic gradient
6. k = Linear measure of effective roughness:

i) 100 x 10^{-6} m for 80, 100, 150, 200 & 250 mm dia
ii) 60 x 10^{-6} m for 300, 350, 400, 450 & 500 mm dia
iii) 25 x 10^{-6} m for 600, 800, 900 & 1000 mm dia

For loss of heat due to friction for various combination of dia and velocity, a table based on COLEBROOK-WHITE Rational formula can be had from Dadex Customer Services Department.

3.4 SELECTION OF PIPE DIAMETER AND CLASS

The determination of nominal internal diameter of pipe depends on the quantity of water required to be pumped/to flow in a given time.

The greater the velocity, the smaller the nominal internal diameter of pipe but the loss of heat due to friction will increase.

If a small velocity is selected, the nominal internal diameter of pipe will be larger resulting in larger initial cost but long term saving in power costs. Consequently, a larger velocity will result in smaller nominal internal diameter of the pipe resulting in lower initial cost but would lead to long term disadvantage of greater power cost.

3.5 WATER HAMMER PRESSURE

This phenomena is a cause of many pipeline problems. If a column of water in motion is brought to a sudden stop, a pressure wave is generated in the pipeline. By the next positive wave the separated water masses may collide with each other and the shock can impair the pipeline.

The sudden stoppage of water column can be due to sudden closing of control valve, shutting down of pumps intentionally or by power failure. To take care of such possibilities, a safety device should be provided.

3.6 PRACTICAL RANGE OF VELOCITIES

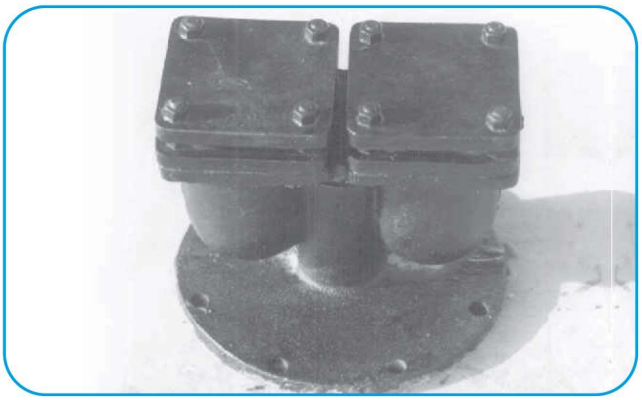
The velocity of flow should not be less than 0.75 m/sec (2.5 ft/sec) or more than 3.5 m/sec (11.5 ft/sec).

Very high velocities may cause turbulent flow and loss of pressure due to turbulence and high frictional losses will prove to be uneconomical.

3.7 AIR INLETS AND OUTLETS

In any pipeline system, especially pumping mains, air valves should be provided which allow air to escape from the pipeline during start of pumping and allow entry of air during emptying of line, purposely, by power failure or by an accidental break in the line.

For this purpose, Single Acting or Double Acting Air Valves should be installed at all high points where air tends to collect.



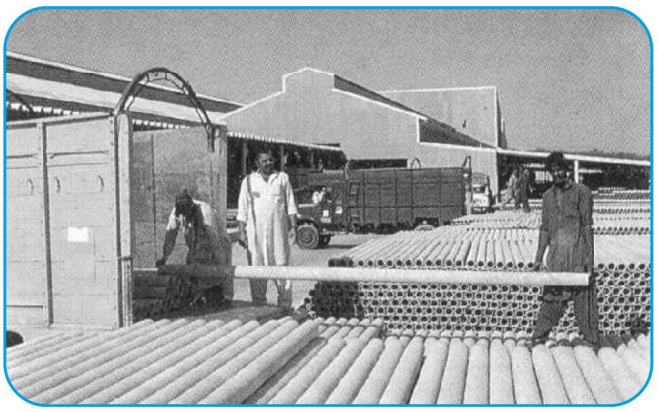
Double Acting Air Valve

4. TRANSPORTATION AND STORAGE

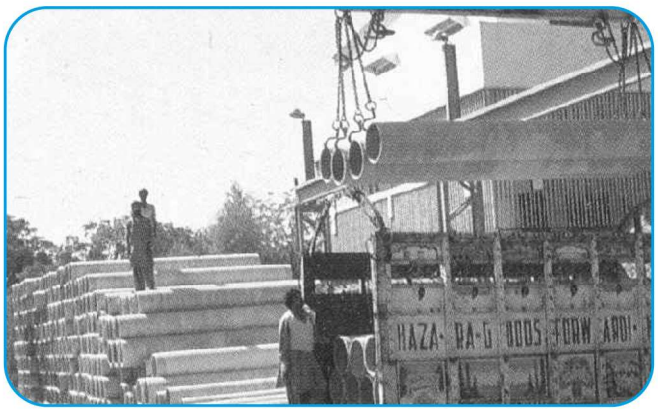
4.1 LOADING

The trucks deliver pipes directly to site.

Dadex AC/FC pressure pipes of nominal internal diameter 80, 100, 150 and 200 mm are loaded one by one, manually, at factory whereas pipes having nominal internal diameter greater than 200 mm are loaded by overhead travelling crane.



Loading by hand



Loading by crane

4.2 RECEIVING AND INSPECTION

The following inspection rules should be applied by the customer or his representative at the time of receiving and unloading goods at site or storage area.

Each pipe should be inspected with care on its arrival.

Total quantity of pipes, couplings, rubber rings, and any other accessories supplied should be carefully checked.

In case of site delivery, damage must be pointed out on the receipt or delivery challan. Also each missing item must be pointed out to the dispatcher and noted on the delivery challan.

Material that has been damaged during transportation should be stored separately in order to avoid confusion when laying them out.

4.3 UNLOADING

Instructions for Unloading

The small pipes and accessories are unloaded by hand. The sizes of pipes range from 80 to 200 mm and can be carried easily.

For heavy and very cumbersome pipes, some mechanical means of handling should be used such as a mobile crane, fixed crane, gin, derrick, etc.

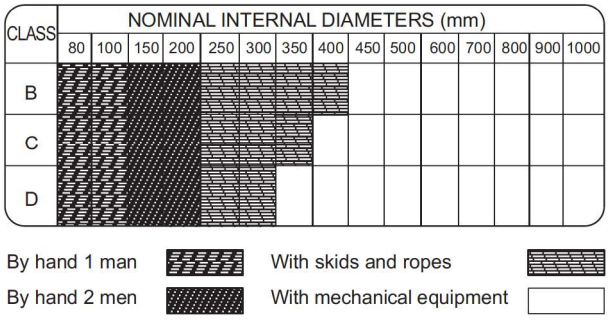
The pipes can also be lifted by using suspension hooks at the ends of the pipes and fixed to the hook of the crane or to a rocking lever. The hooks should be properly covered with rubber pads to avoid damage to pipe ends.

Precautions

Banging of pipes against each other and dropping them on ground may create fine hair cracks, invisible to the eye, which may lead to problems during field testing and operation.

Avoid damaging the turned ends by rubbing pipes against each other during pulling and dropping of free end of half pulled pipes over rough ground.

The adjacent table should be used to establish the unloading procedure.



4.4 OFF-LOADING ALONG THE TRENCH

The best method is to unload the pipes alongside the trench directly from the trucks.

When it is not possible to set out the pipes along the line of the trench, they must be stored. The storage area should be situated as near to the pipe laying site as possible in order to reduce the amount of handling.

When the pipes are unloaded alongside the trench, it is advisable to observe the following points:

- If the trench has already been excavated, set the pipes down on the opposite side to the excavated earth so that they can be lowered to the bottom of the trench easily
- If the trench has not yet been dug up, decide on the side where excavated soil will be thrown and set the pipes down on the other side
- Store pipes on level ground or timber bearers

4.5 PIPE STORAGE ON SITE

If the pipes are to be stored for a short period due to any reason, then proper stacking for short periods is required.

Pipes being carried to the trench

Pipes laid along the trench

Stacking of Pipes

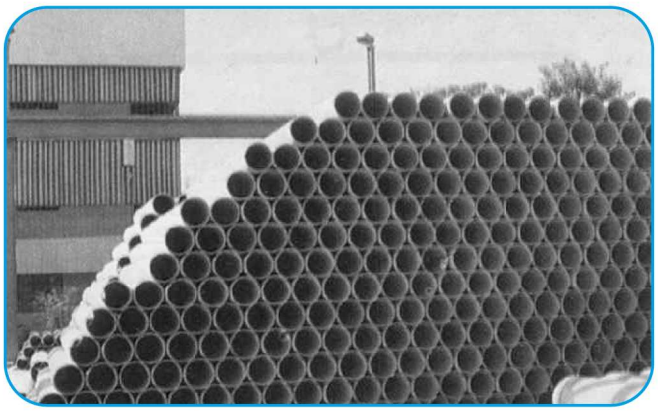
Stacking should be done on a firm and level ground.

The first layer should be stacked on two hard wood battens about 3" x 3" thick laid at about 0.8 meter from the ends of the pipes.

The piles should be in the shape of a pyramid or in well balanced layers. The latter is advisable for pipes of small diameter.

Wooden wedges nailed to the cross pieces should be placed on both sides of the first layer in the stack. This gives stability to the stack and avoids sliding off the whole pipe stack.

Stacked pipes should not exceed a certain height. This height is limited for safety and practical reasons, please refer to the table.



Pipes stacked in a pyramid form

Table: Max. Height of Pipe Stack

Nominal internal diameter of pipe (mm)	80 - 400	450 - 600	700 - 1000
Number of layers in a stack	20 - 4	4 - 3	4 - 3
Maximum height (m)	2	3.2	3.3

4.6 STORAGE OF COMETE COUPLING AND RUBBER RINGS

The Comete couplings should be kept in closed premises from where they will be taken when needed.

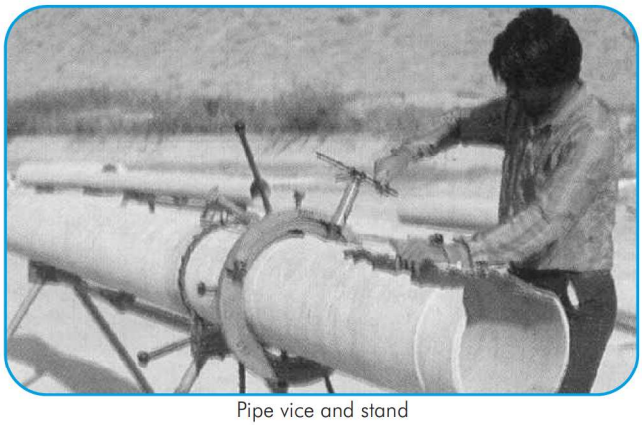
Dadex Rubber Rings are packed and supplied in opaque polythene bags.

They should be stored in a cool and dark place away from sunlight to avoid deterioration in their quality.

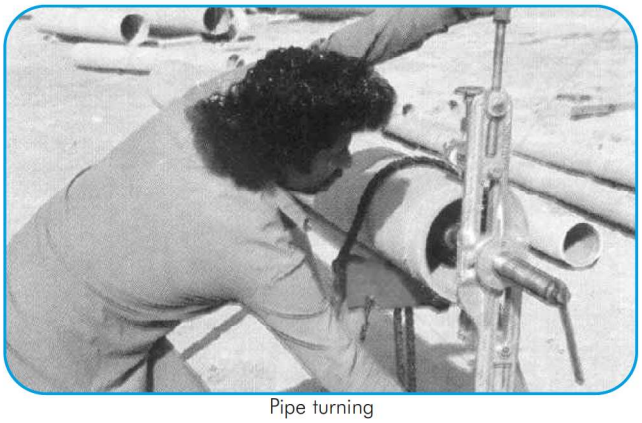
5. WORKING AT SITE

To ensure proper laying and jointing of Dadex AC/FC pressure pipes all working equipment, such as tools, and accessories should be available on site (these tools are in addition to spanners, cutters, pincers, screw drivers, hammers, etc., which are part of any field work).

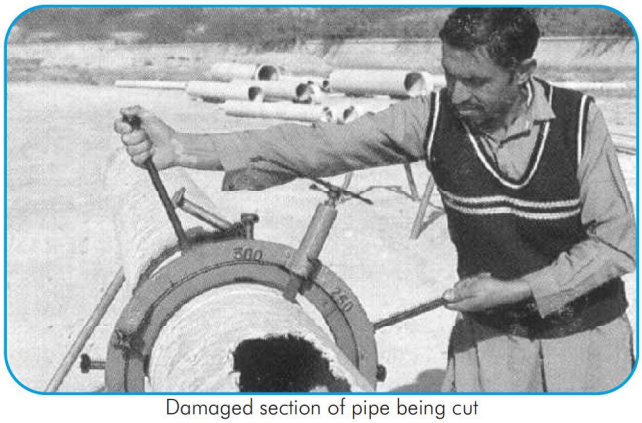
Coupling being lubricated before jointing



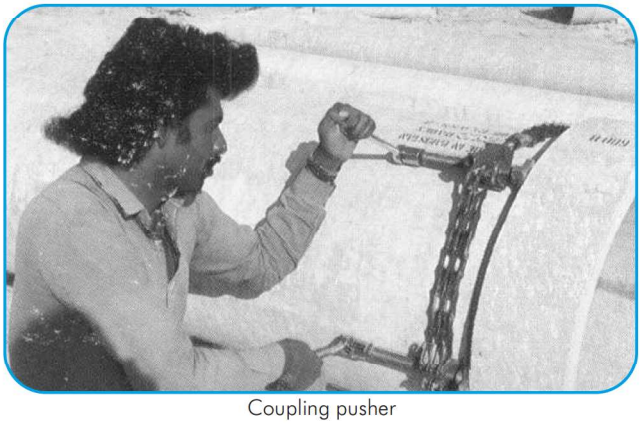
Pipe vice and stand



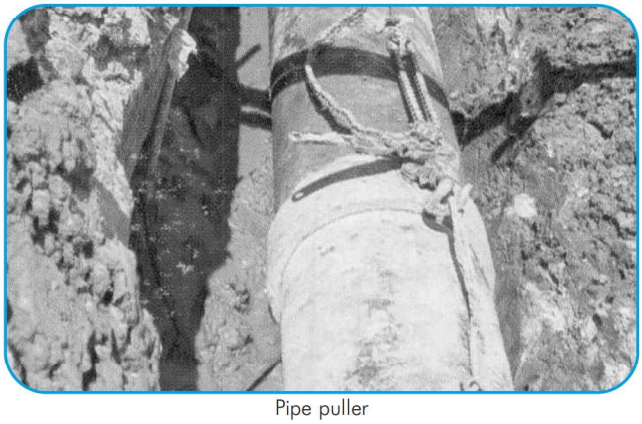
Pipe turning



Damaged section of pipe being cut



Coupling pusher



Pipe puller

Hand power puller

FIELD TOOLS

1. Lubricating the comete & rubber ring.
2. Pipe Supporting Stand (pipe vice & stand)

3&4. Cutting and Turning Machine

5. Coupling Pushers
6. Pipe Puller
7. Hand Power Puller

6. THE TRENCH

6.1 TRENCH BOTTOM

Proceed with the digging of trench as follows:

The excavated earth is deposited on one side of the trench.

In trenches with a steep slope, it may be necessary to anchor the pipes and to provide means for draining water that might seep in and flood the trench.

In loose ground, the excavations must be carefully shuttered with timber when they reach a certain depth.

Bottom of the trench should be made uniform, remove all uneven portions, hard stones, etc., where trench bottom is uneven due to rock, etc. A layer of sand 4" to 6" as cushion should be provided.

6.2 CURVES IN THE LINE

To a certain extent horizontal or vertical curves in the pipe line could be achieved without the use of C.I. Bends.

Cast Iron bends of 11¼°, 22½°, 45° and 90° can be used where short radius curves are required.

The maximum angular deflection allowed for Comete joints when using Dadex AC/FC pressure pipes and couplings is given in the table.

Nominal Internal Diameter mm	Max. Deflection Allowed degrees	Displacement α for 4m lengths cm
80	6°	42
100	6°	42
150	6°	42
200	5°	35
250	5°	35
300	5°	28
350	4°	24
400	3° 30′	24
450	3°	21
500	2° 30′	18
600	2° 30′	18
700	2° 30′	18
800	2° 30′	18
900	2° 30′	18
1000	2°	14

Cast Iron bend used for curve in the pipeline

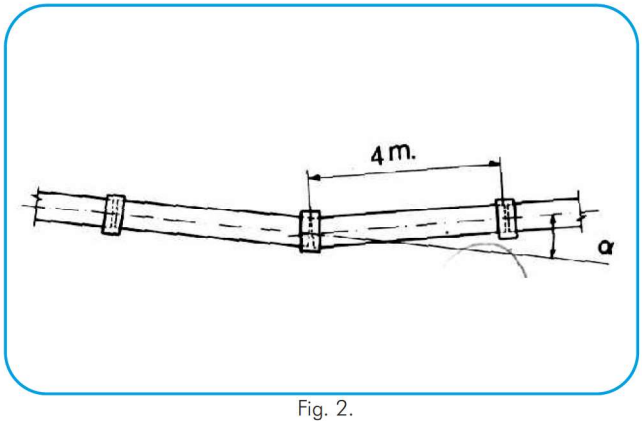


Fig. 2.

6.3 ANCHORAGE

At points in a pipeline where there are horizontal or vertical changes in direction, reduction in pipe size, branches or capped ends, it is necessary to construct permanent anchorages where movement may occur due to thrusts generated by internal pressure.

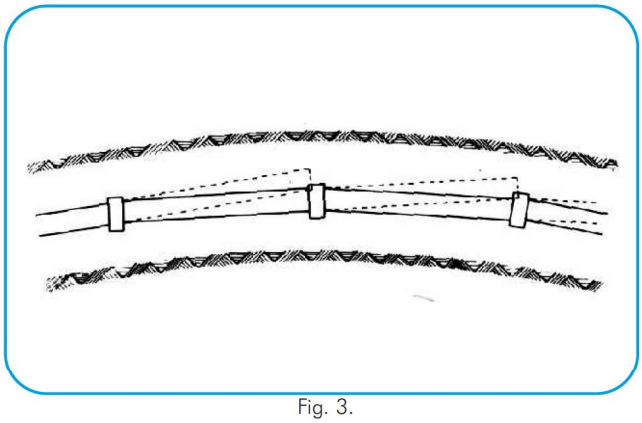


Fig. 3.

6.4 SIZE AND SHAPE OF THE TRENCH

Shape of trench depends on the nature of soil. In case of ordinary soil, a narrow trench is advisable.

Trench Width and Depth

The following table gives the recommended widths and depths of a trench normally in practice for Dadex AC/FC pressure pipes.

Nominal internal Diameter (mm)	Width (mm)	Depth (mm)
80 - 300	500 - 600	150 mm + Nominal internal Dia of pipe + 1000 mm cover over crown of pipe
350 - 500	600 - 800	
600 - 800	800 - 1300	
900 - 1000	1500	

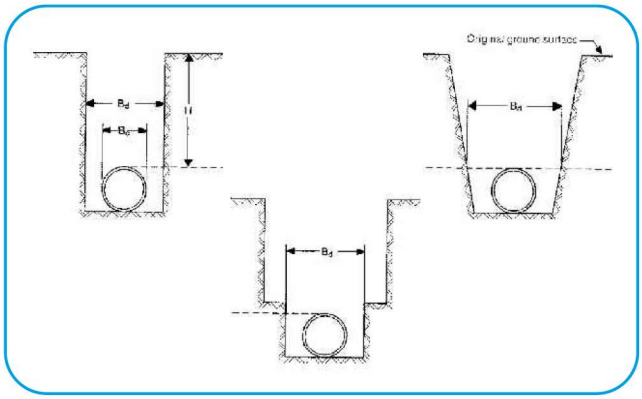


Fig. 4.

6.5 THE SOIL AND FOUNDATION OF PIPE LINE

Dadex AC/FC pressure pipes are laid in very different types of soils such as clay, sand, silt, marshy, muddy, etc., and in different circumstances: under the water-table, above the water-table, in stabilized soils, in disturbed soils, etc.

The designer of the project is responsible for determining the supporting strength of the subsoil and for making the necessary arrangements in the trench.

Pipes being laid in muddy soil

7. PIPE LAYING AND JOINTING

7.1 GENERAL RECOMMENDATIONS

Careful site organisation precedeg the laying of pipes at the required time, the contractor should have all the materials, and equipment necessary for carrying out the work.

A final check is made so as to put aside any pipe that may show some defect, such as cracks, chipping at the ends, crushing of the side, etc.

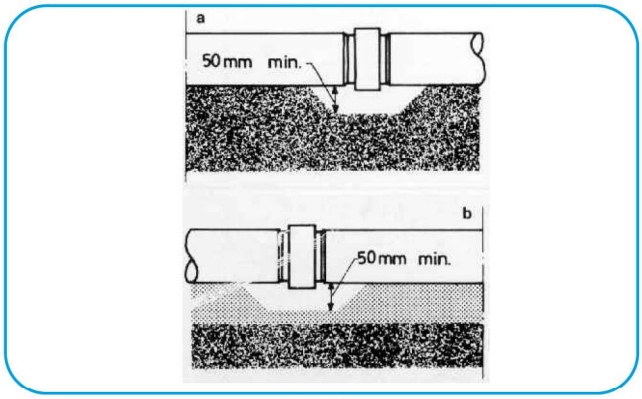


Fig. 5.

7.2 PIPE SUPPORTS

A distinction may be made between the following three types of laying, which are described in detail in the coming sections.

- Continuous Supports
- Intermittent Supports
- Suspended Installation

7.3 LAYING ON CONTINUOUS SUPPORTS

Normal Gradients

This is the normal type for the pipe lines laid in trench or in embankment conditions. The pipe should be in contact with the soil over their entire length and under no circumstances should their weight be carried by coupling. Refer Fig. 5.

Steep Gradients

In case of steeply inclined runs it is necessary to provide transverse anchors to prevent movement of the pipeline. Refer Anchorage section 6.3.

By clamping two semi-circular flat steel straps of suitable dimensions to the pipe at a point adjacent to a joint fixed firmly at the bottom of the trench.

A layer of bitumen, impregnated felt or other suitable material of a thickness approximately 5 mm should be inserted between the clamp and the pipe to take care of the effect of minor soil settlements.

By casting a concrete block of suitable dimensions on a short pipe to ensure flexibility of the pipeline.

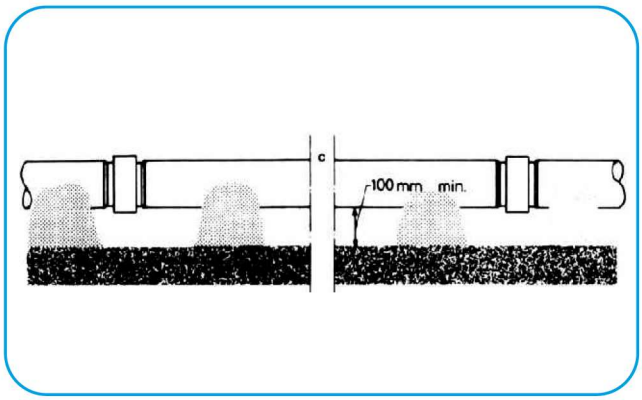


Fig. 6. Laying on continuous supports.

7.4 LAYING ON INTERMITTENT SUPPORTS

This type is required when a pipeline is laid in critical soil conditions such as peat soils, swamps, etc., with high settlement rates or on cradles or saddles (e.g. in tunnels) or on piles (e.g. crossing rivers or cuttings). Special precautions in design and construction should be taken when a pipeline supported in this way is subject to external load (e.g. backfill, traffic, etc.).

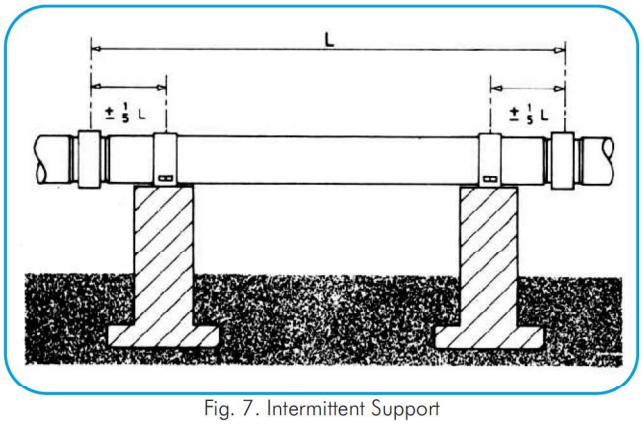


Fig. 7. Intermittent Support

7.5 SUSPENDED INSTALLATION

This type of installation is required when a pipeline is suspended from a structure, e.g. building walls or ceilings, under bridges, in utility ducts, or in tunnels.

The pipes are supported by straps at specified intervals. The straps should be of flat steel, at least 50 mm wide, and under no circumstances should they compress the pipes.

Intermittent Supports

7.6 EXCEPTIONAL LAYING CONDITIONS

Unstable Ground

In case of unstable ground pipeline designers should consider all factors to determine appropriate laying method. The following possibilities should be considered:

- Use of short lengths
- Special preparation of trench bottom

Passing Under Highways or Railways

Backfill above the crown of the pipes should have a height of at least 1m. The pipe bedding, side backfill, and the first 30 cm of material covering the pipe should be either non-cohesive soil or granular material.

Submerged Pipeline

In soils where the dewatering of the aquifer is difficult some pipes can be assembled outside the trench and then lowered into the trench.

Dadex pipeline near seashore

7.7 LOWERING THE PIPES INTO THE TRENCH

The men on top of the trench must ensure that the pipes are ready, and possibly fitted with a Comete coupling. If the pipe is lowered by means of ropes, everything must already be in the correct position, so that the pipe arrives at the bottom in exactly the right place.

The pipes are lowered into the trench either by hand, by means of two ropes, or if they are too heavy, with the help of a mobile crane. With two or four men, pipes weighing up to 400 kg can be lowered in this way. For heavier pipes, it is advisable to wrap a rope around the pipe twice, in order to better control its descent.

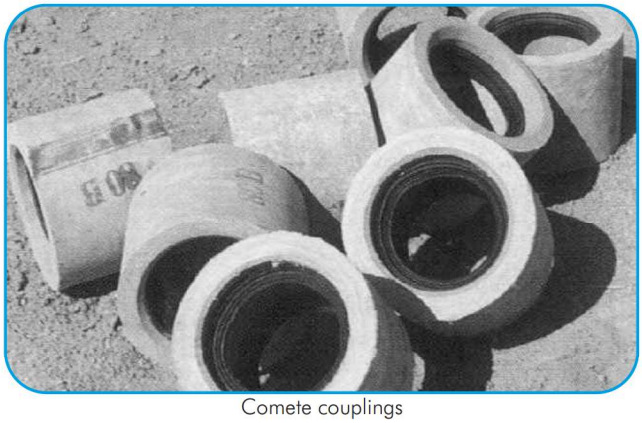
Lowering of pipe into the trench.

Caution

Although most pipes up to 500 mm diameter can be lowered into the excavation in the manner described above, it is often advantageous to use a crane in order to speed up the work and use less labour. For this purpose an excavator may be used.

The Comete joint consists of a fibre cement coupling and two rubber rings of a special shape, placed in appropriate grooves in the coupling.

These rings are wedged longitudinally between the pipe and the coupling. The special design of the rings ensures the self-tightness of the joint. This tightness increases as the hydraulic pressure inside the pipe rises.



Comete couplings

The Comete joint allows a sliding connection when the turned end of the pipe, previously coated with a lubricating product, is introduced into the coupling equipped with rubber rings.

The coupling can be mounted on the pipe to be laid outside the trench on either end of the pipe. It is, however, usually put in position on the rear end, that is to say in the direction of the piping already laid. This is done by pushing the pipeline to be assembled simply and easily.

Naturally, much of the pipe laying is done by mounting the coupling in the trench onto the last pipe already laid then mounting the following pipe, and then again a coupling and so on.

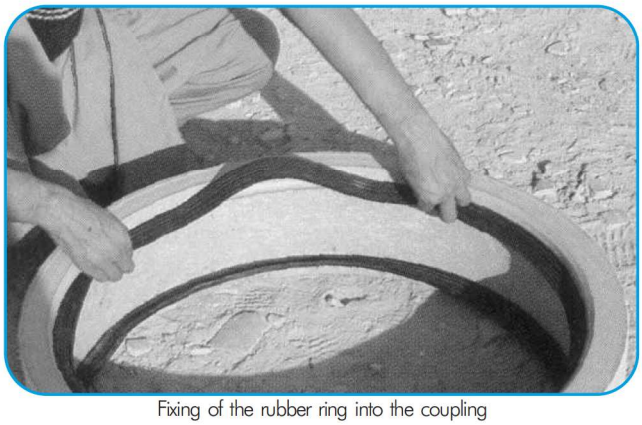
7.8 FITTING THE RUBBER RING INTO THE COMETE

The turned end of the pipe, the internal grooves of the coupling and the rubber rings are carefully cleaned.

The turned end and the grooves are then applied with a lubricant (soft soap solution).

Caution

Use of lubricating oils, grease and similar materials is not recommended, as they are harmful to the rubber rings. The rubber ring is placed in the groove with the tail turned to the inside of the coupling.



Fixing of the rubber ring into the coupling

The ring will then be worked by hand so as to distribute the ring round the groove as carefully and evenly as possible. The ring is thus somewhat "taut" on the inside of the groove.

7.9 MOUNTING THE COMETE COUPLING

After the two rings have been fitted in the grooves, the tails of these rings are turned back in the direction of their final position, and the part of the tail which will be in contact with the turned end of the pipes is lightly coated with a lubricant.

Pipes of small diameter, up to and including 300 mm, can generally be mounted manually using crow bars.

For larger diameters, a removable steel strap (position clamp) can be fixed to each end of the pipe to be laid; this strap controls the insertion of pipe into the comete.

Pipes of a diameter larger than 300 mm are laid with the help of a pipe puller.

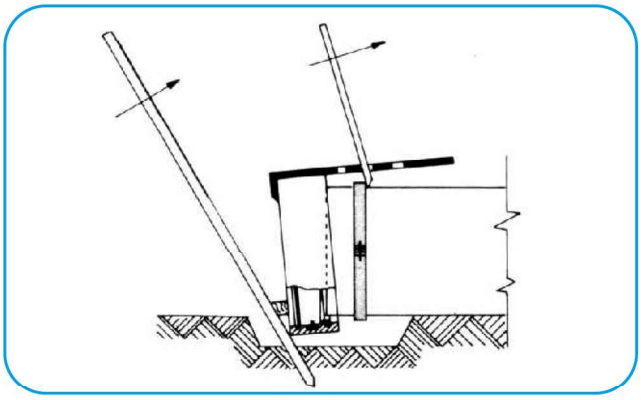


Fig. 8. Position clamp for Comete coupling

Mounting the coupling

During jointing or mounting of coupling it is necessary to insert wood packing between the crow-bar and the coupling in order to prevent damage to the coupling.

For all diameters, the pipe can then be mounted in the trench on to the end of the pipe already laid. This operation is normally carried out by pushing the end of the pipe with a lever thus causing it to slide over the soil at the bottom of the trench. When the resistance due to soil friction becomes too great, the pipe can be suspended horizontally from a derrick or a crane. This method also has the advantage that the pipe can find its way into the coupling easily and in such a way that there is no risk of the ring being dislodged or distorted.

7.10 USING SHORT LENGTH PIPES AND REPAIRS

Short Length pipes are used in Dadex AC/FC pressure pipe laying in situations such as:

- At fixed points (buildings, pumping stations, water reservoirs, and other structures)
- For curves
- To make a repair
- To accommodate a fitting
- To fill a gap in the pipeline
- At closures
- In extreme conditions with very small diameter pipes

Pushing the pipe into the coupling

Short Length pipes of the required length are machined at the ends to make turned ends of diameters similar to those of normal pipes. The Short Length pipes are then joined together as described earlier in this chapter.

Making Repairs in the Pipeline

A new pipe, shorter by about 30 mm than the gap to be filled or the pipe to be replaced is prepared for jointing into the line. The ends of the pipe are suitably turned to a longer length and chamfered to fully accommodate the new couplings.

The couplings are mounted on each end of the pipe in such a manner that the lips of both the rubber rings point outwards.

The replacement pipe with the two Comete couplings fitted on the ends is placed in the trench to fill the gap.

The Comete coupling should now be pushed halfway over the two adjoining pipes in the trench to complete the joint.

The pushing of couplings in the trench without the aid of proper tool is very difficult especially for large diameter pipes. For this purpose a Coupling Pusher should be used.

7.11 THE GIBAULT JOINTS

The Gibault joints are ideal for making connections in pipeline gaps or for replacing damaged or burst pipes.

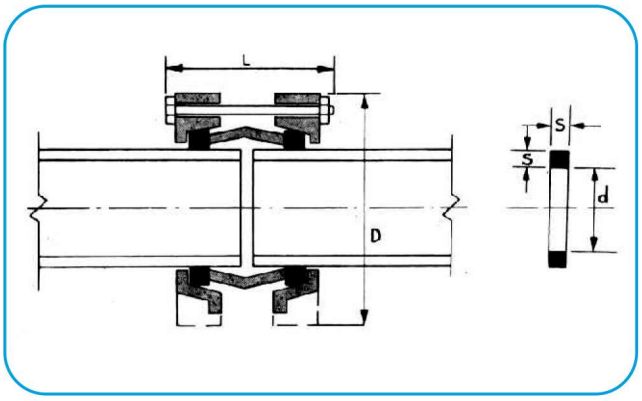
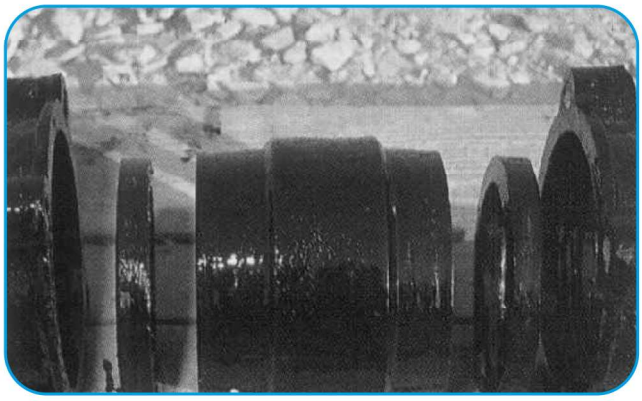


Fig. 9. Section of Gibault joint



Gibault joint

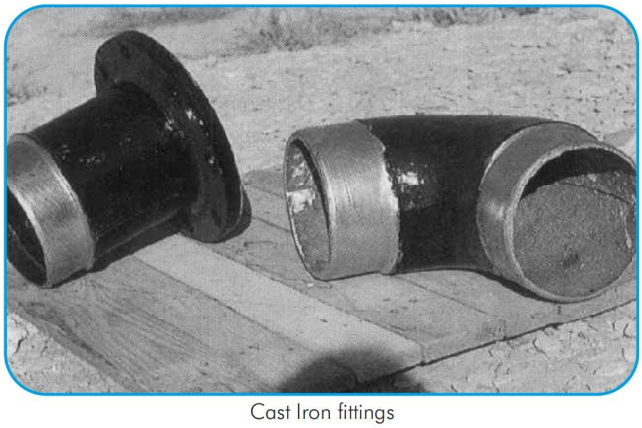
They are easy to assemble when repairs are needed. But they are relatively costly and the bolts need special protective coating for prevention of corrosion. For detailed dimensions please refer to our brochure on CAST-IRON FITTINGS.

7.12 CAST IRON FITTINGS

The fittings such as bends of various degree, tees, crosses, reducers and special fittings are made of high grade cast-iron.

Basically the Cast-Iron Fittings have ends which can be described as spigot ends. Ensure that these are machined to exactly the same outside diameter as the Dadex AC/FC pressure pipes. These are jointed with the Dadex AC/FC pressure pipes in the same manner as jointing pipe to pipe with the help of Dadex couplings and rubber rings.

The dimensions of body of these cast iron fittings generally follow ISO Standard No. 13 : "CAST IRON PIPES, SPECIAL CASTINGS AND CAST IRON PARTS FOR PRESSURE MAINLINES".



Cast Iron fittings

7.13 SERVICE CONNECTIONS

The connections to consumers can be made either before the main is put into use, that is to say, at the same time as the distribution system is being laid, or when the latter is already in operation.

The connections from a distribution line are fixed by means of a strap, square or rectangular in section. Round straps are not advisable because when the bolts are too tight, the pressure of the collar gets concentrated along the line of contact. The walls of the pipe should be drilled after fitting the Cast Iron Saddle Clamp on the pipe.

8. FIELD PRESSURE

8.1 GENERAL

More and more engineers now realise the importance of field testing of pressure pipelines. Pressure testing of pipelines helps to check correct laying and jointing work. The field testing procedure is a costly affair and should be planned and executed carefully.

For Dadex AC/FC pressure pipes, the type of test required is described in the following pages. Pressure testing is carried out as a single operation on individual test sections (ISO 4483).

8.2 LENGTH OF TEST SECTION

The length of the test section should normally be 500 meters, smaller or longer sections may be permitted, always ensure that during the test, the pressure of the highest point of the section does not exceed the desired test pressure.

If for any reason the pressure gauge is installed at a high point, the reading of the gauge should take into account difference of levels.

8.3 PREPARATION OF THE SECTION TO BE TESTED

Backfilling Before the Test

The pipes comprising the test section should be securely held down by partially backfilling the trench to at least 30 cm above the crown of pipes (not exceeding 200 mm diameter) to about 50 cm for pipes of larger diameter.

The backfill shall be placed and compacted so that the internal pressure will not give rise to any transverse or vertical displacement of the pipes. The joint should remain uncovered for visual inspection during the test.

Test equipment

Anchorage

The pressure test shall be carried out after all permanent anchor blocks have been placed, have developed adequate strength to reduce time. Rapid hardening cement may be used.

Temporary anchorage for closure caps (Cast Iron Dead Ends) on test sections should be designed to suit the magnitude of the test pressure and load bearing capacity of the supporting soil.

Filling of the Test Section

The section of the pipeline to be tested should be filled with water sufficiently at a slow rate to ensure that all air is expelled through air values arrangement.

8.4 TEST EQUIPMENT

The hydraulic pressure in the test section is raised by means of a testing pump. The test equipment comprises of a water-pump, a valve, a manometer, possibly fire-cocks and air-vents. Pumping is generally done at the lowest point of the section. Air-Vents are located at the highest points of the section.

Manually operated pressure testing pump is suitable for building up required pressure at a slow rate. However for large diameter pipelines motorized or powered pump may be used, it should be equipped with control valve to control the speed of pump at a slower rate.

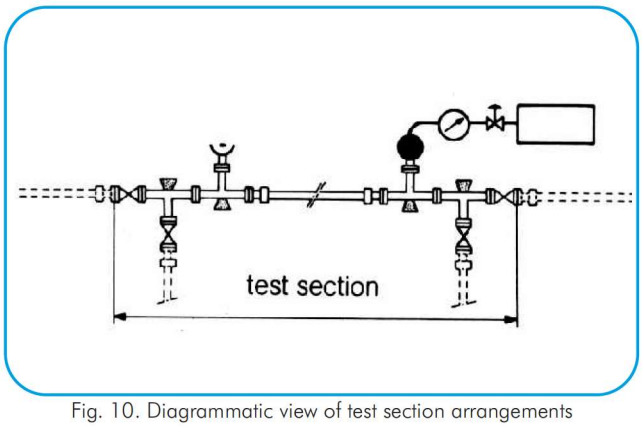


Fig. 10. Diagrammatic view of test section arrangements

8.5 TEST PROCEDURE

After filling with water, the test section shall stand for an initial period of approximately 24 hours under a static pressure up to the intended working pressure in the section.

Magnitude of Test Pressure

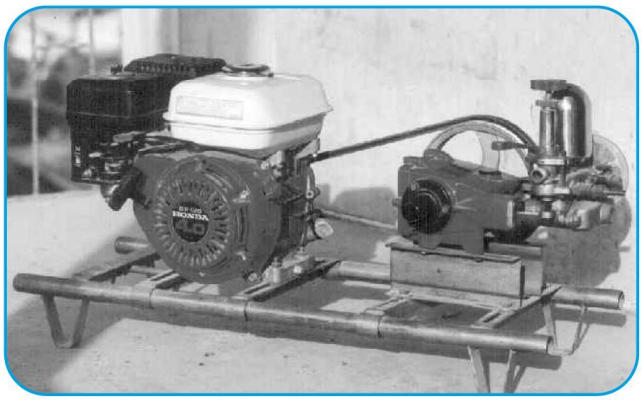
The Field Pressure Test (FPT) shall normally not be less than one and a half times the actual working pressure, where this does not exceed 1.0 MPa (10 bar) but shall not exceed FPT given by the following expression.

FPT = I.5 WP for W P < 1.0 MPa

FPT = WP + 0.5 MPa for WP > 1.0 MPa

The Field Pressure Test shall never be less than 0.4 Mpa (4 bar) irrespective of the magnitude of the actual working pressure.

This recommendation regarding the Field Pressure Test conforms to ISO 4483.



Motorised pump for testing large dia pipelines

Duration of Pressure Test and Water Absorption

The test pressure should be maintained in the test section for at least 1 hour. A longer period may, however, be specified by the pipeline designer (up to a maximum of 6 hours).

8.6 TESTING OF PRESSURE PIPELINES LAID ON OR ABOVE GROUND LEVEL

Pressure pipelines laid on or above ground level should be tested by the method described earlier, but care should be taken to ensure that the pipes and fittings are securely anchored in order to prevent displacement of the pipeline.

8.7 CAUSES OF FAILURE OF A TEST

Pressure drops due to a break, a fissure of a pipe, or by faulty assembly of joints may be due to the following causes:

- Displacement of the mains, for instance, due to movement of an anchorage.
- Porosity of the cast iron accessories.
- Leakage of the pressure pump.
- In the best of conditions of pipe laying and jointing some leakages may occur from the joints.
- Gate valves are not suitable for closing the ends of a test section and can cause failure.

The American Water Works Association (AWWA) specifies that the leakage from any pipe line should be less than the following formula:

$$Q = \frac{nd\sqrt{p}}{1850}$$

Where Q = the allowable leakage in gallons per hour

n = the number of Joints in the test section

d = the nominal dia of pipeline in inches

p = the test pressure in lbs per sq. inch

9. BACKFILLING AND COMMISSIONING

Initial backfill

9.1 INITIAL BACKFILLING

The initial backfill has to provide firm support and a proper bedding under.

Material for initial backfilling should be free of large stones (i.e. with size more than 25 mm). If excavated soil is not stone-free and also contains loose materials (i.e. sand earth), one can sieve it outside the trench and use it for initial backfilling. Initial backfilling should be done in layers of 6".

9.2 WATER TAMPING

Tamping can also be carried out with water if it is available. This method should be used for highly permeable soils like sand.

Place the backfill material by hand up to the crown of the pipe. The material must be evenly distributed filling all voids around the pipe.

9.3 THE FINAL BACKFILLING

After completion of testing operation for a length of the pipeline, the final backfilling must be carried out as soon as possible to avoid any risk of damaging the line.

The filling in should be done in layers 150 mm thick, carefully rammed down one on top of the other. Selected materials should be used such as sand, or fine earth, free from stones, and vegetable or organic matters susceptible to decomposition.

The materials used for upper layers can be coarser than that used for the initial backfill. Avoid stones which are too large that may damage the pipe when dropped into the trench.

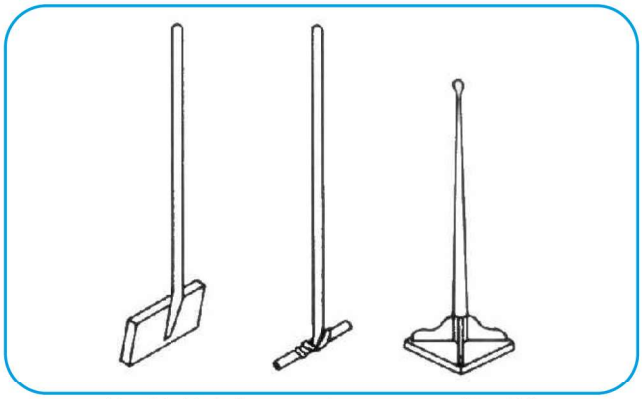


Fig. 11. Tools for manual compaction of backfill

9.4 COMMISSIONING OF THE PIPELINE

Filling in of the Trench

When the test has been completed and found satisfactory, the trench is filled in. The pipes may be emptied if circumstances require.

Placing the Line in Service

The filling of the pipeline should be done carefully. Water should be let in slowly, for instance, at the rate of 1/10 of the normal flow.

All air valves and air escapes should be opened and shut as soon as only water escapes from them. The pipeline is then ready for operation.

Initial backfilling

PRESSURE EQUIVALENTS

Atmospheres (atm)	bar	Centimetres of mercury	Feet head of water (ft/water)	Inches head of mercury (in Hg)	Kilograms per sq cm (Kgf/cm^2)	Pounds per sq in ($lbf\ in^2$)	Meters head of water (m/hd water)
1.0	1.0133	76.000	33.899	29.921	1.0332	14.696	10.332
0.98692	1.0	75.006	33.455	29.530	1.0197	14.504	10.197
0.013158	0.013332	1.0	0.44603	0.39370	0.013595	0.19337	0.13595
0.029500	0.029891	2.2420	1.0	0.88267	0.030480	0.43353	0.30480
0.033421	0.033864	2.5400	1.1329	1.0	0.034532	0.49116	0.34532
0.96784	0.98067	73.556	32.808	28.959	1.0	14.223	10.000
0.068046	0.068948	5.1715	2.3067	2.0360	0.070307	1.0	0.70307
0.096784	0.098067	7.3556	3.2808	2.8959	0.10000	1.4223	1.0

USEFUL EQUIVALENTS

Length	1 mm	= 0.03937 in	1 in	= 25.4 mm
Area	1 m	= 3.2808 ft	1 ft	= 0.3048 m
	1 mm^2	= 0.00155 sq in	1 sq in	= 645.2 mm^2
	1 m^2	= 10.76 sq ft	1 sq ft	= 0.0929 m^2
Volume	1 cm^3	= 0.06102 cu in	1 cu in	= 16.39 cm^3
	1 m^3	= 35.31 cu ft	1 cu ft	= 0.02832 m^3
	1 m^3	= 1000 litres	1 cu ft water	= approx. 62.5 lb
	1 litre	= 1.7598 pints	1 pint	= 0.568 litres
	1 gall water	= approx. 10 lb	1 gall	= 4.546 litres
Force	1 kg/f	= 2.205 lb/f	1 lb/f	= 0.4536 kg/f
Pressure	1 kN	= 224.809 lb/f		
	1 bar ($10^5 N/m^2$)	= 14.5038 lbf/in^2 = 1.033 kgf/cm^2		
	1 atm	= 14.6959 lbf/in^2 (standard atmosphere)		
	1 atm	= 1 kg/cm^2 = 14.2233 lbf/in^2 (metric technical atmosphere)		
	1 kN/m^2(1 kPs)	= 0.145038 lbf/in^2		
	1 lbf/in^2	= 6.89471 kN/m^2(1 kPa)		
	1 mbar	= 0.0295 inHg		
	1 kg/cm^2(1 Kp/cm^2)	= 14.223 lbf/in^2		

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