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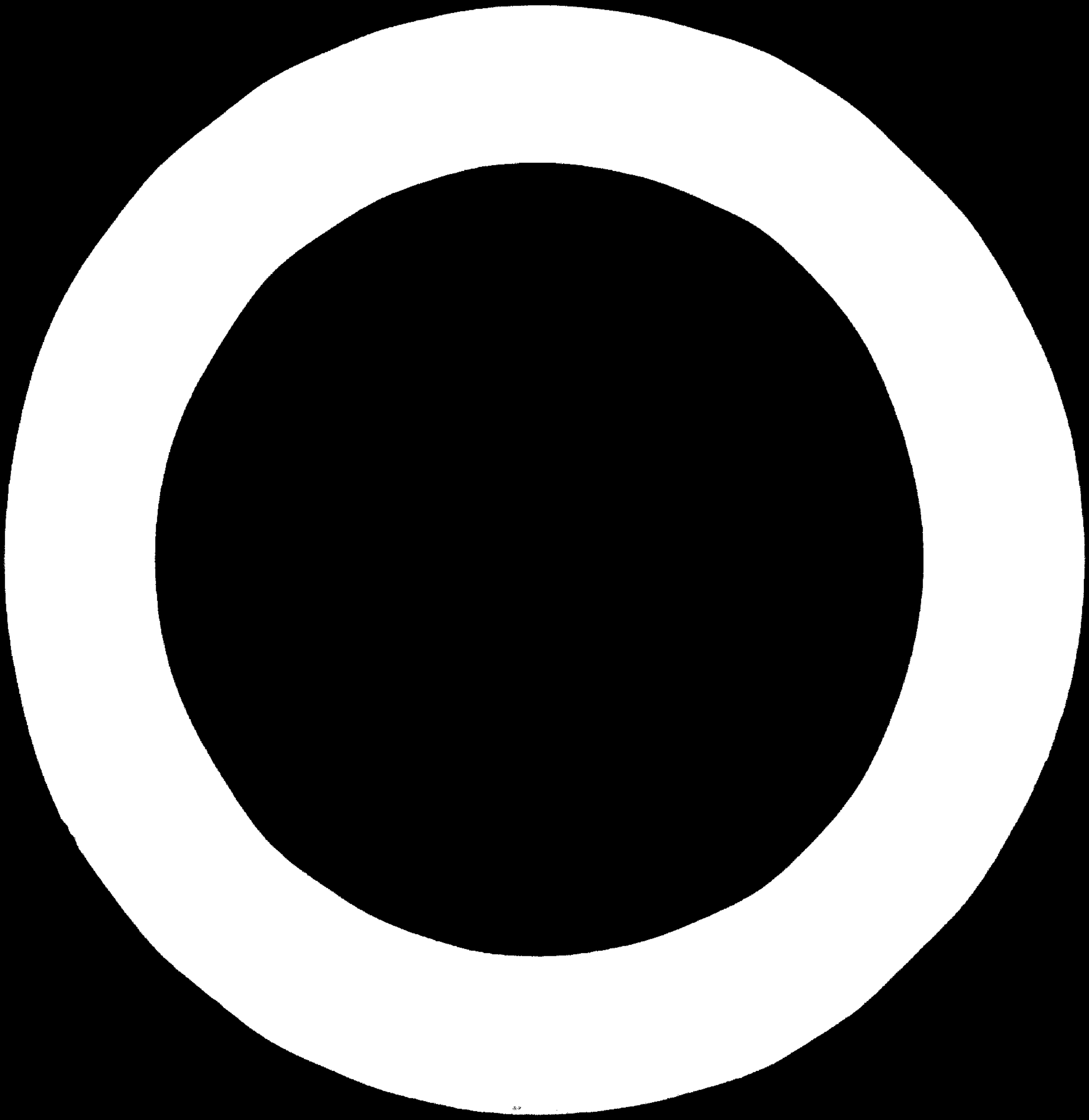

United Nations Development Programme

ADVICE IN ENGINEERING AND PROCESS ENGINEERING FOR FERTILIZER PROJECTS, NEW DELHI

DP/IND/[illegible]/045

INDIA

Technical report: High pressure piping

Prepared for the Government of India
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of J. Nicholson, expert in high pressure pipework

United Nations Industrial Development Organization
Vienna, 1976

Explanatory notes

Reference to "tons" (t) indicates metric tons.

Reference to "dollars" ($) indicates United States dollars.

The monetary unit of India is the rupee (Rs). During the period of the project its mean value in relation to the United States dollar was $1 = Rs8.25.

The following abbreviations are used in this report:

atm = atmosphere
EIL = Engineers India Limited
ICI = Imperial Chemical Industries

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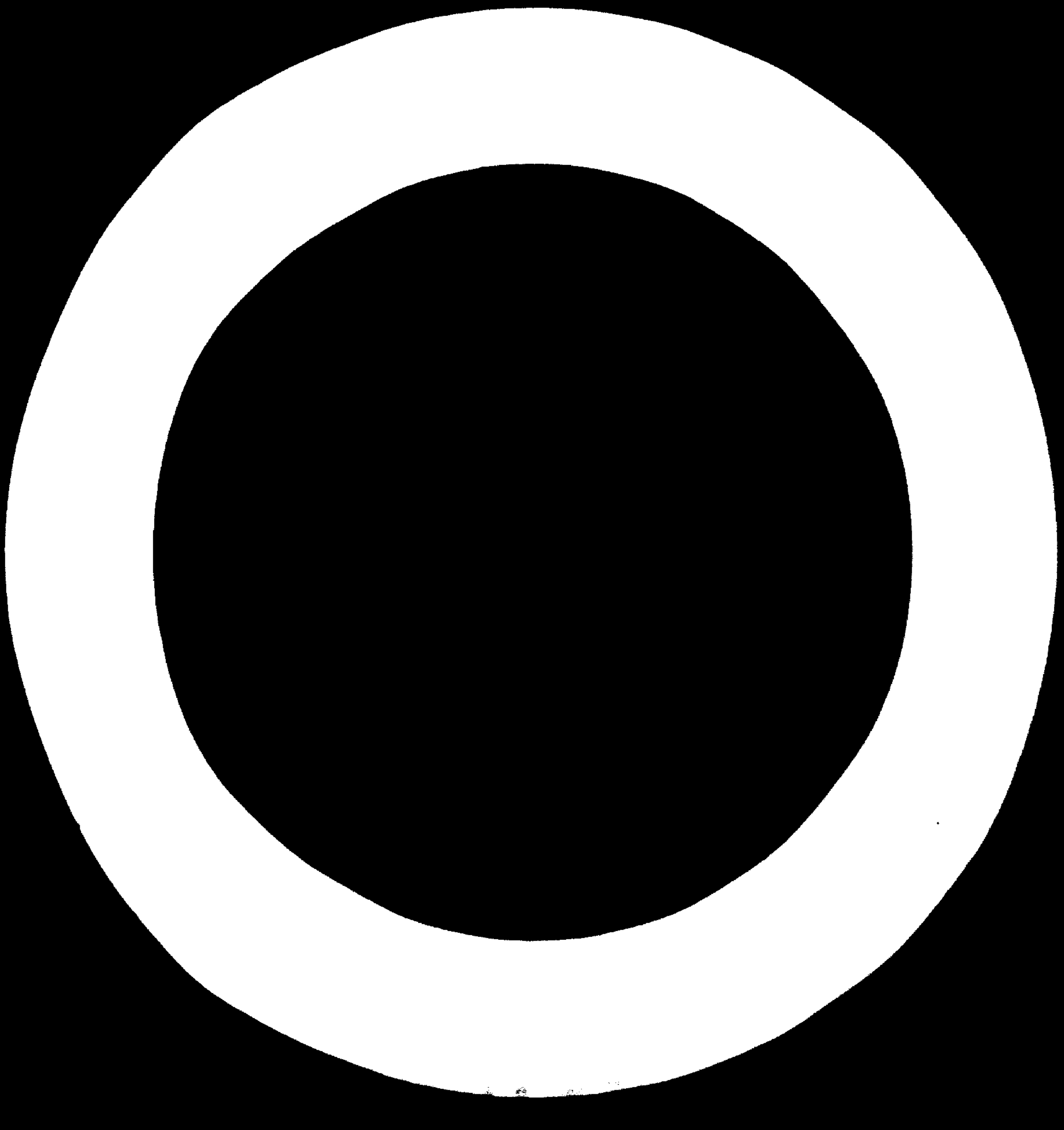


SUMMARY

In January 1974 the Government of India entered into agreement with the United Nations Development Programme (UNDP) for the provision of advice to Engineers India Limited (EIL) in connexion with the design and construction of urea fertilizer plants. The advice was to be provided by three experts, one for rotary machines, one for high pressure pipework, and one for the partial oxidation process.

The expert for high pressure pipework began his 12 month assignment on 9 December 1974 and terminated it on 5 December 1975.

The long-range objective of the project is to develop quickly Indian capability in the field of fertilizer manufacture from fuel oil using the partial oxidation process.

The immediate objectives are to obtain proper advice and guidance during the detail engineering phase of the fertilizer projects now in hand.

As regards the immediate objectives, in particular the design of high pressure pipework, it is the opinion of the expert that EIL now has sufficient information and expertise to design the essentials and to prepare standards for high pressure pipework including design of high temperature/pressure piping associated with gasification processes.

Greater safety in the operation of the ammonia and urea plants will be ensured by application of the safety policy changes to the process licensers plant and instrument diagrams as advocated by the expert. These changes included:

(a) Relief valves which protect low pressure equipment downstream of a pressure let-down of liquid from a high pressure source should be sized to cover abnormal conditions, such as failure of a let-down valve resulting in loss of liquid and breakthrough of the high pressure gas;

(b) Adequate isolation between a high pressure system and a low pressure system.

EIL were also advised to give particular attention to the installation in chemical plants of the correct materials.

A centralized piping design department, with a piping liaison officer attached to the relevant project sections, may give better results than those obtained by the task-force concept where the piping design draughting team is attached to the project section.

The process licensers of the fertilizer plants have provided EIL with advisory staff for the detail mechanical design of the pipework. The expert's help has not been utilized in this respect.

The junior design staff of EIL should be given the opportunity to obtain experience of plant construction and commissioning and to obtain knowledge of maintenance problems.

The efficiency of the Company's operation could undoubtedly be increased if the staff were housed in one building or nearer together.

INTRODUCTION

In January 1974 the Government of India entered into agreement with the United Nations Development Programme (UNDP) for the launching of a project, "Advice in Engineering and Process Engineering for Fertilizer Projects" (IND/73/045). The Government co-operating agency was the Ministry of Petroleum and Chemicals acting through Engineers India Limited (EIL). The executing agency was the United Nations Industrial Development Organization (UNIDO).

The advice was to be provided by three experts in (a) rotary equipment; (b) high pressure pipework as used in ammonia and urea plants; and (c) partial oxidation process for synthesis gas production.

The formal agreement was completed and signed on 11 January 1974. The project had been submitted in November 1973 and the proposed starting date was April 1974. The planned duration was 15 months.

The Government contribution was to be Rs 405,000 and the UNDP contribution was to be $US92,000.

J. Nicholson, expert in high pressure pipework, was appointed on 7 December 1974 and on arrival in India was assigned to work with the EIL Piping Design Section.

P. Sen, manager of the Mechanical Engineering Design Section, was appointed as counterpart until June 1975 when K.D. Banerjee, head of Piping Task-Force Fertiliser Group, was appointed.

The objectives of the project were as follows:

(a) *Long-range*. To develop to the maximum extent and as rapidly as possible Indian engineering design and consultancy capability in the field of fertiliser manufacture from fuel oil, using partial oxidation processes based on the latest technology;

(b) *Immediate*. To obtain proper advice and guidance during the detail engineering phase of the three fertiliser projects in the following areas:

(i) Proper selection and specification of critical rotary equipment such as compressors;

(ii) Development of proper P & I diagrams for high-pressure pipework in ammonia and urea plants from the operations point of view;

(iii) Proper selection, specification, and detailing of high-pressure equipment in ammonia and urea plants;

(iv) Adoption of proper technology and choice of equipment for the recovery of carbon and its recycling through the partial oxidation reactor, with adequate disposal of un-recycled carbon as auxiliary fuel, or in the production of active carbon/carbon black;

(v) Checking on the basic design supplied by the various process licensers for these projects;

(vi) Ensuring that proper amounts of stand-by equipment, spares, etc., are provided from an operational point of view.

EIL are contracted in association with the Toyo Engineering Corporation of Japan for the following fertilizer plants: at Bhatinda in the State of Punjab, commissioning date October 1977; and at Panipat in the State of Haryana, commissioning date February 1978.

The techno-economic feasibility study for the Government of India Fertilizer Project (Bhatinda), EIL Job No.0194, was completed in September 1973.

The feasibility study indicated a period of 30 months from the receipt of design data from licenser to mechanical completion.

These plants are each designed for the following outputs (ton/year):

Ammonia	297,000	(intermediate product) (technology by Halder Topsøe)
Urea	511,500	(finished product as fertilizer) (by Toyo)
Sulphur	6,600	(by-product) (by Toyo)

The feedstock for the process will be heavy fuel oil. Coal will be used for steam generation in a separate boiler plant.

A brief description of the gasification, ammonia synthesis, and urea synthesis processes is given in annex I.

I. FINDINGS

HIL piping design organization

During the expert's assignment HIL changed the organization of its piping design from a centralized piping design department to the task-force concept in which each project section has its own piping design and detail section. This organizational change disrupted for some time the collaboration with the piping design personnel. The expert's experience is that a centralized piping design section with a liaison piping designer attached to the project section gives better results. Possible reasons are:

(a) More efficient use can be made of the high calibre piping engineer;

(b) Greater manpower flexibility;

(c) Demand on higher qualified personnel is reduced;

(d) More incentives for promotion to higher grades within the piping section;

(e) Information and knowledge of piping work is centralised and more uniformly applied;

(f) Closer liaison can develop with other functional sections, i.e., vessels and instrumentation.

High pressure pipework for the ammonia and urea plants

The detail mechanical design of the high pressure pipework was carried out by HIL in close collaboration with the advisory staff of the plant licenser attached to HIL. The services of the expert were not utilised.

Collaboration in design

Specialist knowledge of other disciplines is not readily available and the collaboration normally associated with chemical plant design does not exist to the extent to be expected. The dispersal of staff in three buildings remote from each other militates against good collaboration.

Action on advice of expert

Following the expert's written advice on the urea plant P and I diagrams, there has been full collaboration between the process and operations staff and every effort has been made by them to implement his recommendations. One of the objectives of the project, development of proper P and I diagrams, has thereby to a considerable extent been fulfilled.

Advice provided

Advice was tendered to FIL personnel on the following subjects:

(a) Fire testing of ball valves;

(b) Installation in chemical plants of the correct materials as intended;

(c) Establishment within the organization of an information section;

(d) Guidance notes for FIL engineer visiting foreign contractor;

(e) Piping section check-list;

(f) Assessment of electric resistance welded tubing;

(g) Review and comments on proposed manual for inspection and expediting;

(h) Examination and comments with respect to drawings of steam piping;

(i) Comments following examination of ammonia plant P and I diagrams;

(j) Assessment of ball valve manufacturers' ([illegible] and [illegible]) works and products;

(k) Responsibilities of project piping personnel and preparation of design aid manuals;

(l) Layout of pipework associated with a compressor unit;

(m) Supporting of reboilers;

(n) Supplier of high pressure valves;

(o) Isolation of reformer catalyst tubes by nipping the transfer (pigtail) tubes (annex II);

(p) Comments following examination of urea plant P and I diagrams;

(q) Proposed action for preparation of high pressure piping standards;

(r) Welding of alloys for high temperature duties;

(s) Internal thermal insulation of vessels, furnaces and pipework;

(t) Design of high temperature/pressure tubing associated with gasification processes (annex III);

(u) Design of high pressure tubes and sketches of a particular standard submitted (annex IV).

Information concerning the following subjects was made available:

(a) Control problems on steam reforming plants of large integrated ammonia plants with complex steam systems;

(b) Vapouriser fouling problems;

(c) Selection of materials to resist potassium salt corrosion to reformer gas boilers;

(d) Performance of waste heat boilers in ammonia plants.

In addition, the expert was able to provide FIL with valuable information concerning the reliability of centrifugal pumps on urea plant carbamate duty.

[illegible] OF THE ADVICE PROVIDED

The expert's most important advice dealt with recommendations relating to plant safety:

(a) It was suggested that in a pressure let-down system there should be no possibility of over-pressurization of the lower pressure equipment. For example, in the removal of the condensed ammonia from a high pressure synthesis loop system to a low pressure flash tank, the liquid ammonia is collected in a catchpot at high pressure ([illegible]50 atm) and the level of ammonia liquid is controlled by level control instrumentation which allows the liquid ammonia to flow through a control valve to the low pressure flash vessel. From the flash vessel the liquid is flow-controlled to the storage vessel and the flashed ammonia gas is released under pressure control. The essential feature is that the flash vessel must have a relief valve to protect the vessel from over-pressurization and that this relief valve must be so sized as to take the full gas rate, should there be a failure of the level control system resulting in a complete loss of liquid ammonia from the high pressure catchpot and a gas breakthrough into the lower pressure flash vessel.

This design safeguard was brought to the attention of the plant licensors and it was later confirmed that the plant was safe in this respect.

(b) A number of instances were found of a high pressure system, [illegible]50 atm, being isolated from a low pressure system by a single high pressure valve. The risk here is that a leaking high pressure valve or maloperation of valves, i.e., closure of a downstream low pressure valve before the high pressure valve, could result in the over-pressurization of the lower pressure pipework. With the pressure differentials involved, failure of the low pressure equipment would be certain.

Following this advice, a change of specifications for certain pipelines and valves was being considered by EIL in collaboration with the plant licensors.

(c) It was stressed that extreme care is necessary to ensure the installation in chemical plants of the correct materials. In recent years a number of failures have occurred because of the mistaken installation of a wrong material, such as one plate of mild steel in a vessel which should have been completely of low alloy steel. The inspection requirements to meet this risk are considerable.

II. RECOMMENDATIONS

To improve experience and knowledge within the Company, EIL should make every endeavour to give the younger staff experience of plant construction and commissioning and, if possible, the opportunity to visit operating plants for discussions with operating and maintenance personnel.

An essential factor in the design of modern chemical plants is the close collaboration of many disciplines. If it is to be fully effective in chemical engineering consultancy and design, EIL should take all necessary steps to institute specialist services and to ensure their full involvement and collaboration in all aspects of the Company's design and consultancy service . The safety of plants should receive particular attention as it seems that some process licensers are securing more economic initial plant-cost by the erosion of safety considerations.

EIL now possesses the information and expertise to formulate standards for high pressure piping for ammonia and urea synthesis plants. A task-force should be formed for the preparation of such standards and the associated specifications. The collaboration of metallurgists, stress analysis specialists, and other disciplines is necessary and their participation in this work should be ensured.

After a trial period of the task-force concept as applied to piping design, EIL should reconsider the organization of its piping design organization. This would be more effective if all sections could be housed in one building.

The Company should review their internal communications so as to keep the staff fully informed of all the aids and expertise available.

Possibly the present task-forces will develop into separate divisions of the Company, but this is to take a very long-term view.

Annex I

BRIEF DESCRIPTION OF PROCESS FOR UREA FERTILIZER PLANTS

General

The ammonia plant will have a capacity of 900 tons per stream day and the urea plant will have a capacity of 1,550 tons per stream day of prilled urea. The annual on-stream factor for each plant will be 330 days.

Gasification

Heavy petroleum fractions are gasified in a continuous non-catalytic partial oxidation reactor under pressure and waste heat is recovered as high pressure steam. The carbon produced in the reaction is separated in the form of homogeneous carbon-oil slurry. The major proportion of this carbon is recycled and the remainder is burnt and the heat recovered. Two-stage Rectisol process is used for desulphurization and decarbonization of the raw gas. The decarbonized gas is then treated in a nitrogen wash unit to reduce the CO and CO_2 content to traces.

Ammonia synthesis

The purified synthesis gas is compressed to 200 to 210 kg/cm^2 gauge pressure by a centrifugal gas compressor driven by a steam turbine.

The ammonia synthesis plant is of Haldor Topsøe design and uses their design of quench type ammonia synthesis converter.

The coupling joints used for the loop pipework are ASA 2500 lb with metal ring type gaskets.

Urea synthesis

The urea plant is designed by Toyo Engineering Corporation of Japan and produces prilled urea by the total recycle process using anhydrous liquid ammonia and by-product carbon-dioxide from the ammonia plant.

The synthesis section includes CO_2 compressor, liquid ammonia feed pumps, liquid ammonia preheater and a urea synthesis reactor.

The operating condition in the reactor is 250 kg/cm^2 gauge pressure at a temperature of 200°C.

The coupling joints for the urea synthesis loop pipework are a special Toyo trapped joint design.

Annex II

ISOLATION OF REFORMER CATALYST TUBE BY NIPPING OF THE TRANSFER (PIGTAIL) TUBES

The object is to isolate a catalyst tube that has failed in some manner - either by the failure of a butt weld or a longitudinal split.

The failed tube has to be correctly identified and the exit and inlet pigtails nipped to stop the gas escaping from the tube into the furnace chamber.

It is imperative that a failed tube should be discovered as early as possible to avoid consequential damage to adjacent tubes or furnace walls by the flame from the damaged tube.

The failed tube must be correctly identified, otherwise the wrong tube may be isolated and ruined.

An absolute isolation is not always obtained, but almost always enough to enable the plant to be kept on stream without loss or further damage.

Identification of a failed tube

The following symptoms and action may assist in identifying a failed tube:

Reduction in the gas exit temperature of the failed tube

A sharp blue pencil of flame from the failure

Local overheating of other tubes in the vicinity of the failure

Incondensant brickwork adjacent to the failed tube

A different noise level as picked up by ultrasonic leak detection equipment applied to the top flanges of the catalyst tubes

Use of an infra-red camera to pick up the flame from the leak

Appearance or change in the appearance of the failed tube

Significant change in the length of the catalyst tube as compared with the other tubes and indicated by the position of the top or bottom flanges, depending upon the method of tube suspension

The process foreman should be responsible for the identification of the failed tube and should be assisted in this task by the duty or plant engineer.

Normal practice is to nip the bottom gas exit pigtail tubes first because nipping the inlet tubes first would reduce the gas flow and the tube temperature, making the nip harder to accomplish on the exit pigtail.

Inlet gas pigtail tubes

Inlet gas pigtail tubes are comparatively cool and their nipping is a fairly simple task. Essential is that the tube material will withstand the nipping operation without cracking. For this reason the tubes should be of a fairly ductile steel. Tubes of ordinary carbon steel are subject to cracking when nipped.

Exit gas pigtail tubes

A normal operating temperature for the tubes is about 850°C. The tubes must be in a nippable condition. That is, there must not be excessive carbonisation and the diametrial growth must be within set limits.

It is not possible to measure the carburization when the plant is on line. When the plant is shut down and cool, the degree of carburization may be measured by an "Elcometer". If it is assessed that the tube will be over-carburised before the next scheduled plant shut down, the pigtail tube should be replaced.

The diametral growth of the tube may be checked when the plant is operating at the time of catalyst tube failure. This may be done by means of a go no-go gauge.

The limit applied to Incoloy 800 tubes is a maximum diametral growth of 2½ to 3 per cent. A record should be kept of the initial outside diameter of each tube. If a tube at any time exceeds the allowable growth, it should be replaced.

Location of nip

If possible the tube should be nippled at a point which will leave space for a further nip, should the first nip be unsuccessful. Allowance for the second nip should be on the pressure side of the first nip; i.e. related to normal flow - inlet pigtail upstream - outlet pigtail downstream.

Degree of nip

The amount of nip may be determined by using wedge gauges to measure the distance between the clamp plates of the nipping tool.

Care must be taken to avoid shearing the tube completely.

A later design of tool for the nipping of close-spaced tubes which are in a hot environment has a stop incorporated to prevent over-nipping.

It should be noted that, according to ASTM B407, a $1\frac{1}{4}$" nom. bore Sch. 160 Incoloy 800 tube may have the following manufacturing tolerances:

	Nominal	Maximum	Minimum
Wall thickness	0.25	0.275	0.225
Tube outside diameter	1.66	1.67	1.65

Safety:

Under no circumstances should any attempt be made to bend pigtails which have been nipped.

The person delegated to examine the nip should have available a heat-resistant, air-cooled suit which should be worn if circumstances dictate.

General

ICI Agricultural Division Ltd has developed nipping tools which, together with a detailed description of the procedure, are available from them.

At the furnace design stage the number and location of the sight-holes provided in the furnace chamber casing need very careful consideration in relation to the identification of failed catalyst tubes.

Annex III

THE DESIGN OF PIPEWORK FOR HIGH TEMPERATURE/PRESSURE DUTY

Design method

This design method has been used for the design of reformer catalyst tubes, hot gas exit pipes from the catalyst tubes, i.e. exit transfer or pigtail tubes, and of the gas-collecting manifold tubes. It can be applied to tubing required to operate in the creep stress range.

The main aspects to be considered in designing high temperature pipework is the strength in the creep range, resistance to degradation by the environment and the weldability of the material.

Strength factor

The strength factor usually adopted is the strength to rupture in 100,000 hours. This stress to rupture may be obtained from the data provided by the material manufacturer or from the calculated Larson-Miller parameter and the Larson-Miller diagram curve for the particular material.

The allowable safe design stress is then obtained by applying a suitable safety factor and the wall thickness calculated by the use of the mean diameter formula.

An extra thickness is allowed for carburization/oxidization if considered necessary.

The detailed procedure is as follows

A. Obtain the stress to rupture in 100,000 hours

(i) from the manufacturers' data, or

(ii) calculate the Larson-Miller parameter from the formula

$$P = 10^{-3} \times T\,(C + \log_{10} N)$$

where P = Larson-Miller parameter

C = constant

T = maximum tube wall temperature (K)

N = design life in hours

For general use C = 15

and N = 100,000 hours

B. From the Larson-Miller diagram find the mean rupture stress (fr) relating to the parameter (P) calculated.

<u>Note</u>: Since the graph covers a range of readings for each parameter, the mean value of the curve is suggested and an over-all safety factor adopted for each duty as below.

C. Apply a safety factor to give the allowable design stress (fs) as follows:

Allowable design stress (fs) = rupture stress (fr) x safety factor. For the duties indicated the writer suggests the following safety factors:

Reformer catalyst tubes	0.8
Pigtail (transfer) tubes	0.8
Headers or manifolds	0.6

D. Use the mean diameter formula to calculate the required wall thickness given the outside diameter of tube:

$$fs = \frac{p\,(do - t)}{2t}$$

$$t = \frac{p\;do}{2\,(fs + 0.5p)}$$

given the inside diameter of tube

$$fs = \frac{p\,(di + t)}{2t}$$

which gives

$$t = \frac{p\;di}{2\,(fs - 0.5p)}$$

where

fs = allowable design stress
p = internal gas pressure
t = wall thickness
di = tube inside diameter
do = tube outside diameter

<u>Resistance to degradation</u>

For reformer catalyst tubes and header manifolds an additional thickness should be added to allow for the carburisation/oxidation, say 3/32 in. or 1/8 in. or 1/8 in. extra.

Note this calculation is based on the tangential stress due to the internal gas pressure. The tubes are generally supported so that the longitudinal stress is very low in comparison with the tangential stress.

In a reformer tube, degradation of the metal always begins on the process side and is initiated by carburization, i.e. diffusion into combination with the metal, giving a structure more readily oxidized by steam. Because of the carburisation oxidisation effect, the practical operating limit for H K 40 material was considered to be about 960°C. Further operating experience may now indicate that this figure may be increased.

The practice in the writer's experience was that all spun cast reformer tubes were internally machined. With reference to ethylene furnaces an experimental furnace has confirmed that bore-machined tubes were much less affected by carburisation than as-cast bores.

The transfer tubes on many reformers are designed to take considerable differential thermal expansion between the catalyst tube and the gas collecting manifold. For this reason they may be long and bent to suit a particular shape so as to secure flexibility, access, and reasonable compactness. This explains the term "pigtail" tube used by some companies.

These transfer tubes require a fair amount of flexibility. If the policy of design and operation is to nip the transfer tube to isolate a catalyst tube, the transfer tube requires to be maintained in a nippable condition. This means that when the tube material has been carburised to a certain extent or diametrical growth has exceeded a pre-determined amount, the tube is replaced by a new tube. The transfer tubes therefore have a fairly short life and it is not necessary to add very much additional thickness, if any, to the tube wall thickness for carburisation/oxidation allowance.

Weldability

The internal machining of the spun cast tubes removes the porosity in the surface metal of the cast bore. It also permits a more thorough examination of the casting material throughout the length of the tube. If porosity exists after the bore is machined to size, the acceptance of the tube is doubtful.

The tendency of catalyst to bridge across the tube and form empty packets within catalyst-bed is also reduced if the tubes are bore-machined.

The information available to the writer indicated the following:

Alloys of the HP (25/35 Cr-Ni) type although more difficult to weld than HK 40 can be welded up to 1 in. in thickness. Alloys with higher alloy contents, like supertherm and NA-22-H, can be welded with difficulty up to 3/4 in. thickness. Thicker tubes may be unweldable. Information concerning welding should be sought before proceeding with the use of these alloys.

The information obtained from some tube-makers and engineering contractors should be treated with reserve. If possible, information should be obtained from plant operators. They are more likely to be able to give factual information about the material under service conditions. The information supplied by Henry Wiggins of the United Kingdom (Huntingdon Alloys of the United States) relating to Incoloy 800 stresses to rupture is an example of the data supplied by the manufacturers which may be used subject to the application of the requisite safety factor and possible carburisation allowance.

With reference to reformer gas exit manifolds, the design should take cognizance of the multiplicity of branches for connecting transfer or pigtail tubes and ensure that the material removed for these branches is adequately compensated.

It is a wise precaution to provide excess metal in the manifold socket branches, to which the transfer tubes are welded, so that when replacement of the transfer tubes is necessary the carburised metal may be cut away leaving sufficient sound metal for welding requirements.

Sample calculation

The following calculation and diagram for 25/20 Cr-Ni are from "A time-temperature relationship to rupture and creep stresses" by F.R. Larson and J. Miller, Trans.ASME, July 1952, (page 765).

Reformer catalyst tube - material 25/20 Cr-Ni

A. (i) Information supplied:

Operating pressure = 300 lbs/in.^{2}
Maximum tube wall temperature = 900°C
Design life = 100,000 hours
Internal diameter (machined) = 4 in.
Safety factor = 0.8 Carburisation allowance = 1/8 in.

(ii) Calculate Larson-Miller parameter (P):

$$P = 10^{-3} \times T\,(C + \log_{10} H) \qquad T = 900 + 273 = 1173\ K$$

$$= \frac{1173\,(15 + 5)}{1000} \qquad C\text{-constant} = 15$$

$$= 23.46 \qquad H = 100,000$$

B. From Larson-Miller diagram:

From P = 23.46 the rupture stress = 2200 lbs/in^2

C. Allowable design stress = 0.8 x 2200 = 1760 lbs/in^2

D. Wall thickness $t = \frac{p\ d}{2\,(S_d - 0.5p)}$

$$t = \frac{300 \times 4}{2(1760 - 0.5 \times 300)}$$

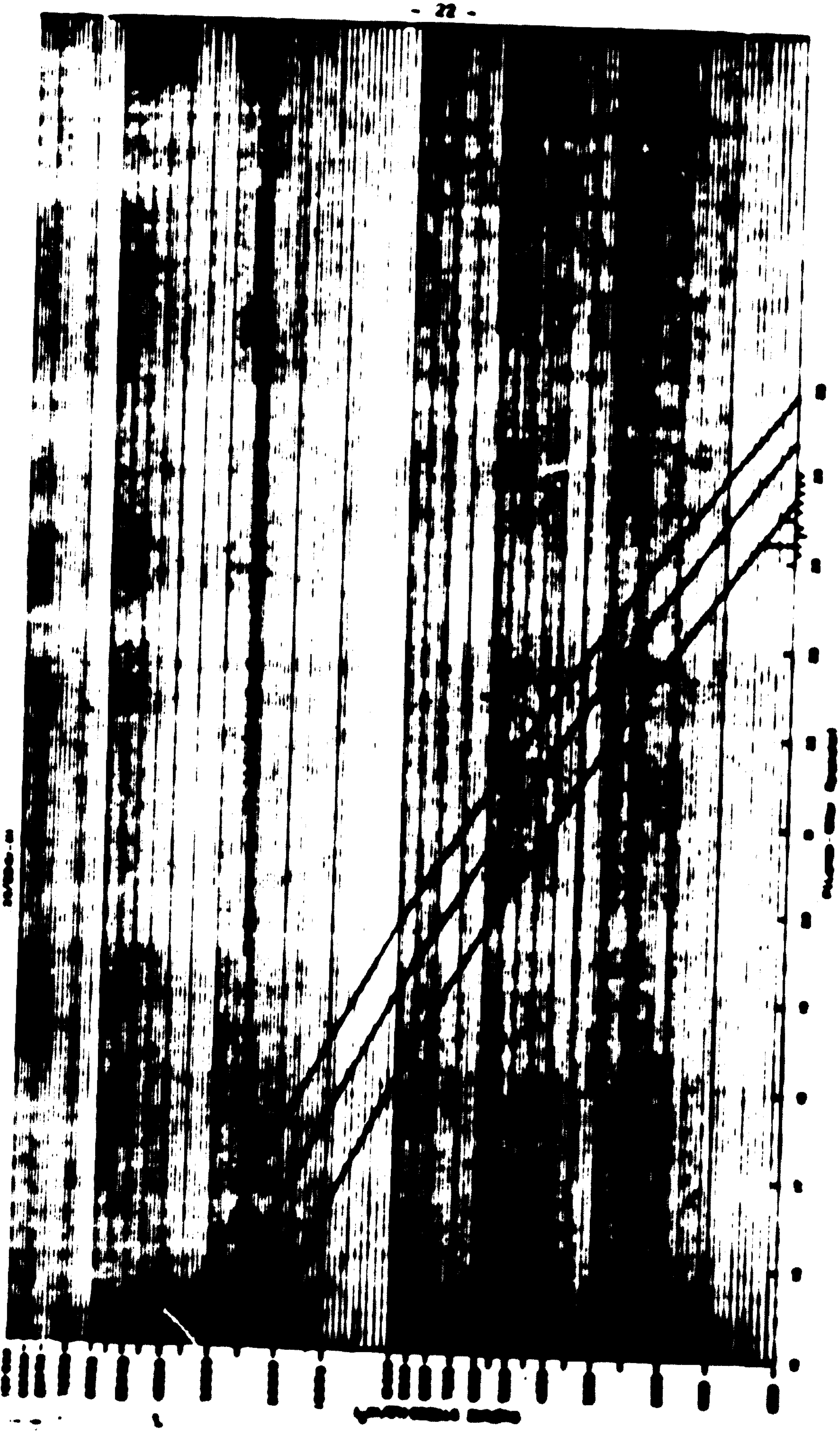
$$= \frac{1200}{2(1760-150)} = \frac{1200}{3220}$$

$$t = 0.372 \text{ in.}$$

Allowing for carburization

$$t = 0.372 + 0.125 = 0.497 \text{ in.}$$

A nominal wall thickness of 0.5 in. is therefore the minimum sound wall thickness for the tube as installed.



Annex II

STANDARDS FOR HIGH PRESSURE PIPING

EIL do not possess piping standards for the high pressure pipework associated with the urea synthesis or the ammonia synthesis above the range of the American A.S.A. standards, but they have in their possession standard drawings supplied by licensors for urea synthesis plants. The pressure temperature duty of the present stage ammonia plants use the 2,500 lb A.S.A. standards.

It was suggested to EIL that they should establish a small study group to consider general policy with regard to high pressure pipework standardization and that the following points may be relevant:

Assessment of the possible requirements of EIL
Assessment of information available
Consideration of the alternative designs
Consideration of the economics of the various alternatives
Evaluation of the previous operating experiences
Decision on the pressure ranges to be standardised

Following the study group recommendations, assessment of priorities, preparation of workload programmes, and management approval, it was further suggested that a task-force should be formed to carry out the complete design and preparation of the standards and the associated specifications. The following aspects were given for consideration in the selection of the type of joint and coupling:

Experience in similar duties
Reliability of seal
Safety - possible failure and extent
Overall simplicity
Resistance to temperature variations
Required coupling bolt loading, i.e. bolt stress
Required degree of skill to make joints
Ease of uncoupling joints

Acceptance of piping misalignment

Adoption for acceptance of fittings, such as orifice plates

Welding requirements

Availability of matching equipment, valves etc.

Comparison of costs

Avoidance of proliferation of standards

Spares requirements

Supplies indigenous to India

Acceptability of mating flanges of dissimilar materials

Weight of joint assembly and corresponding tube

Overall flexibility

Lining up of flanges

Required accessibility for a flanged joint

Resistance to vibration

Required accuracy of machining

The recommendation given verbally was to standardise the lens ring type joint.

Determination of tube thickness

It was suggested that the design methods based on the Lamé formulae be adopted as given in "High Pressure Engineering" by Manning and Labrow. A copy of this book is in the HIL library. (Mr. S. Labrow was my colleague at Imperial Chemical Industries (ICI) in England and responsible for a great deal of the ICI Design (Stress) Manual.)

The following standards for high pressure pipework lens ring joints and couplings were made available to HIL for their guidance and copies are attached (see appendix).

Std. No.	Pages	Description	Pressure (atm)	Temp. Range
6050	2	Carbon steel flanged pipe joints 2 in. to 6 in. nom. bore	320 to 325	35° to 200°C
6055	2	Carbon steel flanged pipe joints with clearance for socket spanners 2 in. to 6 in. nom. bore	300	35° to 200°C
6060	2	Carbon steel flanged pipe joints connecting 3 per cent Cr. steel hot pipeline to carbon steel pipeline (300°C max.) 2 in. to 5 in. nom. bore	300 to 345	-

Std. No.	Pages	Description	Press. (atm)	Temp. range
6075	2	Carbon steel flanged pipe joints 1/16 in. to [illegible] in. nom. bore	410 to 57[illegible]	[illegible]
6078	2	Carbon steel flanged pipe joints connecting 3 per cent cr. steel hot pipeline to carbon steel pipeline 200°C max. 1½ in. to 5 in. nom. bore	410 to 435	
6080	2	Carbon steel flanged pipe joints with clearance for socket spanners 1/16 in. to 4½ in. nom. bore	300	35° to 200°C
6115	2	Flanged pipe joints - 3 per cent cr. steel 1/16 in. to 5 in. nom. bore	-	[illegible]°C
6120	2	3 per cent cr. steel flanged pipe joints with clearance for socket spanners 1/16 in. to 5 in. nom. bore	-	300°C
6212	2	Pipe coupling screwed carbon steel 1/16 in. to 3/8 in. nom. bore	495	200°C

These or similar standards have been used successfully over a period of many years for ammonia synthesis plant pipework.

The information now available to HEL is sufficient for them to prepare the required standards. It was emphasised that time and effort are required to standardise each range of pipework and associated equipment, such as valves and instruments. The collaboration of many disciplines is required.

Furthermore a copy of a catalogue of proprietary joint fittings (Grayloc) was handed to HEL. This type of joint ring in combination with A.S.A. flanges is now used by ICI. The benefit is that a Class 1,500 flange is used on a Class 2,500 duty and the bolt loading is quite low.

A copy was obtained from British Engines Ltd, of Newcastle upon Tyne, of its catalogue of high pressure valves and submitted to HEL with the suggestion that these valves could be used as one of their standards for high pressure equipment. Such valves are used by ICI for many high pressure applications.

CARBON STEEL
FLANGED PIPE JOINTS

[illegible]
[illegible] TEMPERATURE RANGE

DB	6050

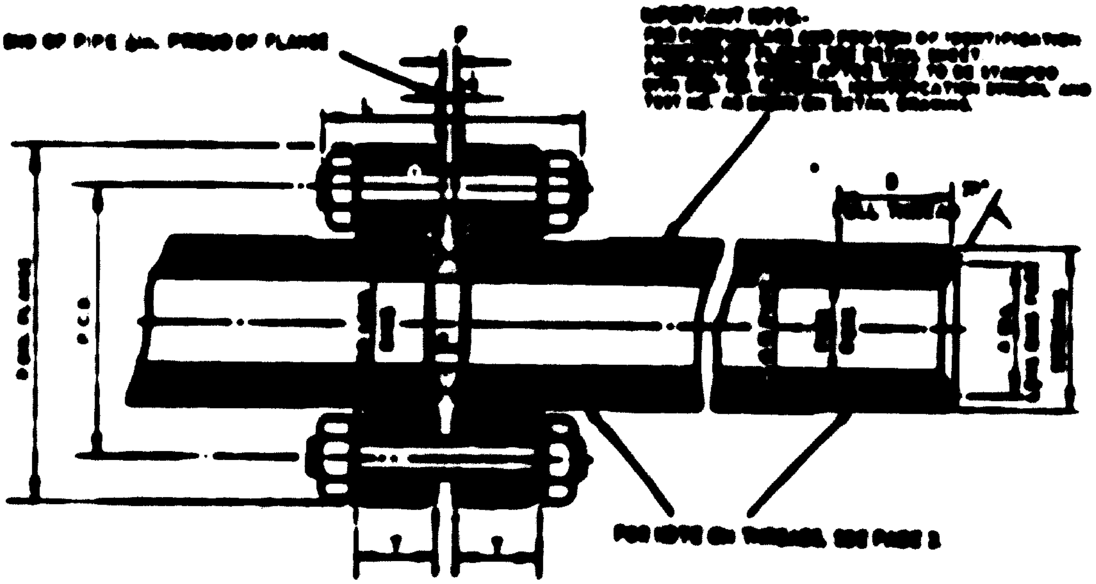
[illegible] 1 [illegible]
[illegible] DATE [illegible]
[illegible] DATE

[illegible]

GENERAL REFERENCES

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
STUD BOLTS	[illegible]

[illegible]



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ALL DIMENSIONS IN INCHES

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									[illegible]	[illegible]	[illegible]						[illegible]	[illegible]
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4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
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[illegible]

DB	[illegible]
	6050
PAGE [illegible] OF [illegible]	
[illegible] NO 7 DATE [illegible]	
[illegible] NO DATE	

PIPE THREADS - [illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]	[illegible]		
	[illegible]		FLANGE
	PLAIN	[illegible]	
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]	STUD BOLTS	
2	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]

CARBON STEEL
FLANGED PIPE JOINTS

[illegible]
[illegible] DESIGN PRESSURE
[illegible] 20°C TO 200°C TEMPERATURE RANGE
2 in TO 8 in [illegible] SIZES

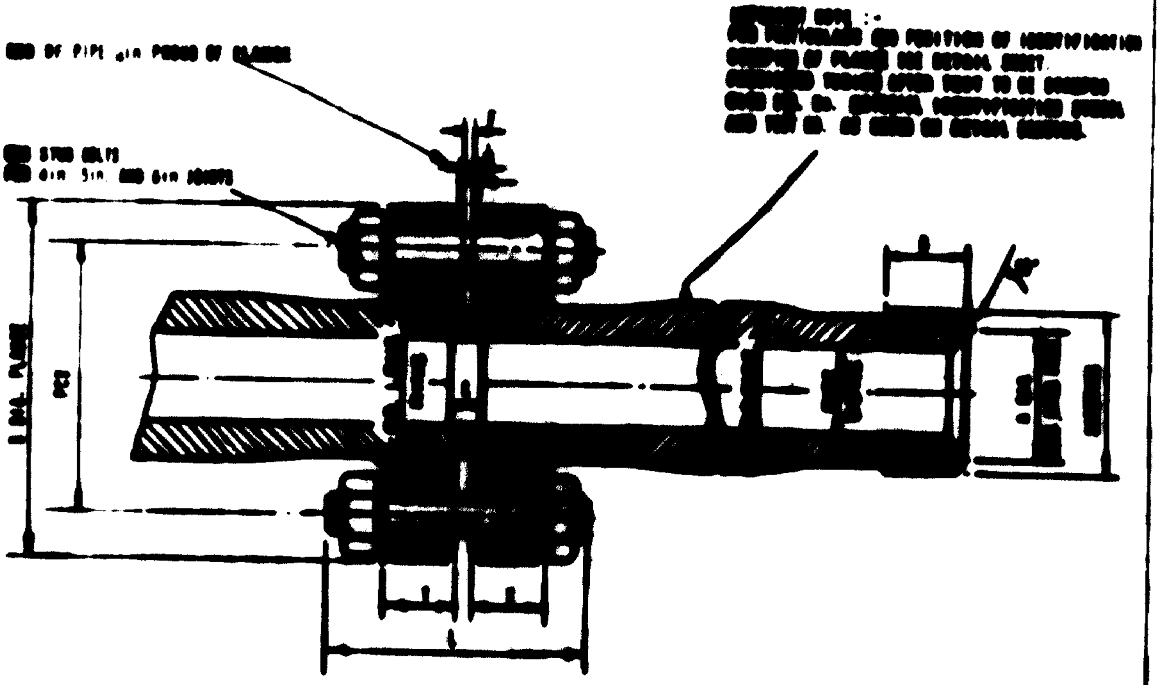
DB	[illegible]
	6055
PAGE 1 OF 2	
[illegible] ISSUE NO. 2	DATE [illegible]
DIV ISSUE NO.	DATE

GENERAL REFERENCES — SPECN. [illegible]

TUBES	[illegible] 3700
FLANGES	[illegible]
[illegible]	[illegible]
STUD BOLTS	[illegible] 0589

[illegible] HYDRAULIC TEST [illegible]. [illegible]

ALL DIMENSIONS IN INCHES



[illegible]

FOR CODE OR REF. NOS. AND AGRICULTURAL DIV. REF. NOS. SEE PAGE 2.

[illegible]	O.D.	A	B	F	PIPE [illegible]		D	T	No.	DIA.	PCD	DIA.	L	O.D.	C	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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THIS SHEET WILL BE KEPT UP-TO-DATE ONLY WHEN ISSUED TO A REGISTERED ICI STANDARDS BOOK. LOOSE COPIES WILL NOT BE KEPT UP-TO-DATE.

	[illegible]
DB	6055

PAGE 1 OF 1

HQ ISSUE NO 1 DATE [illegible] 70

DIV ISSUE NO DATE

A. DIMENSIONS IN INCHES

PIPE THREADS FOR NOMINAL BORE SIZES 2IN TO 6IN INCLUSIVE, SCREW THREADS TO CONFORM TO B.S.84 WHIT.S. MEDIUM CLASS GAUGED TO B.S.919.

[illegible]	[illegible]					
	[illegible]					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	STUD BOLTS
2						
3						
4						
5						
6						

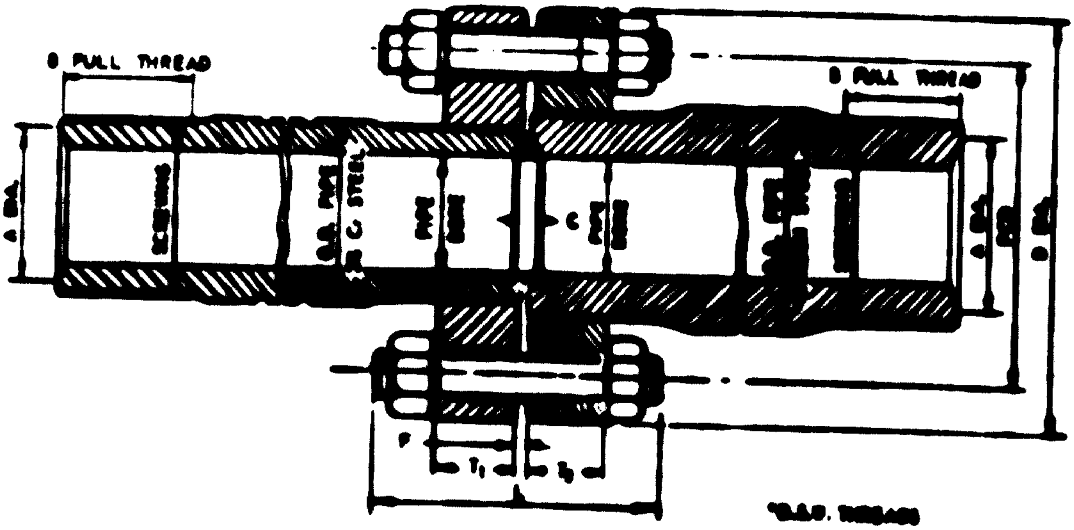
CARBON STEEL
FLANGED PIPE JOINTS

[illegible] DESIGN PRESSURE
CONNECTING [illegible] C STEEL HOT PIPELINE TO
CARBON STEEL PIPELINE. [illegible]°C MAX. TEMP.

[illegible] REFERENCE
DB 6060
PAGE 1 OF 2
[illegible] ISSUE NO [illegible] DATE [illegible]
[illegible] ISSUE NO [illegible] DATE [illegible]

GENERAL REFERENCES

PIPE [illegible] C STEEL	[illegible]
PIPE CARBON STEEL	[illegible]
FLANGES	[illegible]
[illegible]	[illegible]
STUD BOLTS	[illegible]



*B.S.P. THREADS

ALL DIMENSIONS IN INCHES

NOM. BORE	F	[illegible] C STEEL PIPE					CARBON STEEL PIPE					FLANGE					
		O.D.	A	B	PIPE SCREWING		O.D.	A	B	PIPE SCREWING		D	T1	T2	BOLT HOLES		
					DIA.	TPI*				DIA.	TPI*				NO.	DIA.	PCD
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]
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NOM. BORE	STUD BOLTS		LENS RING	
	DIA.	L	DIA.	C
2	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible] I.C.I. AGRICULTURAL [illegible] I.C.I. [illegible]

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DB	**6060**
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CARBON STEEL
FLANGED PIPE JOINTS

400 TO 570 atm. DESIGN PRESSURE
MINUS 30°C. TO 200°C. TEMPERATURE RANGE

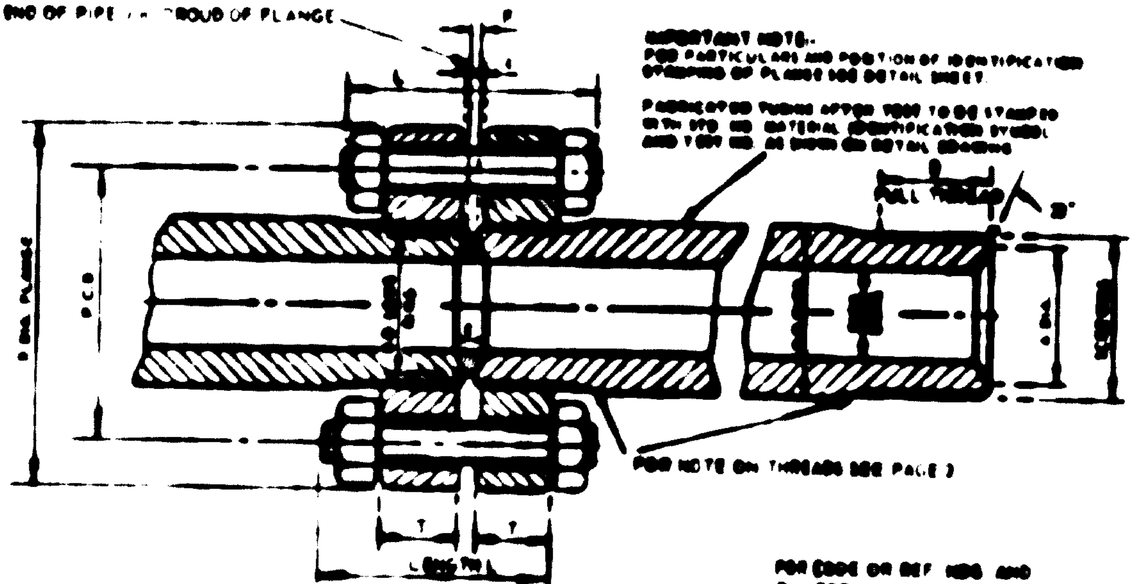
ICI REFERENCE	
DB	6075
PAGE 1 OF 2	
ICI ISSUE NO 10	DATE DEC 70
DIV ISSUE NO	DATE

FORMERLY D430

GENERAL REFERENCES

TUBES	DB 5765
FLANGES	DB 5915
LENS RING	DB 6235
STUD BOLTS	DB 0509

NOTE: FOR DESIGN, [illegible] ATTAINABLE AND HYDRAULIC TEST PRESSURES SEE TABLE.
FOR DETAILS OF ITEMS WITH 10/10 [illegible] TIPPED LENS RING FACES SEE AGRICULTURAL DIVISION STANDARDS [illegible]



IMPORTANT NOTE:-
FOR PARTICULARS AND POSITION OF IDENTIFICATION STAMPING OF FLANGE SEE DETAIL SHEET.

FABRICATED TUBING AFTER TEST TO BE STAMPED WITH STD. NO. MATERIAL IDENTIFICATION SYMBOL AND TEST NO. AS SHOWN ON DETAIL DRAWING.

FOR NOTE ON THREADS SEE PAGE 2

FOR CODE OR REF. NOS. AND DIV REF. DRGS. SEE PAGE 2

FOR PLANTS UNDER THE CONTROL OF [illegible] DIVISION OPERATING AT [illegible] PRESSURE AND TEMPERATURE CONDITIONS OF [illegible] atm. [illegible] THE STANDARD HYDRAULIC TEST PRESSURE APPLIED WILL BE [illegible] atm., IF OPERATING CONDITIONS IN EXCESS OF [illegible] atm. [illegible] FOR THIS STANDARD ARE REQUIRED, SPECIAL ARRANGEMENTS MUST BE MADE FOR THE [illegible] HYDRAULIC TESTING.

ALL DIMENSIONS IN INCHES

CARBON STEEL PIPE							CARBON STEEL FLANGE					STUD BOLTS		LENS RING		TEST PRESSURE atm.		
NOM. BORE	O.D.	A	B	P	PIPE SCHEDULE		D	T	BOLT HOLES			DIA.	L	O.D.	C	DESIGN	[illegible]	
									NO.	DIA.	P.C.D.						[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	570	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
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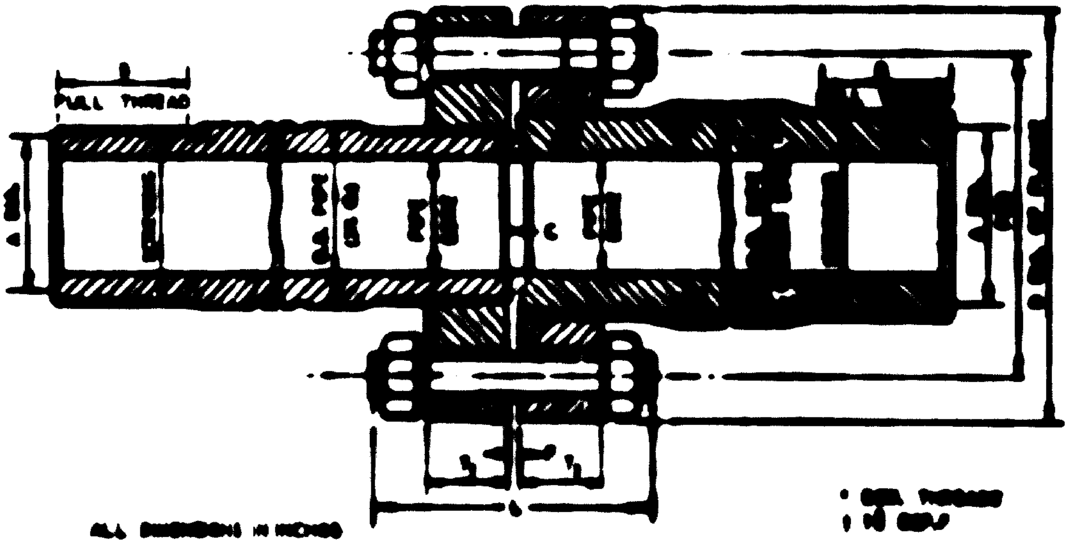
CARBON STEEL
FLANGED PIPE JOINTS

[illegible] DESIGN PRESSURE
CONNECTING [illegible] Cr STEEL HOT PIPELINE TO
CARBON STEEL PIPELINE. [illegible]°C MAX. TEMP.

DB 6078

GENERAL REFERENCES

[illegible] Cr. STEEL	[illegible]
[illegible] CARBON STEEL	[illegible]
FLANGES	[illegible]
[illegible]	[illegible]
STUD BOLTS	[illegible]



ALL DIMENSIONS IN INCHES

[illegible]	P	[illegible] Cr STEEL PIPE					CARBON STEEL PIPE					FLANGE					
		O.D.	A	B	PIPE SCHEDULE		O.D.	A	B	PIPE SCHEDULE		D	T1	T2	BOLT HOLES		
					[illegible]	[illegible]				[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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DB 6078

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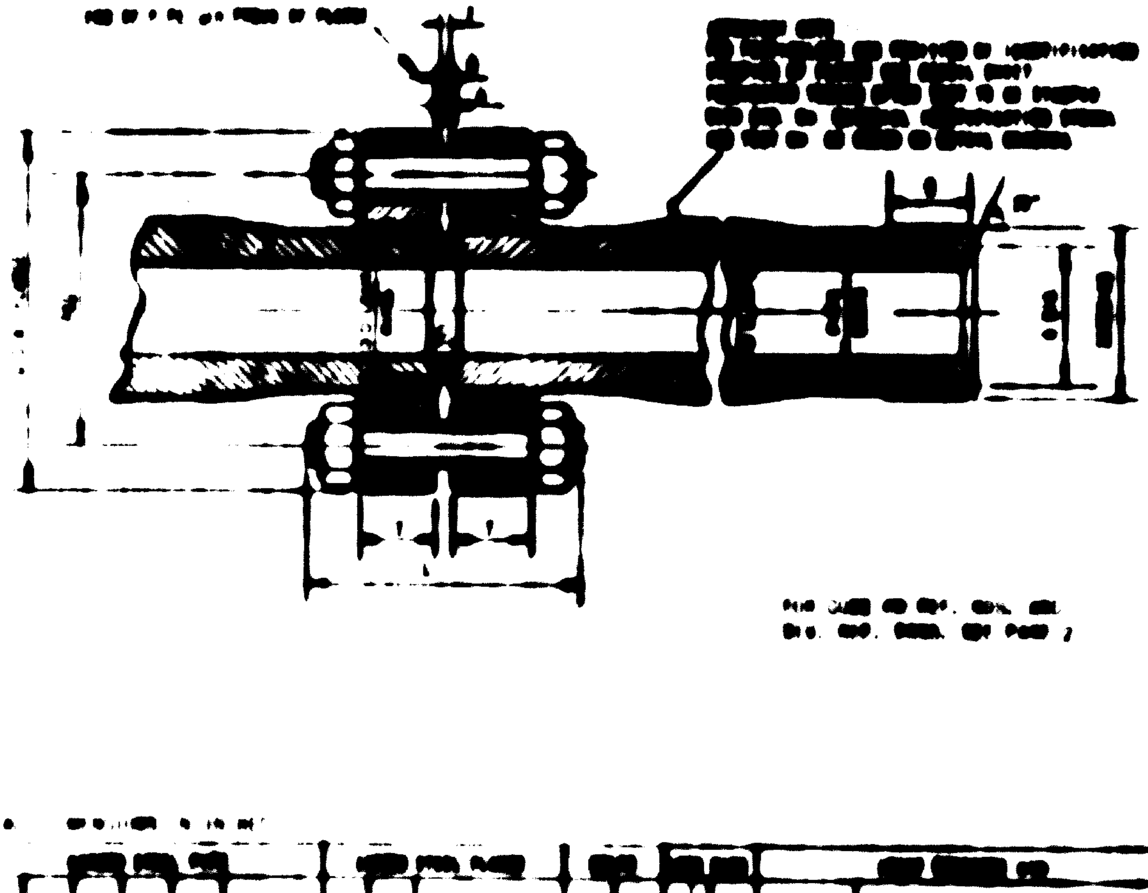
CARBON STEEL FLANGED PIPE JOINTS

DB 6080



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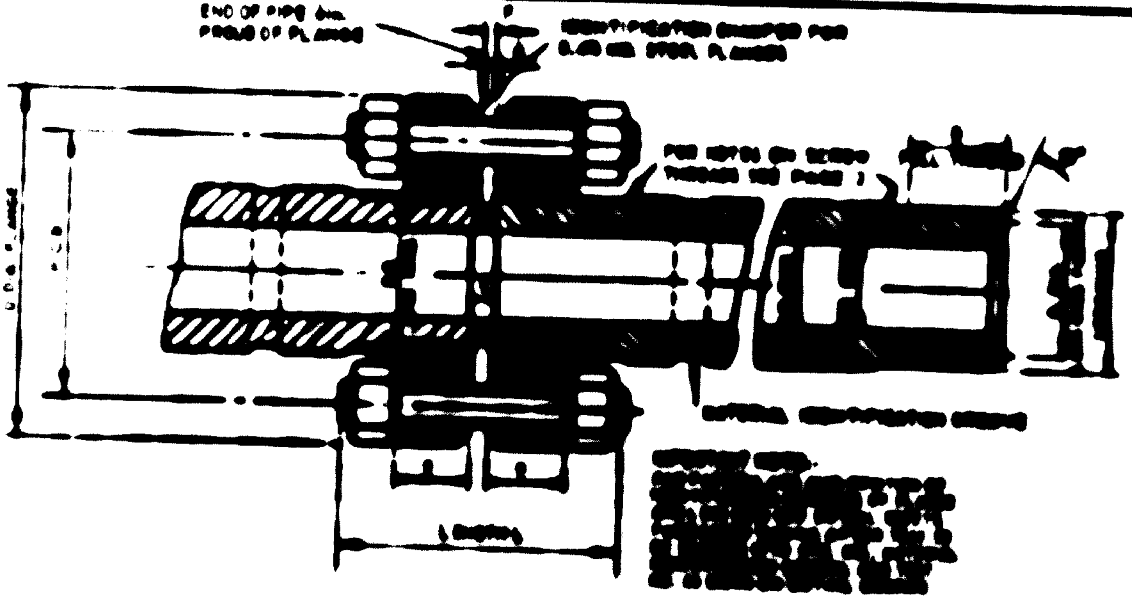
FLANGED PIPE JOINTS — [illegible] Cr. STEEL

[illegible]

DB 6115



[illegible]

[illegible]	[illegible]		
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[illegible]

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[illegible]	[illegible]
[illegible]	[illegible]
PAGE 1 OF [illegible]	

SPECIAL [illegible]

[illegible] SHEET

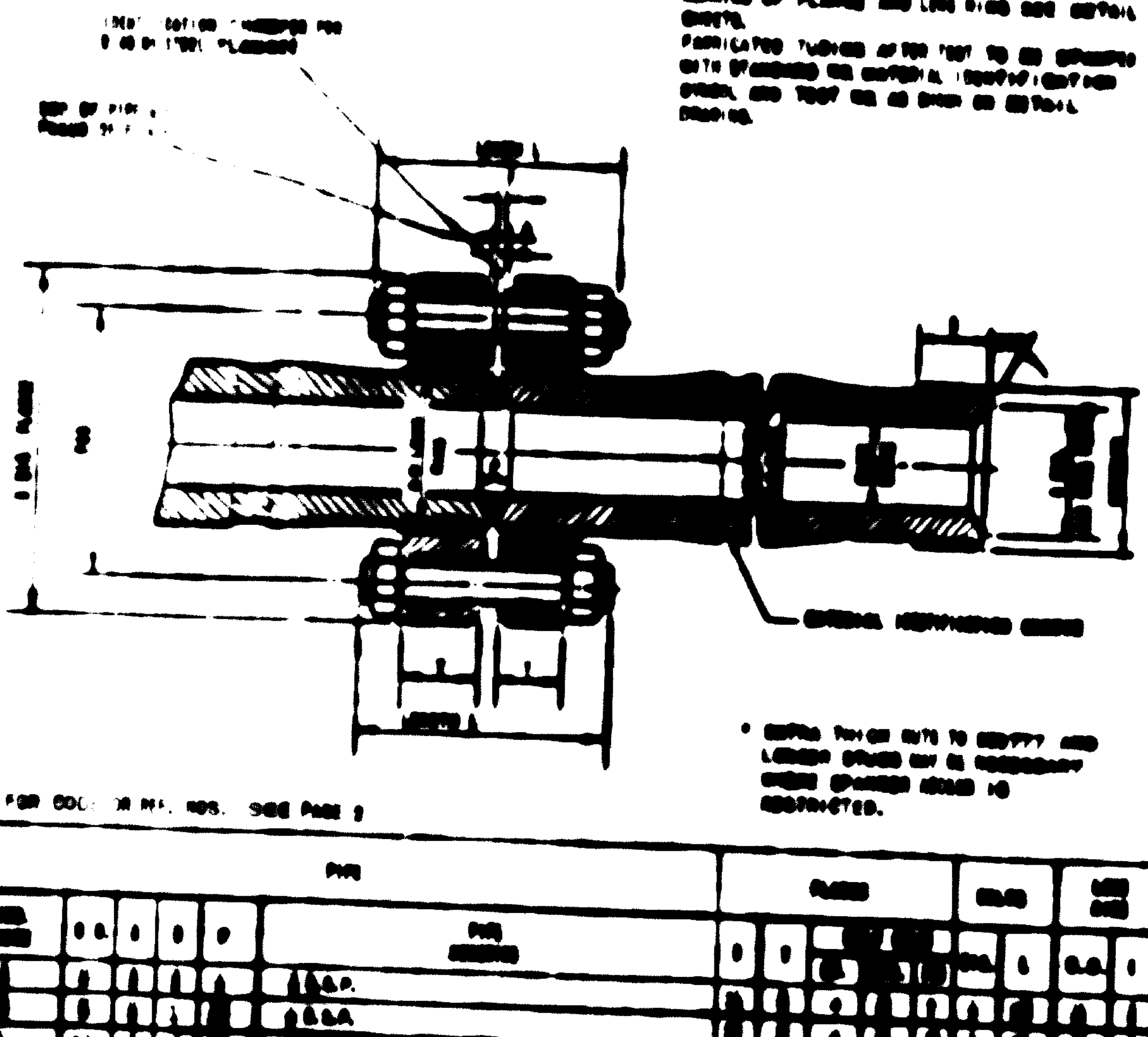
[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

NOTE:- [illegible]

ALL DIMENSIONS IN INCHES

IMPORTANT NOTE.-
FOR PARTICULARS AND POSITION OF IDENTIFICATION MARKINGS OF FLANGES AND LENS RINGS SEE DETAIL SHEETS.
FABRICATED TUBING AFTER TEST TO BE STAMPED WITH [illegible] MATERIAL IDENTIFICATION SYMBOL AND TEST [illegible] AS SHOWN ON DETAIL DRAWING.



* EXTRA THICK NUTS TO IDENTIFY AND LONGER STUDS MAY BE NECESSARY WHERE SPANNER ROOM IS RESTRICTED.

FOR DOC. [illegible] REF. NOS. SEE PAGE 2

PIPE						FLANGE						[illegible]		[illegible]	
[illegible]	O.D.	[illegible]	[illegible]	[illegible]	PIPE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DIA.	[illegible]	O.D.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] B.S.P.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] DIA. [illegible] T.P.I.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] DIA. [illegible] T.P.I.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] DIA.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] DIA.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	I.C.A. [illegible]		
	[illegible]	[illegible]	
PAGE 1 OF 1			
I.C.A. [illegible]			
[illegible]			
[illegible]			

[illegible] STEEL FLANGED PIPE JOINTS

[illegible]

[illegible]

[illegible] [illegible]

[illegible]

GENERAL REFERENCES

THREADS: FOR NOMINAL BORE SIZES [illegible] TO [illegible] INCLUSIVE SCREW THREADS B.S.P.F.
TO CONFORM TO B.S. [illegible] MEDIUM CLASS GAUGED TO B.S. [illegible]
FOR NOMINAL BORE SIZES [illegible] AND OVER SCREW THREADS TO
CONFORM TO B.S. [illegible] WHIT.S. MEDIUM CLASS GAUGED TO B.S. 919.

[illegible] [illegible]

[illegible]	[illegible]			
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PIPE COUPLING SCREWED

CARBON STEEL, BILLINGHAM DESIGN [illegible] atm

DIVISION	I.C.I. REFERENCE	
	DB	6212
PAGE 1 OF 2		
I.C.I. ISSUE NO. [illegible] DATE [illegible]		
DIV. ISSUE NO. DATE		
REF. DRG.		

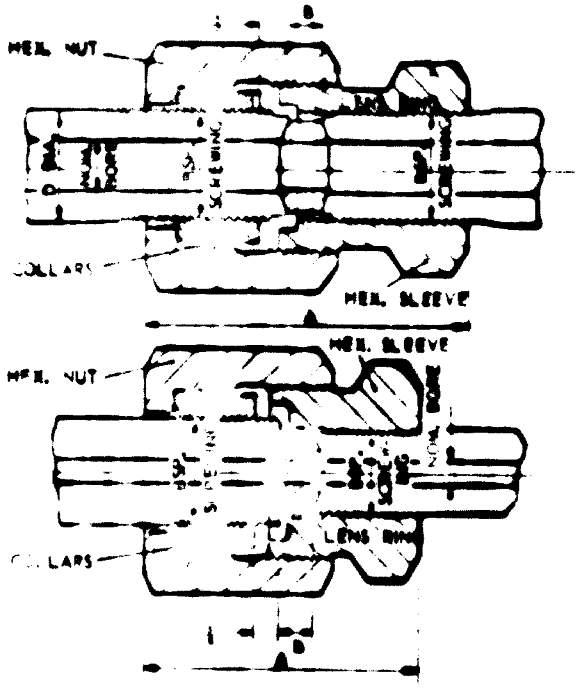
SPECN. B.S.970 En 3A, En 3B OR En 4

INFN. SHEET

GENERAL REFERENCES

NOTE - MAXIMUM ATTAINABLE PRESSURE OF ASSEMBLED COUPLINGS WITH ASSOCIATED PIPES:- [illegible] atm
HYDRAULIC TEST PRESSURE:- [illegible] atm
MAXIMUM ALLOWABLE TEMPERATURE:- [illegible]°C

ALL DIMENSIONS IN INCHES



FITTING SCREWED
[illegible] in BSP.F x [illegible] in LONG

FOR COUPLING COMPONENTS, NUT, COLLARS AND SLEEVE DETAILS SEE PAGE 2

NOTES REGARDING THE ASSEMBLY OF ALL COUPLINGS

SLEEVE TO BE SCREWED BACK ON PIPE UNTIL ITS FRONT FACE IS FLUSH WITH LENS RING AS SHOWN.

TWO COLLARS TO BE SCREWED HARD AGAINST EACH OTHER LEAVING [illegible] in GAP AT THE END OF THE PIPE OR FITTING AS SHOWN.

[illegible] in N.B. H.P. TUBE TO [illegible] DESIGN TO BE SCREWED [illegible] in BSP.F x [illegible] in LONG. TWO END THREADS REMOVED. TUBE END FACED FOR LENS RING.

[illegible] in N.B. H.P. TUBE TO [illegible] DESIGN TO BE SCREWED [illegible] in BSP.F x 1[illegible] in LONG. TWO END THREADS REMOVED. TUBE END FACED FOR LENS RING.

ALL THREADS TO B.S. 2779 MEDIUM CLASS GAUGED TO B.S.[illegible]

FOR DETAILS OF ITEMS WITH 10 DEG. TIPPED LENS RING FACES SEE AGRICULTURAL DIVISION STD [illegible].

COUPLING COMPONENTS, NUT, COLLARS AND SLEEVE TO BE CLEARLY STAMPED WITH FULL CODE REF. AND MATERIAL SYMBOL.

B.S.970 En 3A MATERIAL SYMBOL [illegible]
B.S.970 En 3B MATERIAL SYMBOL [illegible]
B.S.970 En 4 MATERIAL SYMBOL [illegible]

* COUPLING ASSEMBLY SUPPLIED COMPLETE WITH NUT, COLLARS, SLEEVE AND LENS RING.

TUBE					COUPLING		CODE OR REF. NO.		
NOM. BORE	SCREWING BSP.F	O.D.	THK'S	SPECN.	A	B	*COUPLING	TUBE	LENS RING
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]	AGL. DIVISION [illegible]	[illegible]	[illegible]	[illegible]212P	B20/018	[illegible]/018
[illegible]	[illegible] TO [illegible]	—	—		2[illegible]	[illegible]	[illegible]212H		
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]		2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]/20

TUBE					COUPLING		CODE OR REF. NO.		
NOM. BORE	SCREWING BSP.F	O.D.	THK'S	SPECN.	A	B	NUT	COLLAR 2 OFF	SLEEVE
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]	AGL. DIVISION [illegible]	[illegible]	[illegible]	[illegible]212A	[illegible]212P	[illegible]
[illegible]	[illegible] TO [illegible]	—	—		2[illegible]	[illegible]		[illegible]212R	
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]

THESE FITTINGS MAY BE BOUGHT FROM I.C.I. AGRICULTURAL DIVISION, BILLINGHAM.
THIS DRAWING [illegible] I.C.I. [illegible]

[illegible]	I.C.I. REFERENCE
	DB 6212
PAGE [illegible] OF [illegible]	
I.C.I. [illegible] NO. 4 DATE: [illegible]	
DIV. ISSUE NO. DATE:	
REF. DRG.	

PIPE COUPLING SCREWED

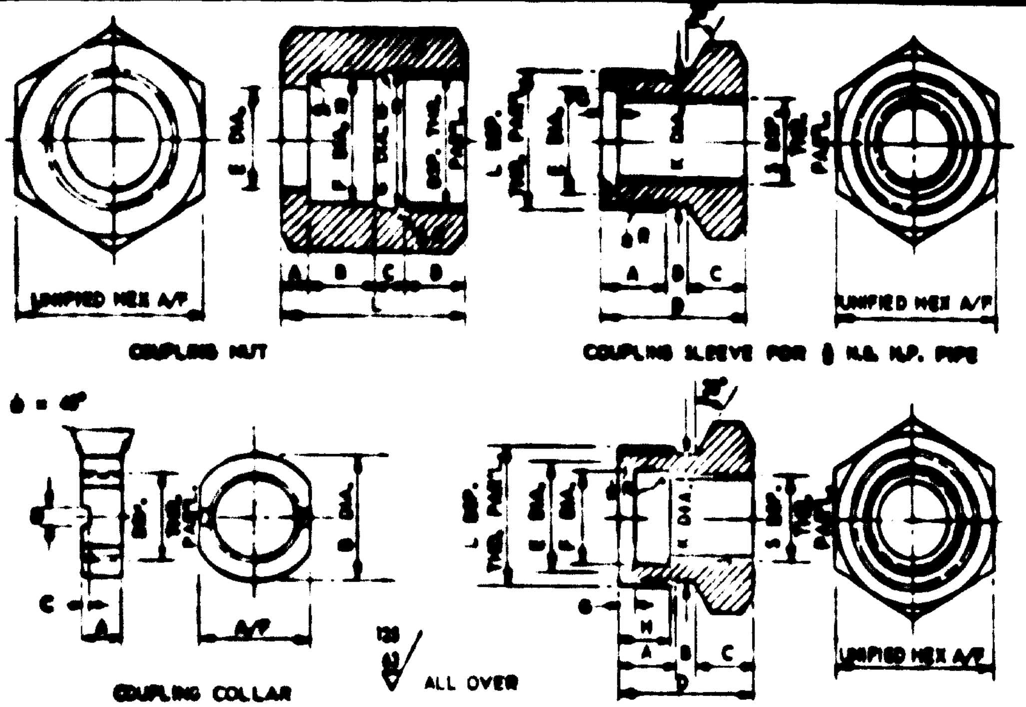
CARBON STEEL, BILLINGHAM DESIGN, [illegible]

SPECN. [illegible]

[illegible] SHEET

NOTE:—COUPLING COMPONENTS NUT COLLARS AND SLEEVE TO BE CLEARLY STAMPED WITH FULL CODE OR REFERENCE NO. AND MATERIAL IDENTIFICATION SYMBOL

GENERAL REFERENCES



COUPLING NUT

COUPLING SLEEVE FOR [illegible] N.B. H.P. PIPE

COUPLING COLLAR

COUPLING SLEEVE FOR [illegible] in N.B., H.P. PIPE

ALL DIMENSIONS IN INCHES

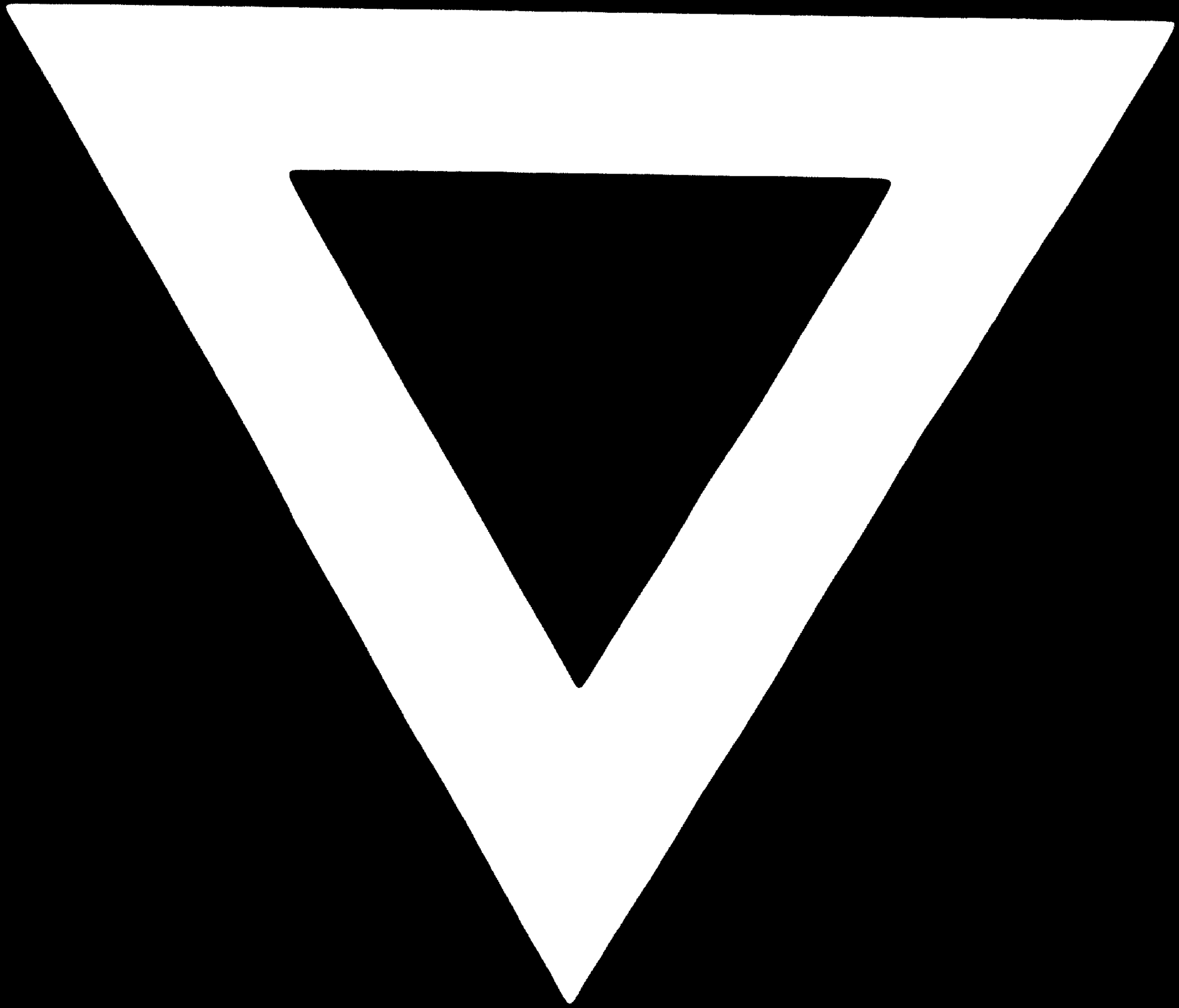
TUBE		NUT DIMENSIONS								ACROSS FLATS		BSP. THREAD	CODE OR REF. NO.
NOM. BORE	SCREWING BSP.	A	B	C	D	L	E DIA.	F DIA.	G DIA.	MAX.	MIN.		NUT
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	1.[illegible]	1.625	1.[illegible]	1	[illegible]212A
[illegible]	[illegible] TO [illegible]												
[illegible]	[illegible] TO [illegible]												

TUBE		SLEEVE DIMENSIONS									BSP. THREAD		ACROSS FLATS		CODE OR REF. NO.
NOM. BORE	SCREWING BSP.	A	B	C	D	E DIA.	F DIA.	G	H	K DIA.	L	S	MAX.	MIN.	SLEEVE
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	1	[illegible]	1.[illegible]	1.[illegible]	[illegible]212B
[illegible]	[illegible] TO [illegible]														
[illegible]	[illegible] TO [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	1.[illegible]	1	[illegible]	1.[illegible]	1.[illegible]	[illegible]212C

TUBE		COLLAR DIMENSIONS				ACROSS FLATS		BSP. THREAD	CODE OR REF. NO.
NOM. BORE	SCREWING BSP.	A	B DIA.	C	D	MAX.	MIN.		COLLAR
[illegible]	[illegible] TO [illegible]	[illegible]	1.[illegible]/1.[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]212D
[illegible]	[illegible] TO [illegible]	[illegible]	1.[illegible]/1.[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]212E
[illegible]	[illegible] TO [illegible]								

NOTE:- COUPLING NUT SLEEVE AND COLLAR TO BE STAMPED UH ON ONE HEXAGON FACE OR FLAT TO INDICATE THE USE OF HEAVY SERIES SPANNER REQUIRED

[illegible] FROM I.C.I. AGRICULTURAL DIVISION, BILLINGHAM [illegible] THE I.C.I. ORGANISATION.



76.05.04