1992 SPECIAL EDITION

NATIONAL BOARD
BULLETIN

An Official Publication of The National Board of Boiler and Pressure Vessel Inspectors

SPECIAL REPORT:

THE CHINESE FLANGE INVESTIGATION

BULLETIN

1992 • VOLUME 48 • NUMBER 2 SPECIAL EDITION

Since 1919

The National Board of Boiler and Pressure Vessel Inspectors

The National Board of Boiler and Pressure Vessel Inspectors was organized for the purpose of promoting greater safety to life and property by securing concerted action and maintaining uniformity in the construction, installation, inspection and repair of boilers and other pressure vessels and their appurtenances; thereby assuring acceptance and interchangeability among jurisdictional authorities responsible for the administration and enforcement of the various sections of the ASME Boiler and Pressure Vessel Code.

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The National Board of Boiler and Pressure Vessel Inspectors

Since 1919

A.M. Matthews, Jr., Acting Executive Director

September 1992

Dear *BULLETIN* Readers:

For approximately the last year, The National Board of Boiler and Pressure Vessel Inspectors has been investigating flanges – made in China and distributed in the United States, Canada and possibly Central and South America – that may be a considerable threat to both lives and property.

By publishing th's *BULLETIN* Special Report, it is our intent to impart the Board's findings in an objective, factual manner. What follows is a series of reports and photos that illustrate the nature of our investigation.

Because of the poor reproductive quality of many of the materials we have gathered, you will note that some sections of this Special Report are not up to the *BULLETIN*'s usual standards. In this single instance, we felt it was more important to present much of the factual material in its original form without benefit of editorial or graphic enhancement. Such is our commitment to letting the reader draw his or her own conclusions.

ONE SIGNIFICANT CAUTION: these suspect flanges are not unique to industrial operations. They may be found anywhere pressure piping, boilers and pressure vessels are employed, including many public institutions. We remind the reader that heat numbers are of particular importance when identifying suspect flanges.

Any questions concerning flanges manufactured in China should be forwarded to the office of the National Board director of inspections at 614/888-8320. Written correspondence may be sent to the National Board at 1055 Crupper Avenue, Columbus, OH 43229-1183.

The National Board has contacted China's State Council of the Communist Party Central Committee and the China Centre of Boiler and Pressure Vessel Inspection and Research (CBPVI) of the Ministry of Labour P.R.C.

On August 31, the National Board office received correspondence from CBPVI. The State Import and Export Commodities Inspection and Testing Bureau has issued an order that as of January 1, 1993, flanges, fittings and tubes for boiler and pressure vessel use will require mandatory inspection and testing by the CBPVI and/or other Chinese government inspection agencies. These inspected products will bear the inspection mark of the respective agency. A copy of this correspondence is included as the closing section of this Special Edition. We intend to meet with the CBPVI early in October to obtain details of this plan and to obtain facsimiles of the inspection marks for publication in the *Winter 1993 BULLETIN*.

The National Board extends its genuine gratitude to Mr. Al Justin, chief boiler inspector, State of Minnesota, for bringing this potentially dangerous problem to our attention.

Although our investigation has been long and arduous, we at the National Board now have sufficient information to alert our membership, *BULLETIN* readers, and the world of this relatively little-known but potentially explosive situation.

For 73 years, the National Board has monitored the boiler and pressure vessel industry to assure that when it comes to safety, there are no compromises.

It is not our promise. It is our commitment.

Sincerely,

A M Matthews Jr

A.M. Matthews, Jr.
Acting Executive Director

1055 Crupper Avenue
Columbus, Ohio 43229-1183 U.S.A.

Phone (614) 888-8320
FAX (614) 888-0750 (Executive)
FAX (614) 847-1828 (Technical)
FAX (614) 848-3474 (Pres. Relief Dept.)

PREFACE

This special edition of the *BULLETIN* has been published in the interest of public safety. The National Board has, for the past several months, been conducting an extensive investigation of flanges produced in China and identified as conforming to ANSI B16.5 and ASTM A105.

In the opinion of the National Board, the flanges identified in this special edition may not meet the criteria of the ANSI standard or ASTM specification noted above. Furthermore, use of these products which are subject to stress due to pressure, may create an extreme hazard to personal safety and property. Within the pages of this *BULLETIN*, we are presenting complete and/or partial copies of laboratory test reports of various flanges carried out by the National Board and other groups. These reports identify flanges that have been fabricated from two (2) pieces of steel, and flanges that have had voids filled with steel rods and face welded to give the appearance of being solid. We also possess a report concerning the use of unknown specifications of steel plate being used to produce flanges of various types. In reading this *BULLETIN*, you will learn of all problems reported to and uncovered by the National Board.

Where possible, we have identified the manufacturer of the flanges. One problem encountered as this investigation proceeded was the lack of evidence that any flange was marked with the manufacturer's name or trademark, as required by ANSI B16.5. In fact, the National Board representative conducting this investigation was informed that a Hong Kong trader was specifying to the flange manufacturer exactly what marks to stamp on each flange. The flanges observed by or reported to the National Board are for the most part, marked with initials that are mistakenly thought to be manufacturers. Some flanges do not even have initials.

The marks and test reports that appear in this article do have a value in that they are consistent in use. That is, the flanges produced by SHOU GANG MACHINERY ENGINEERING CO. and further reported in this *BULLETIN* have slugged weld repairs. These flanges are marked with a heat number 1-406 and are expected to appear on 150 flanges, as reported on that line item of the SHOU GANG MACHINERY ENGINEERING CO. test report.

This same trading company representative reported to the National Board that the steel mills in China do not produce ASTM A105 forgings. One Chinese agency also reported that Chinese-produced ASME boilers and pressure vessels contain flanges not produced in China but rather imported from other countries. At this time, the National Board has not determined the validity of this statement. If so, the chances of purchasing flanges produced in China that are in compliance with the ANSI B16.5 standard or ASTM A105 are indeed remote.

Finally, the National Board was informed that the material used by DING XINANG NAN XI LI FLANGE FACTORY was NOT ASTM A105 although the product is clearly marked A105. It was reported the material used was either 25MN or 16MN, both Chinese steel specifications, and not identical to A105. It was also reported that DING XINANG NAN XI LI FLANGE FACTORY

shipped six or seven containers of flanges, each weighing 17 tons. Although it is reported that each flange is marked both B16 and A105, according to the information, no flange was produced using A105 material.

On May 28, 1992, a representative from the National Board met in Beijing, China with members of the State Council of the Peoples Republic of China and the Centre of Boiler and Pressure Vessel Inspection and Research. This meeting was in response to correspondence addressed to Mr. Su Rung Ju, Vice Premier, Peoples Republic of China, from the National Board. This correspondence was drafted when it was learned that the Vice Premier had recently initiated a quality program to further China's entry into the world market. The program is titled "Quality Long March," after Mao Tse Tung's long march during the revolution. Since that meeting, there has been considerable contact between various agencies of the Chinese government and the National Board. To date, no solution has been found. However, several additional agencies have become involved in an attempt to provide solutions.

Information has been provided to the United States Customs Service and the Nuclear Regulatory Agency, to alert the various agencies of the information received by the National Board on these products. In the interim, the National Board has been advised of several failures of different types of equipment involving flanges produced in China. Fortunately, the failures reported have been found during hydrostatic tests or during in process inspections. Inservice failure of equipment has, to date, not been reported.

LAB REPORTS

FAILURE ANALYSIS OF A SLIP-ON FLANGE

The installation of a 14" slip-on flange in a pipeline was recently witnessed by Al Justin, chief inspector for the State of Minnesota. The flange originally had a 14-3/4" inside diameter, which was reduced by welding a 3/4" ring and machine welding. The ring, however, separated from the flange, giving the appearance of a crack. The flange is reported to have been manufactured in the People's Republic of China.

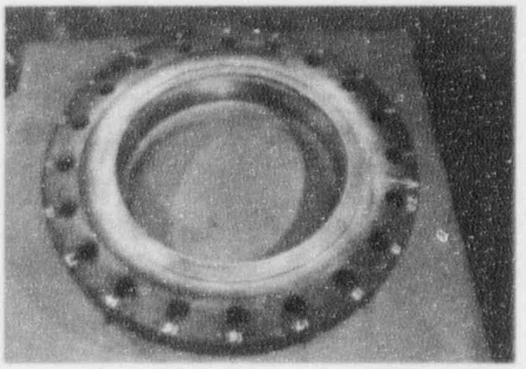


Figure 1: Gasket side of flange.

Several such flanges have been reported in the field. All individuals in the industry should be on the alert for these flanges.

The following is a report by Columbus Metallurgical Services, Inc. on the failure analysis of a slip-on flange.

A "cracked" 14" diameter slip-on flange was non-destructively inspected by using magnetic particle, dye penetrant and ultrasonic test methods. The flange was also checked for material chemical anaiysis and macro and microstructure. On the basis of the results and observations reported, the following conclusion is drawn:

> The subject slip-on flange is not an integral forging or a casting. It has been fabricated by welding and machining a ring insert within a large diameter flange. The flange "cracked" because the welds between the flange and the insert were inadequate to withstand the bolting pressures.

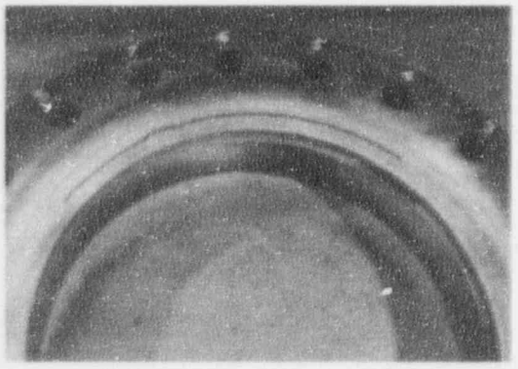


Figure 2: A close-up of the gasket side showing the "crack" indication.

Background

The "cracked" slip-on flange was received by Columbus Metallurgical Services, Inc. in one piece. It had two diametrically opposite cracks located on pipe and gasket sides. It has been reported that several such flanges are in the field. The subject flange has the following engraved markings on the outside diameter (OD):

"14 300 SO RF B16.5 A105 848 CHINA 02F"

To identify the cause of the failure it was planned to perform dye penetrant, dry magnetic particle, ultrasonic and radiographic tests on the subject flange.

Non-Destructive Tests

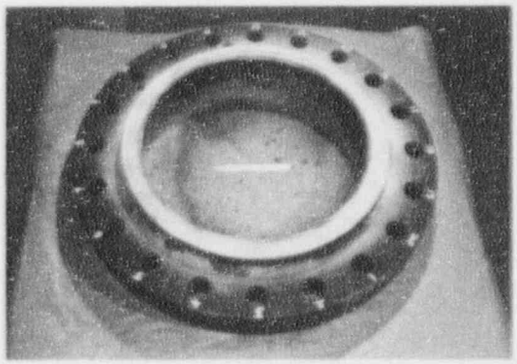


Figure 3: Pipe side of flange.

First, the flange was UT tested from the OD. The indications were rather puzzling because the reflections were consistently from a cylindrical surface about 3.75" from the OD. A dry magnetic particle examination confirmed that the cracks extended more or less continuously in a circular path. The NDT examination was concluded with dye penetrant tests as shown in the photographs in Figures 1 through 4. It was quite evident that the flange was not a single piece component. A large inside diameter (ID) flange was reduced to a 14" ID unit by welding a 0.75" thick ring. The welding faces had been machined.

Chemical Analyses and Metallography

The flange was sectioned into four pieces to obtain specimens for chemistry, as well as for macro and microscopic examination. The original engraved markings have been retained on one of the segments. The chemical analyses are as follows:

C	Mn	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al	V
Main Flange Steel											
.23	.62	.024	.038	.24	.27	.016	.094	.079	.026	.006	.003
Welded Insert Steel											
.26	1.02	.017	.039	.28	.063	.003	.050	.046	.032	.008	.000
ANSI/ASTM A 105											
.35	.60-1.05	.040	.050	.35	[.4*		.4*	.3*	.12*		.03*]

* Sum shall not exceed 1.00%. Indicates maximum percent allowable.

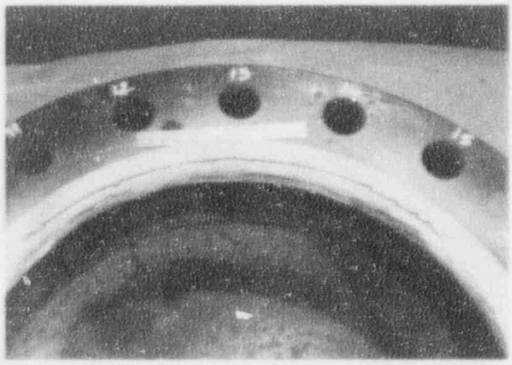


Figure 4: A close-up of the pipe side showing the "crack".

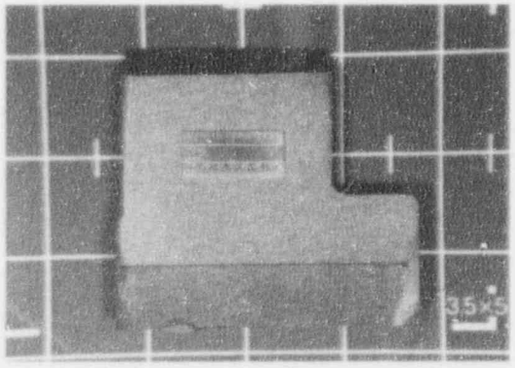


Figure 5: A macro of a radial section. Etched 50% HCl, 15 minutes.

Figure 5 shows the radial macro section of the flange. Note the insert ring welded to the main flange. When another similar piece was further sectioned to retrieve specimens for mounting and polishing, the insert separated from the main flange. The general microstructure (ferritic-pearlitic) at 25X (Nital etch) is shown in Figure 6.

Rockwell Hardness Test

Main Flange:	72,69,70 HRB	Ave = 70 HRB
Insert:	76,78,80 HRB	Ave = 78 HRB

No further work was deemed necessary❖

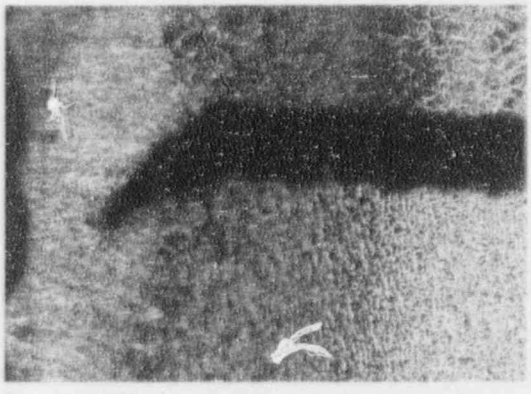


Figure 6: Photo showing general microstructure in the main flange (lower half), insert (upper half) and weld metal (left edge). 25X, Nital etch.

REPORT

EVALUATION

OF

FLANGE B16.5 105 N SO 81D 1-406
AND BLANK PF 105 B16.5 012 CHINA BL

prepared for

THE NATIONAL BOARD OF BOILER AND
PRESSURE VESSEL INSPECTORS

by

WELDING CONSULTANTS, INCORPORATED

June 3, 1992

EXECUTIVE SUMMARY

Welding Consultants, Inc. received, 5/12/92, a portion of a flange and blank for analysis. It is suspected the material is either not forged ASTM A105 material as was specified or was misfabricated and "slugged" (addition of non-homogeneous filler) to correct for under dimensioning or local defects.

The scope of this evaluation is the following:

1. Photograph portions of the flange which appear to have some type of "slugging".

2. Perform chemical analysis of the flange and blank material and compare with the accepted ranges for ASTM A105.

3. Perform tensile tests for each component and compare with the ASTM specification for A105.

4. Cross section and metallurgically prepare the flange and blank to observe the microstructural characteristics which would indicate the material had or had not been forged.

The non-fused filler or "slugging" appears to be two 1/8 inch diameter rounds welded in place and subsequently machined. See photographs in Figure 2.

It can be seen the "slugging" has resulted in very little substratum for the fillet weld shown in Figure 2a.

The chemical analysis revealed only one discrepancy between ASTM A105 and the material tested: the sulfur content for the flange was found to be 0.075% compared to 0.050% maximum as listed in the specification. See Table I. It could be argued that this high sulfur content is significant when one considers the tendency of steels to hot crack when the sulfur content approaches the accepted maximums of 0.04% to 0.05%, sulfur content of 0.075% becomes more suspect.

The tensile test results comply with the ASTM A105 specification.

The cross sectioning of the flange and blank revealed microstructure consistent with hot rolled plate steel. See Figure 2a and 2b. It should be noted the chemistry of the materials tested comply with the compositional requirements of A105 with the exception of the sulfur content of the flange.

INTRODUCTION

On June 12, 1991, Welding Consultants, Inc. received a section of a suspect flange and blank for analysis. The material was supposed to have been forged ASTM A105 steel.

The compliance of this material with the A105 specification will be tested by chemical analysis and by tensile tests.

Often times, a forging is specified for a particular application because of the desirable orientation of grains. A crane hook, for example, may have a forging procedure designed to increase its resistance to opening. That is, it will contain residual stresses which will tend to pull the hook closed. Evidence of the forging operation can be detected by polishing and etching a cross section and observing the appearance and orientation of the grains.[1]

In this case, it is suspected the flange and blank have been fabricated from rolled plate rather than a forging. This will be proven by cross sectioning and etching each component and observing the microstructure.

Lastly, evidence has been found which would indicate the outer rim of the flange face has been built up by the addition of some form of non-fused filler or "slugging". The danger of this situation is obvious.

The nature of the "slugging" will be evaluated here.

1. Reference - American Society of Metals, Metals Handbook Volume 9, USA, 1985, Page 176.

PROCEDURE

The analysis of the flange and blank material proceeded as follows:

1. Chemical analysis was performed using an Angstrom V-70 Vacuum Spectrometer.

2. Tensile testing was performed according to ASTM A370 using a Southwark Emary 200,000 pound tensile machine.

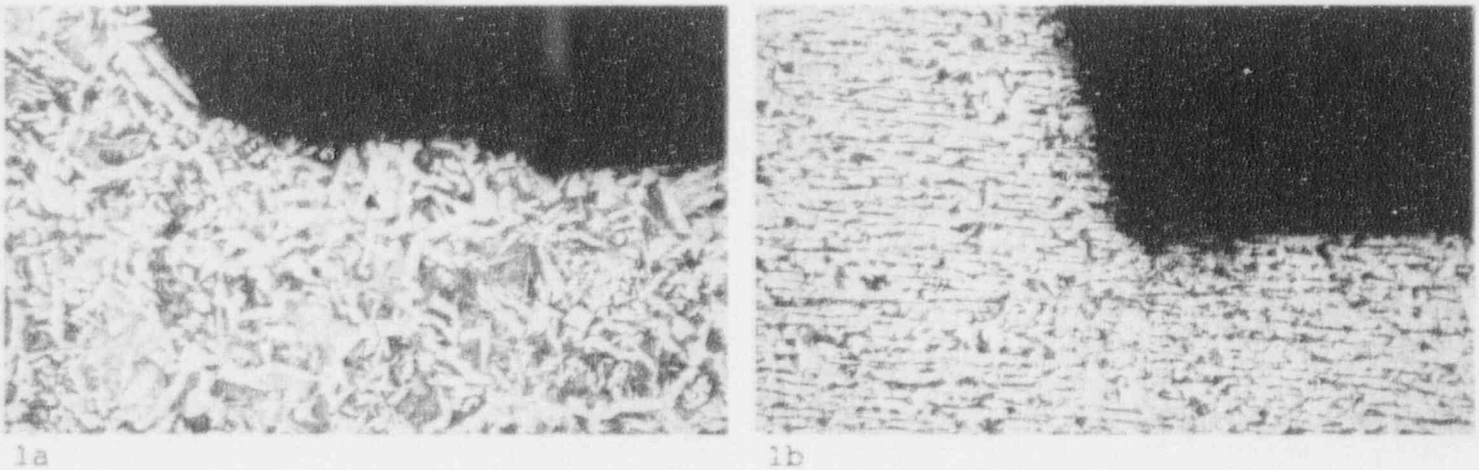
3. The cross sectioning of the flange material was accomplished using a Marvel band saw. The polishing was accomplished in two steps: 1. the samples pictured in Figure 1a and 1b were prepared using rotary sanding equipment; 2. a final polish was accomplished using nap cloth and 15 micron alumina powder. The samples were etched using 5% Nital.

RESULTS

The type of material was tested by chemical analysis and tensile tests. The results are contained in Table I and Appendix I respectively. The sole discrepancy between the ASTM specification and the analysis is the sulfur content of the flange: actual analysis = 0.075% S compared to 0.050% S maximum according to ASTM A105. It could be argued that this high sulfur content is significant when one considers the tendency of steels to hot crack when the sulfur content approaches the accepted maximums of 0.04% of 0.05%, sulfur content of 0.075% becomes more suspect.

The suspicion is that the material was not forged, but was fabricated from rolled plate. The decision was made to cross section and metallurgically prepare portions of the material to observe the nature of the microstructure. The photomicrographs shown in Figure 1a and 1b are evidence the flange and blank, respectively, are fabricated from rolled plate. The somewhat elongated grains particularly noticeable in the photomicrograph of the blank are typical of hot rolled steel.

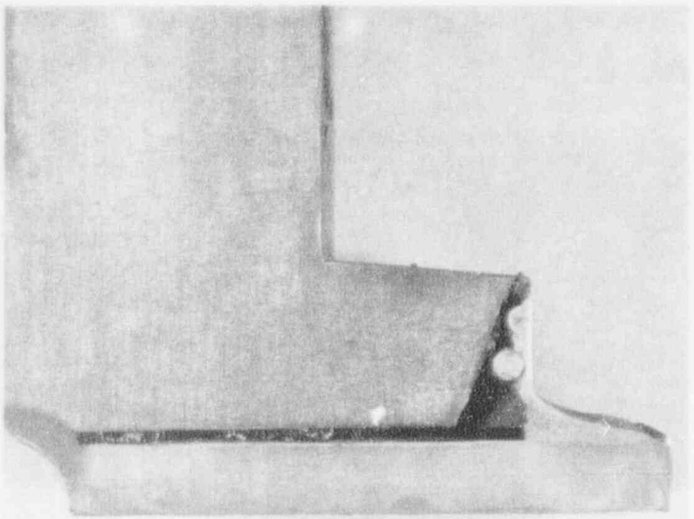
Finally, the nature of the non-fused filler was to be determined. By simply cross sectioning the flange, the sample picture in Figure 2c was easily separated from the rest of the flange manually. The non-fused filler was found to be a pair of 1/8 inch rounds evidently welded to increase the size of or repair defects in the flange. Figure 2b shows the "slugging" extending around the flange. This situation was found in several other locations around the circumference.



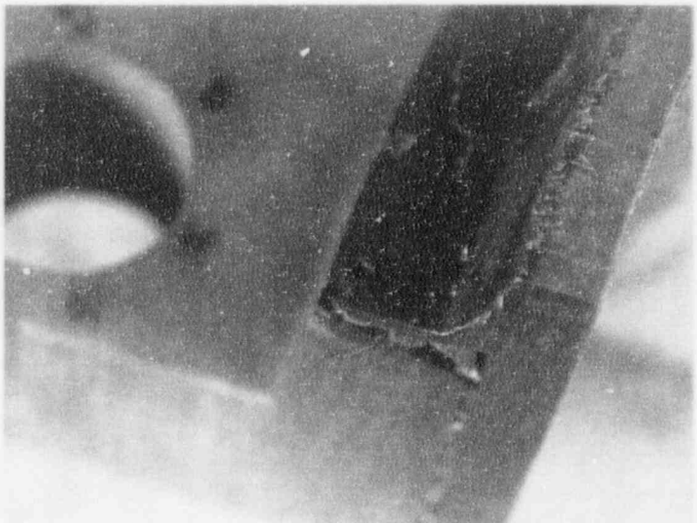
1a 1b

Figure 1. Appearance of Grain Structure of a) the Flange, and b) the Blank Showing Elongated and Grains Indicative of Hot Rolled Plate.

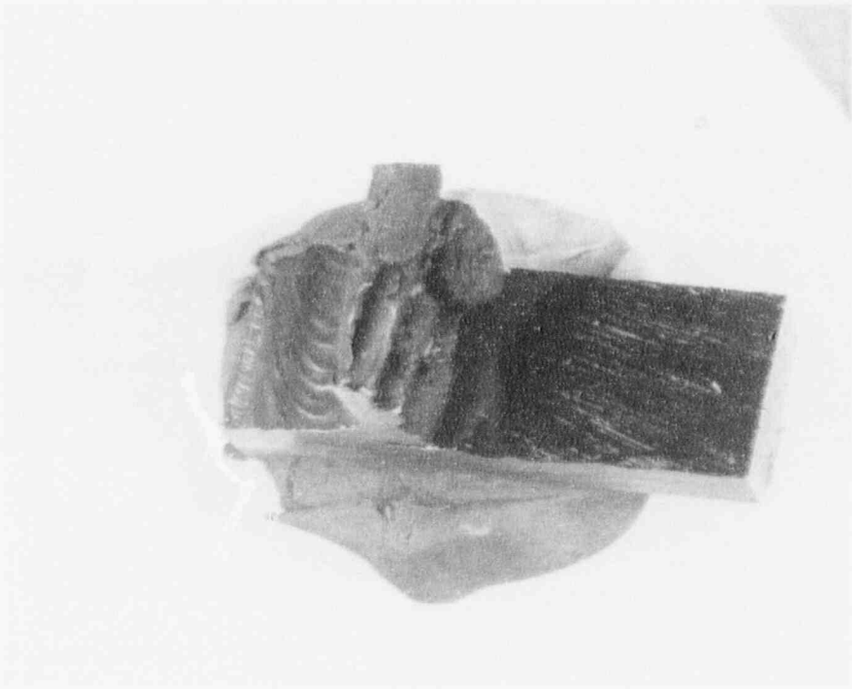
It can be seen the "slugging" has resulted in very little substratum for the fillet weld shown in Figure 2a and 2b.



2a



2b



2c

Figure 2. Appearance of Non-fused Filler or Slugging.

TABLE I. Results of Chemical Analysis

ID	C	MN	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al
Flange	.31	.84	.040	.075	.25	.16	.015	.051	.14	.016	.033
Blank	.21	.89	.019	.037	.22	.16	.017	.051	.027	.017	.033
A105 Spec.	.035*	.6-1.05	.040*	.050*	.35*	.40*	--	.40*	.30*	.12*	--

V	Nb	Zr	Ti	B	Ca	Co	Pb
.001	.000	.000	.001	.0002	.0005	.011	.00
.000	.000	.000	.001	.0001	.0005	.012	.00
.030*	.02*	--	--	--	--	--	--

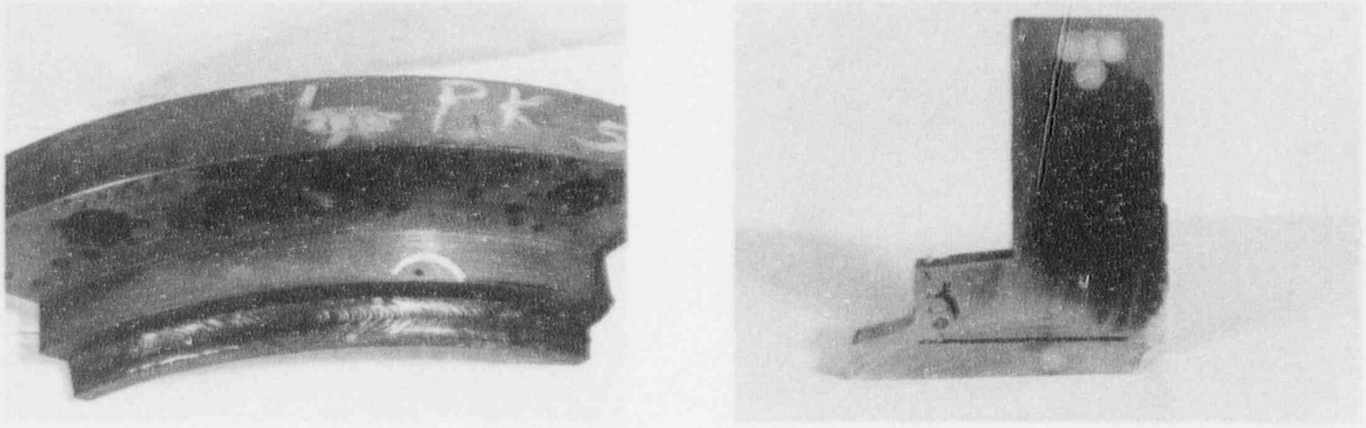
* Indicates maximum percent allowable
-- Indicates no specified limit

CONCLUSIONS

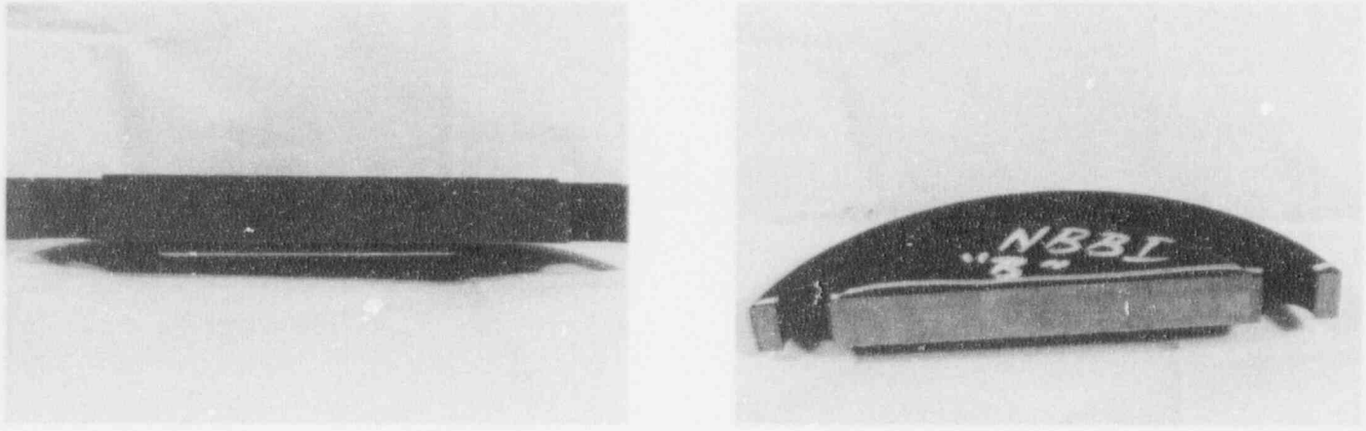
The conclusions of this study are the following:

1. Neither the flange nor the blank were forged steel. It is evident they were both fabricated by machining hot rolled plate.

2. The flange was built up by the insertion of a non-homogeneous filler which was intended to either repair defects in the original fabrication or to compensate for under dimensioning. The filler or "slugging" appear to be two 1/8" diameter rounds welded in place (poorly) and subsequently machined.



Slip-on roised-face flange.



Blind flange marked as A105 is a rolled plate product.

Welding Consultants, Inc.

Professional Engineering and Inspection Services Worldwide

July 30, 1992

The National Board of Boiler and Pressure Vessel Inspectors
Attn: Mr. A. M. Matthews, Jr.
1055 Crupper Avenue
Columbus, OH 43229

SUBJECT: CHINESE FLANGE ANALYSIS
FLANGE ID: 4-300 B16 A105N W/N STD 4-1 CHINA WW

Doc:

Per your request, an analysis has been conducted on the above-referenced weld neck flange that was picked up at your office on Monday, July 27, 1992. The following is a summary of the work performed and the results of the investigation. Figure 1 below shows the layout of the flange and the locations of test samples.

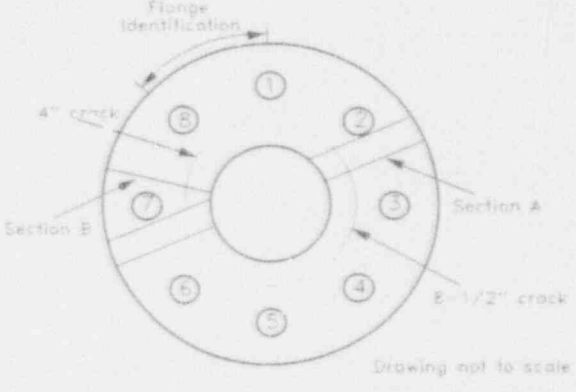


Figure 1, Flange layout and sample locations

When the flange was first received, a visible crack was evident at the transition between the flange and the weld neck. There also appeared to be machining grooves in this same vicinity. To verify the extent of cracking, the flange was subjected to penetrant testing. As can be seen in Figures 2 and 3 below, there was more cracking evident than could be detected visually. In fact, more than 75% of the circumference exhibited cracking.

CHINESE FLANGE ANALYSIS
Flange ID: 4-300 B16 A105N W/N STD 4-1 CHINA WW
July 30, 1992

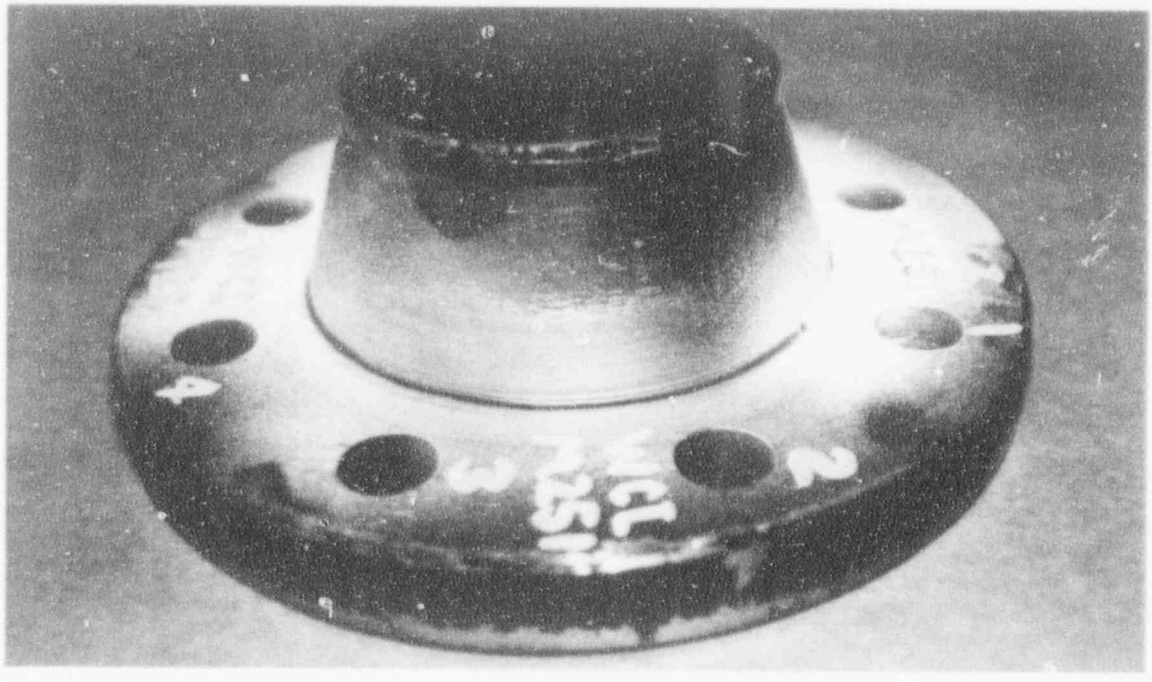


Figure 2. Penetrant test indications

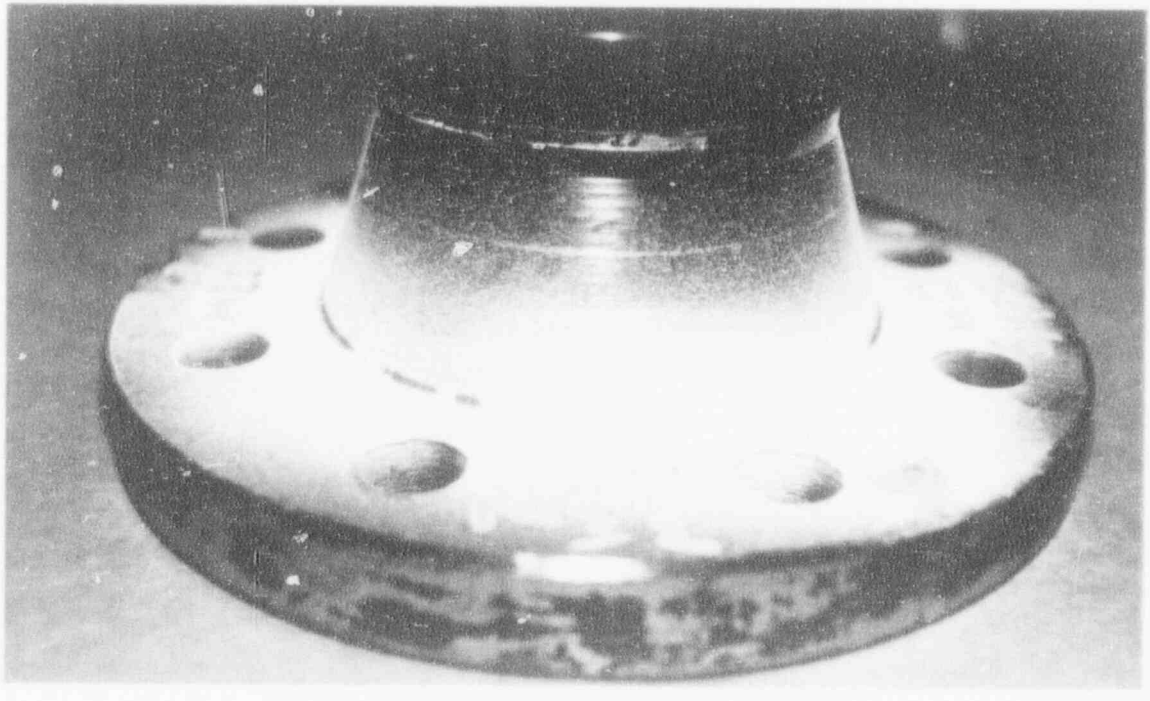


Figure 3. Penetrant test indications

Section A was removed from the region identified in Figure 1. This section was polished and etched to for metallurgical examination. Of initial interest was whether the flange had been fabricated from more than one piece of material. Once the etched surface was visually examined, it was apparent that the flange had been machined from a single piece of metal.

Next, it was necessary to determine whether the flange was a forged material or whether it had been machined from a plate product or a casting. This information was provided once Section A was examined under a microscope. Figure 4 shows the microstructure of the material in the vicinity of the visible crack at the weld neck-flange transition.

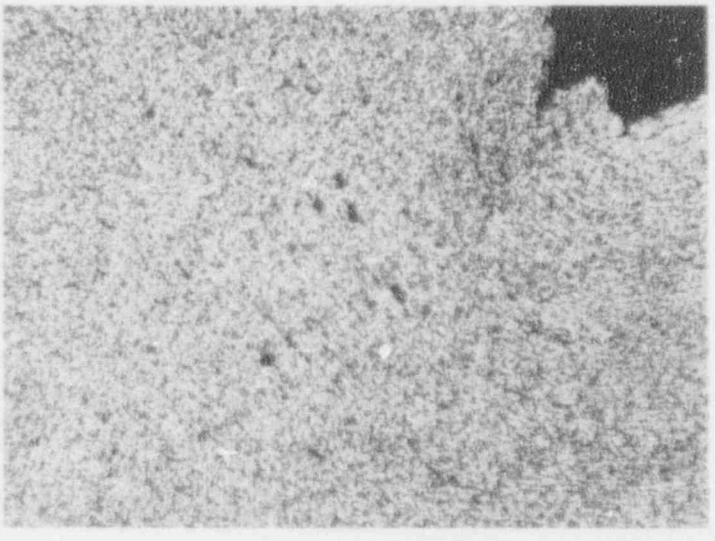


Figure 4, Section A microstructure at visible crack location (50X, Nital etch)

Figure 4 vividly depicts the presence of material flow lines which is indicative of a forged material. Further, the fact that the grain structure appears relatively equiaxed indicates that this material was most likely subjected to a normalizing heat treatment following the forging operation. Another observation here is the fact that the apparent crack did not appear to have a sharp end condition, plus it was quite wide compared to its depth. Neither of these characteristics are typical for a crack.

To obtain some additional information, a second section was removed at location B (see Figure 1). At this location, a crack had been noted during penetrant testing; however, it appeared to be much tighter than that appearing at Section A. Once removed, this section was also subjected to metallurgical polishing and etching. The result appears in Figure 5.

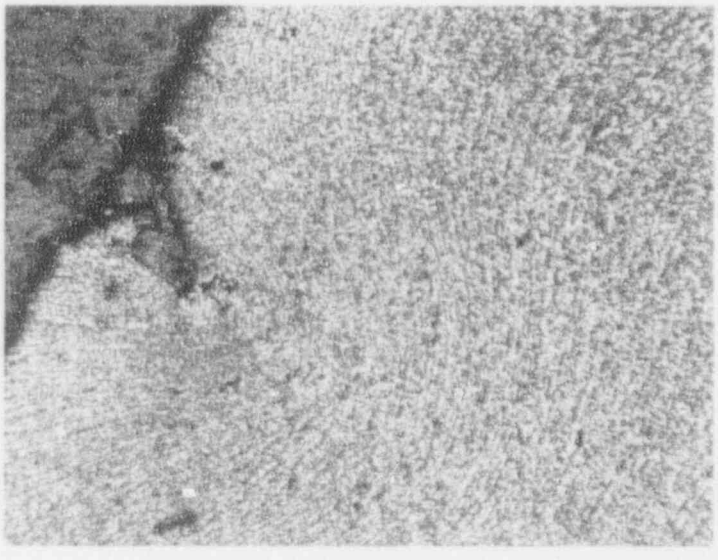


Figure 5, Section B microstructure at crack location (50X, Nital etch)

This cross section also shows an uncharacteristic crack indication. Further, there is increased evidence of flow lines at the end of the indication. Based on these observations, it is felt that the indications noted on this flange are the result of poor forging practice which resulted in a forging lap at the weld neck-flange transition.

The final information to be gained from this analysis involves the material chemistry. This will help determine whether this flange material is in compliance with the chemical requirements for SA105 material. The results of this chemical analysis appear in the table on the following page.

Looking at those results, it is apparent that this flange material has a chemical composition that complies with the requirements of SA105.

CHINESE FLANGE ANALYSIS
Flange ID: 4-300 B16 A105N W/N STD 4-1 CHINA WW
July 30, 1992

Chemical Composition

Element	Amount Present	SA105 Requirement
Carbon	0.19	0.35 max
Manganese	0.71	0.60 - 1.05
Phosphorus	0.020	0.040 max
Sulfur	0.021	0.050 max
Silicon	0.31	0.35 max
Copper	0.15	0.40 max
Nickel	0.063	0.40 max
Chromium	0.043	0.30 max
Molybdenum	0.016	0.12 max
Vanadium	0.002	0.03 max
Columbium	0.000	0.02 max

Conclusions

Based on this analysis, the following conclusions can be made:

1) This flange is a forging.
2) It was normalized following the forging operation.
3) The material complies with the chemical composition requirements of SA105.
4) The crack-like indications are forging laps resulting from poor forging practices.

CHINESE FLANGE ANALYSIS
Flange ID: 4-300 B16 A105N W/N STD 4-1 CHINA WW
July 30, 1992

Doc, hopefully this information will be sufficient at this time. Should you require any further information or analysis, just give me a call. I will be returning all of the sample pieces to your office.

Thank you for allowing us to provide this service.

Sincerely,

WELDING CONSULTANTS, INC.

Richard L. Holdren, P.E.
Vice President/Welding Engineer

Welding Consultants, Inc.

Professional Engineering and Inspection Services Worldwide

August 28, 1992

Mr. John D. McLoughlin
The National Board of Boiler and Pressure Vessel Inspectors
1055 Crupper Avenue
Columbus, OH 43229

SUBJECT: ANALYSIS OF CHINESE FLANGES

John:

Per your instructions, an analysis has been performed on two flanges produced by two Chinese manufacturers. One was a slip-on configuration while the other was a weld neck type flange. The identification markings are as shown below:

Weld Neck: DSI 4-150 RF B16 A105N W/N STD 075 CHINA
Slip-on: LEO 4-150 RFSO B16 A105N T M1-300 CHINA *

* The "N" had been "x"-ed out with a steel stamp.

Our goal was to determine if the chemistries comply with SA105 requirements, whether the material had been forged, and if the material had been normalized. The results of these analyses appear on page 2 of this report.

As can be seen from the chemical analyses, the compositions are acceptable with respect to the requirements of SA105 with the exception of the excessive amount of manganese present in the slip-on flange.

Brinell hardness tests were performed on each of the samples. The weld neck flange exhibited an average hardness of 158 BHN which is approximately equivalent to 78,000 psi. The slip-on flange had an average hardness of 176 BHN, or an equivalent tensile strength of approximately 85,000 psi. Both of these values are in compliance with the strength requirements of SA105 material.

Chemical Analyses

Element	SA105 Requirement	Weld Neck Composition	Slip-on Composition
Carbon	0.35 max.	0.23	0.28
Manganese	0.60 - 1.05	0.69	1.17
Phosphorus	0.040 max.	0.017	0.013
Sulfur	0.050 max.	0.03	0.03
Silicon	0.35 max.	0.21	0.29
Copper	0.40 max.	0.083	0.19
Nickel	0.40 max.	0.072	0.016
Chromium	0.30 max.	0.039	0.010
Molybdenum	0.12 max.	0.019	0.011
Vanadium	0.03 max.	0.000	0.000
Columbium	0.02 max.	0.000	0.000

Cross sections were removed from each of the flanges and polished to reveal the materials' microstructures. Figures 1 through 4, on the following pages, illustrate the polished and etched surfaces of each sample at both 50X and 100X magnifications.

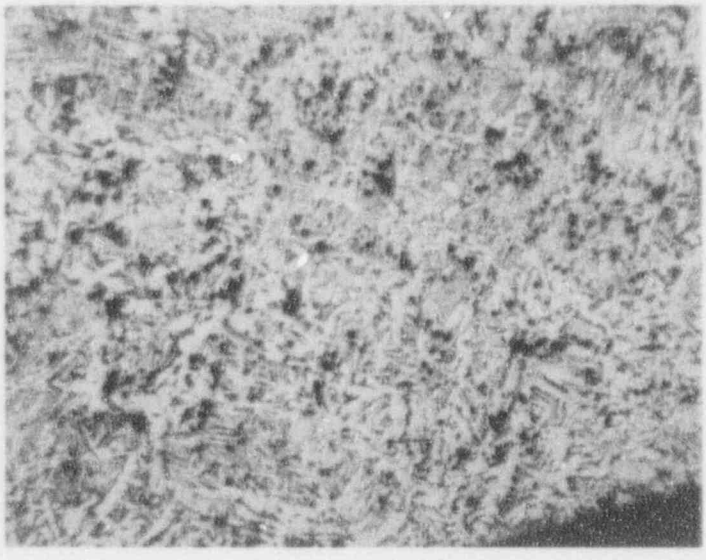
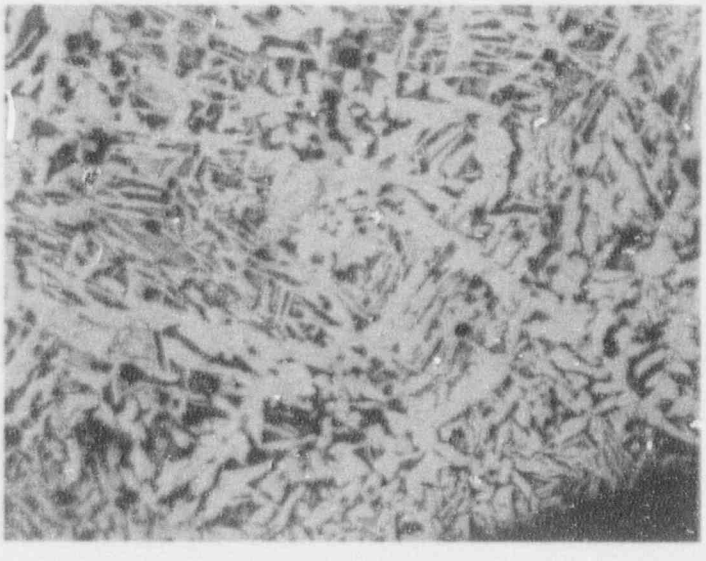


Figure 1, Weld Neck, 50X, Nital Etch



igure 2, Weld Neck, 100X, Nital Etch

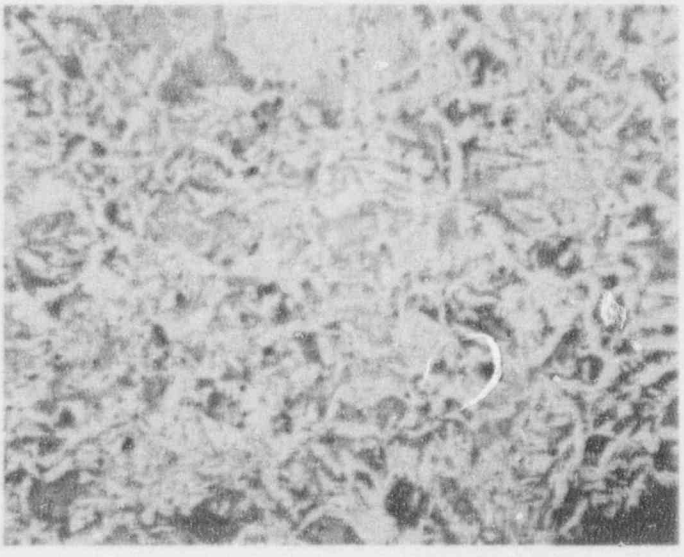


Figure 3, Slip-on, 50X, Nital Etch

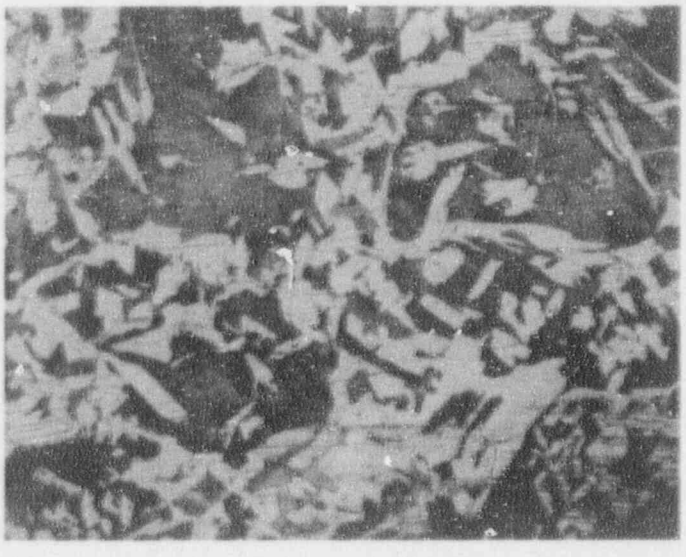


Figure 4, Slip-on, 100X, Nital Etch

Several features are revealed through these photomicrographs. First, the material does not appear to be a forging, nor do they appear to be normalized. However, it is difficult to determine from this brief analysis whether the materials are rolled plate or cast. The presence of extensive numbers of spherical inclusions, and the microstructural appearance suggests the possibility of these being cast materials; however, it is difficult to positively determine without further polishing and microstructural analysis. Should you wish to pursue this further, please let us know. The fact that there is no sign of flow lines is evidence that these are not forgings.

John, hopefully this information will be satisfactory for your present needs. Should you require anything further, just give me a call.

Thank you for allowing us to perform this analysis.

Sincerely,

WELDING CONSULTANTS, INC.

Richard L. Holdren, P.E.
Vice President/Welding Engineer

MSCM Note No. 92-7394

To: MSIP/H

From: MSCM

Date: June 5th, 1992

Written by: J. L. Hau

Approved by MSCM:

Subject: Leaking piping fittings found in new 92'HDS complex revamp piping installations.

Copy to: HL, MS, MA, SIP, SIP/QC, MSIP

Several carbon steel pipe fittings leaked during hydrostatic testing done in new sections, recently fabricated during the Hydroprocessing Rationalization Project, hereafter referred to as HDS 1992 revamp. Up to now, the following items have been identified:

No	Item	Standard(1)	UNIT	Remarks
1	4" Weld Neck Flange	A 105	LDHT	Weld repaired and in service
2	6" Weld Neck Flange	A 105	-	Withdrawn and sent to MSCM Lab
3	8" Weld Neck Flange	A 105	HDS	Withdrawn and sent to MSCM Lab
4	4" T-Joint	A 234 WPB	-	Withdrawn and sent to MSCM Lab
(1). 5	ASTM 6" Elbow			

FINDINGS

1. All defective fittings are carbon steel and are Made in China.
2. Defects were identified as forging laps (folds) or seams, which are internal discontinuities with a crack-like appearance produced during manufacturing of these components.
3. In the case of the flanges, the defects appeared to be located in the neck, near the edge that is to be welded to the pipe.
4. One of the examined flange also contained a very coarse Widmanstätten type of structure, typical of improper manufacturing practices (i.e. too high hot working temperature during forging).

CONCLUSIONS

1. Leaks during hydrostatic testing were produced in through-thickness forging defects, referred to as laps, folds and/or seams.

2. The presence of these through-thickness crack-like defects suggests a lack of quality control during manufacturing and poor workmanship, typical of low quality products, which have recently flooded in the world market.

RECOMMENDATIONS

1. The purchasing and the use of these and probably other low quality and presumably cheap items Made in China should be avoided since their poor quality could compromise the safety of operation.

2. Hydrostatic testing is a proven technique that gives adequate guarantee that the pipe lines and fittings are in serviceable conditions and that no through-thickness defects are present now. However, in the case of undetected subsurface forging defects which do not completely go through thickness and hence that did not produce leaks during hydrotesting, corrosion in the course of operation may reach such defects and hence future leakages in service can not be discarded all together.

3. Hence, identification and the exact location of other pipe fittings Made in China and that were recently installed in the HDS complex should be followed by radiography inspection to ascertain whether or not they contain gross forging defects that could develop leaks or failures in service.

DEFINITIONS

Forging Defects: The forging as well as some other hot working shaping operations can produce mechanical defects known as laps and seams.

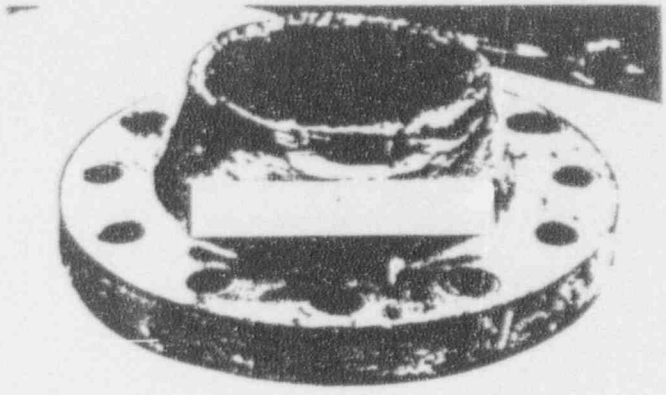
Laps: also called folds, occurs as the results of a protrusion of hot metal being folded over and forged into the surface. Some decarburization and oxidation usually occurs in these protrusions. The oxide present on the internal surface of the lap prevents the metal from joining during further forging. A discontinuity with a crack-like appearance is thus created, usually containing trapped oxide inclusions and with some decarburization being evident in the lap surface.

Seams: are similar to laps in nature and effect. They appear as closed-up surface cracks and are attributable to hot surface tears in the original ingot and to embedded scale that has been torn out leaving a cavity with oxidized wall, which then are prevented from healing during forging. A surface discontinuity with a crack-like appearance is thus created.

Widmanstätten Structure: this is known as an overheated structure and results from heating well above the upper critical temperature when large austenite grains form and upon cooling this gives rise to this type of Widmanstätten structure, characteristically showing both lack of ductility and resistance to shock.

ATTACHMENTS

See attached photographs for findings and evidences.



(a)

(b)

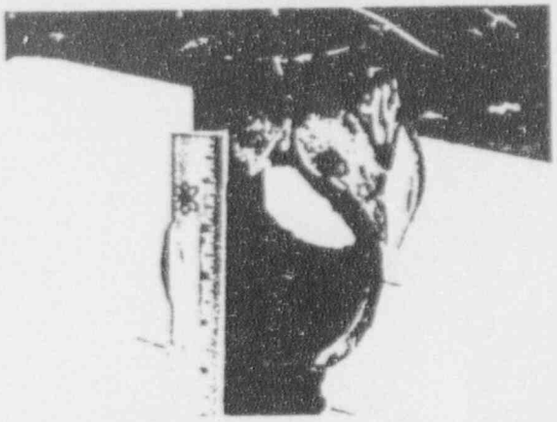
Fig. 1. This is a 6" weld neck flange that leaked during hydrostatic testing. An attempt was made to remove and weld repair the defect but because it went deeper into the neck, the attempt was abandoned.

(a) A general view showing the flange on the side where the repair was attempted. The hole just above the ruler is the excavation left after attempting to remove the defect.

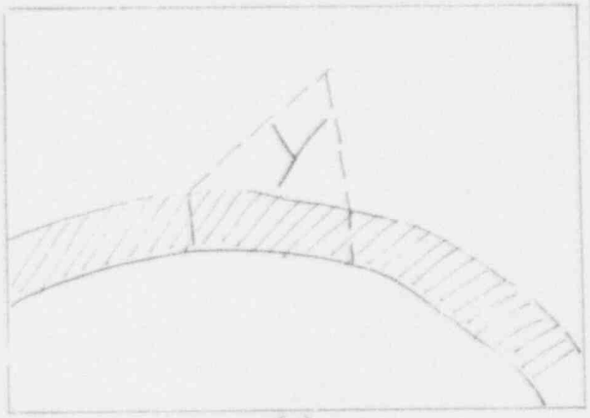
(b) A close-up view of the excavation showing the crack-like forging defect (indicated by an arrow) and also some slack or oxide inclusions (indicated by two arrows) which looked like porous in the material.

SLAG

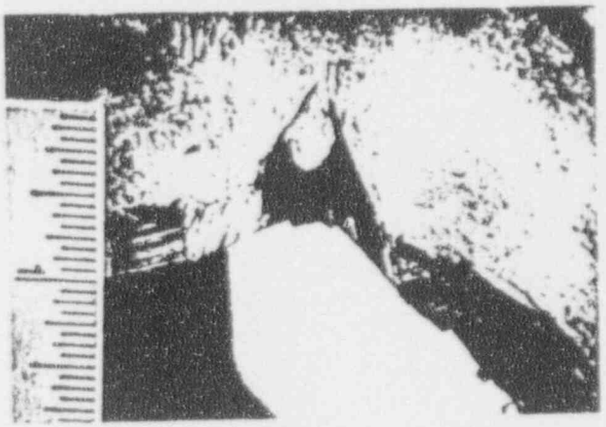
(a)



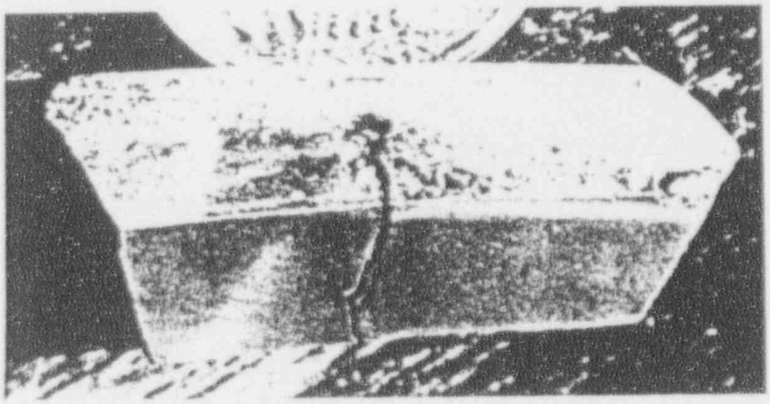
(b)



(c)



(d)



(e)

Fig. 2. This is a 4" Tee Joint that leaked during hydrostatic testing.

(a) A general view showing the ~~flange~~ T-joint on the side where the words Made in China was stamped. The side where the defect was found is indicated by an arrow.

(b) A front view of the side where the defect was found. The V cut was done in an attempt to obtain a small sample of the defective area for metallographic examination.

(c) Sketch showing the original shape and appearance of the defect, as seen from the outside surface.

(d) While attempting to remove the V sample, spontaneous separation of the sample occurred through the crack.

(e) Photograph of the metallographic sample showing the crack-like forging defect.

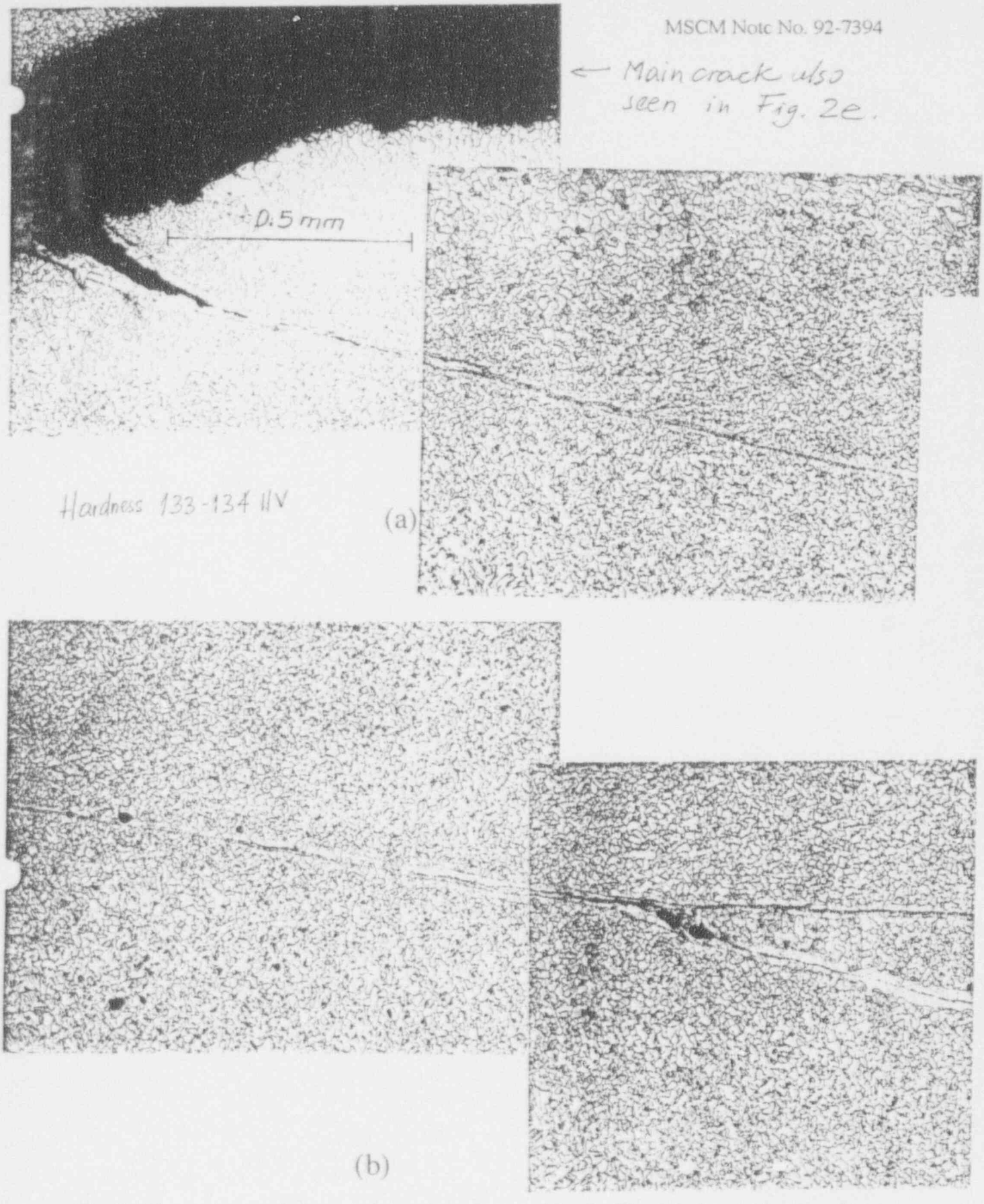


Fig. 3. Photomicrograph through the crack as shown in Fig. 2e. The right-hand side edge of (a) continues on the left-hand side edge of (b). Notice that the decarburization (lack of pearlite) associated with the lap surface as well as the presence of slag or oxide inclusions. This is a minor lap attached to the main crack, which is indicated above.

Fig. 4. Metallographic samples taken from the 8" weld neck flange that leaked during hydrostatic testing. The neck of the flange was radiographed near the weld joining it to the pipe and a area 110 mm long was found with crack-like indications and cavities or porous. These were oxide inclusions embedded in the metal at the neck of the flange.

Metallographic examination was carried out on the spots indicated by the arrows. That on the left is shown in Fig. 5; the arrow on the right-hand side corresponds to the area shown in Fig. 6.

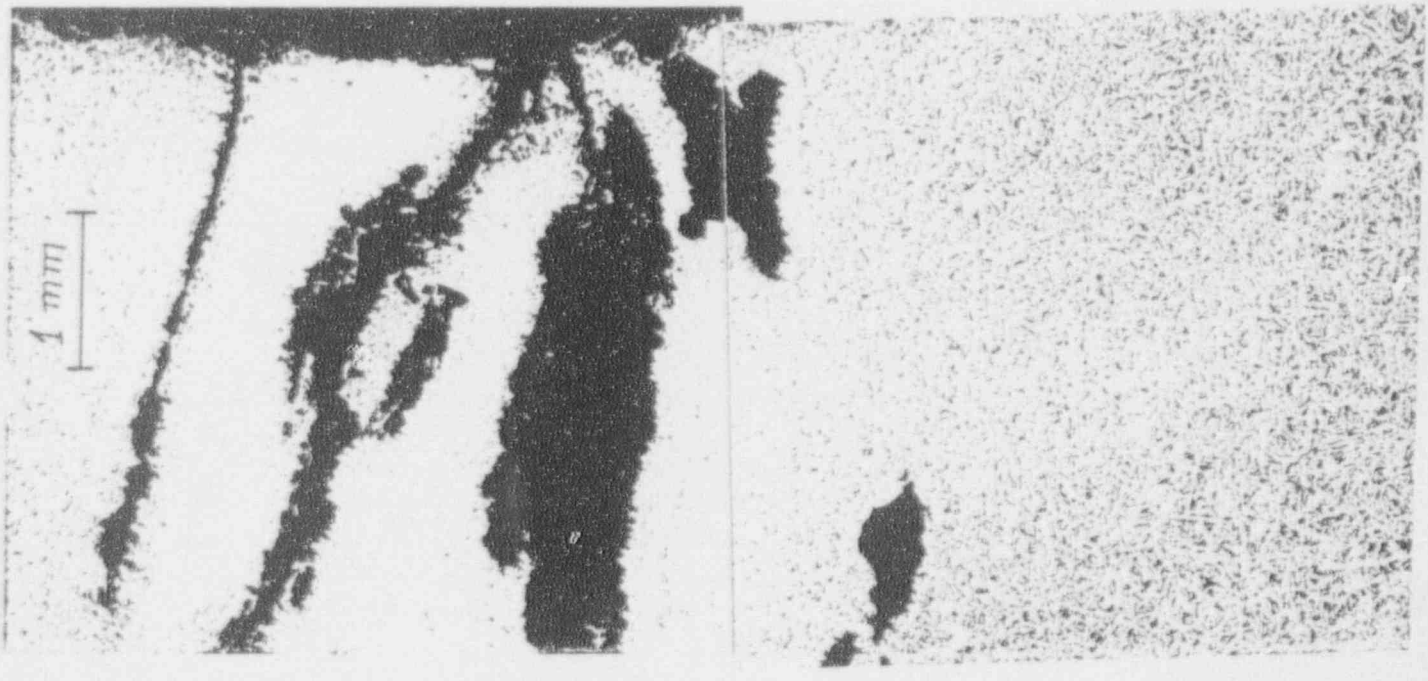


Fig. 5. Photomicrograph taken on the spot indicated with an arrow in Fig. 4. Notice that the cavities were filled with oxide but later on partially removed by polishing and metallographic etching. Also notice that the magnification used is relatively low and yet the Widmanstatten microstructure can be clearly seen. This gives an idea of the coarseness of this type of structure.

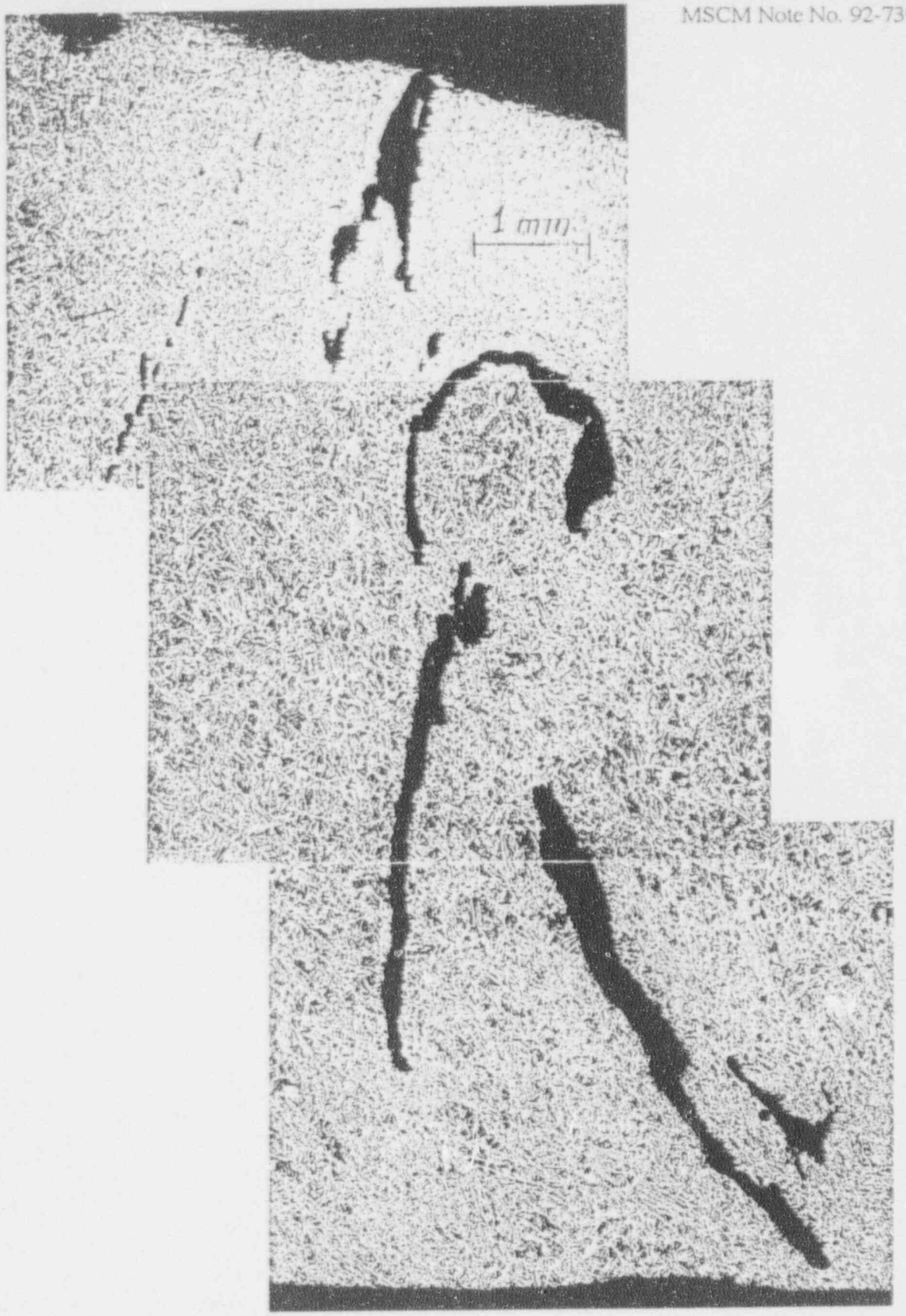


Fig. 6. Photomicrograph taken on the spot indicated with the arrow on the right-hand side of Fig. 4, showing other discontinuities found in the 8" flange. Notice that the Widmanstätten microstructure can be clearly seen despite the relatively low magnification used.

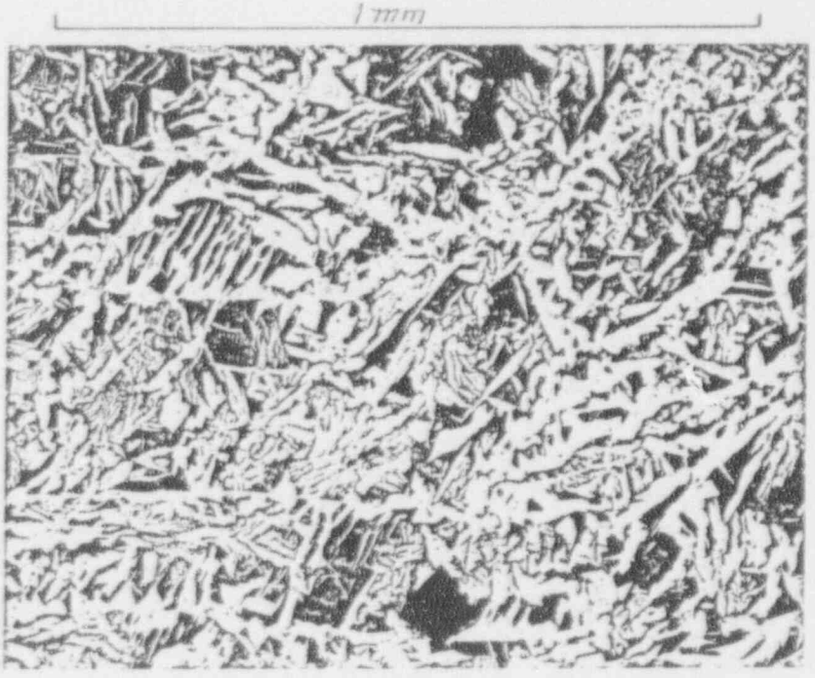


Fig. 7. Widmanstätten and very coarse structure found in the 8" flange and indicating overheating during the manufacturing process. This type of structure is usually associated with low impact properties and ductility. Hardness taken on this sample was 146-152 HV.

PC 5028
MANSUNCA

大钢机械工程总公司
DA GANG MACHINERY ENGINEERING CO.

材料试验报告
MATRIAL TEST REPORTS

CONTRACT: 83/CSM/0032 P.O.NO. 2087
MANUFACTURER: SHAO GANG MACHINERY PLANT
CUSTOMER:
ADDRESS:
MATERIAL: ASTM A105
CONCLUSION OF INSPECTION: 合格 OK
INSPECTED DATE: 1990 9 10

HEAT NO	C %	Si %	Mn %	P %	S %	T.S N/mm²	Y.P N/mm²	ELONG %	R.A %	HB	LOT NO OF HEAT TREATMENT	SPECIFICATION	PART NO	PART QTY
	0.27 MAX	0.35 MAX	0.6~1.05	0.04 MAX	0.05 MAX	70000 MIN	36000 MIN	22 MIN	30 MIN	HB187 MAX				
998	0.24	0.26	0.78	0.015	0.033	72575	42019	32	62	155		8"-150LB - SW BE	6450	750
988	0.27	0.30	0.86	0.019	0.021	82067	49310	23	56	174		6"-150LB - SW BE	10756	125
045	0.27	0.34	0.85	0.018	0.027	84117	50761	27	55	170		8"-150LB - LAP	8600	100
977	0.27	0.26	0.84	0.019	0.031	82667	49310	23	56	174		8"-150LB - SW BE	4300	500
[illegible]	[illegible]	0.24	0.80	0.013	0.035	77491	47660	30	62	160		6" [illegible]	[illegible]	[illegible]

HEAT TREATMENT DATA
NORMALIZING TEMP.
HOLDING TIME
TENSILE STRENGTH
YIELD STRENGTH
ELONGATION
REDUCTION OF AREA
HARDNESS
IMPACT
REMARKS

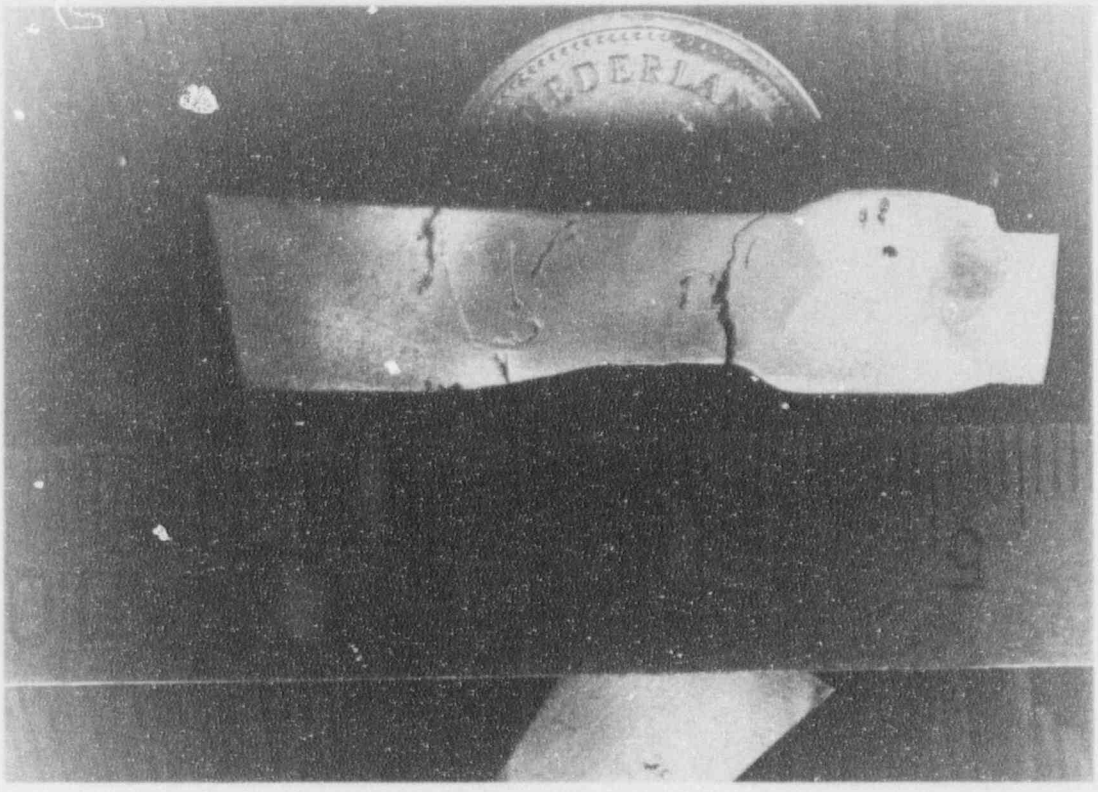
PC: 5028
MANSUNCA

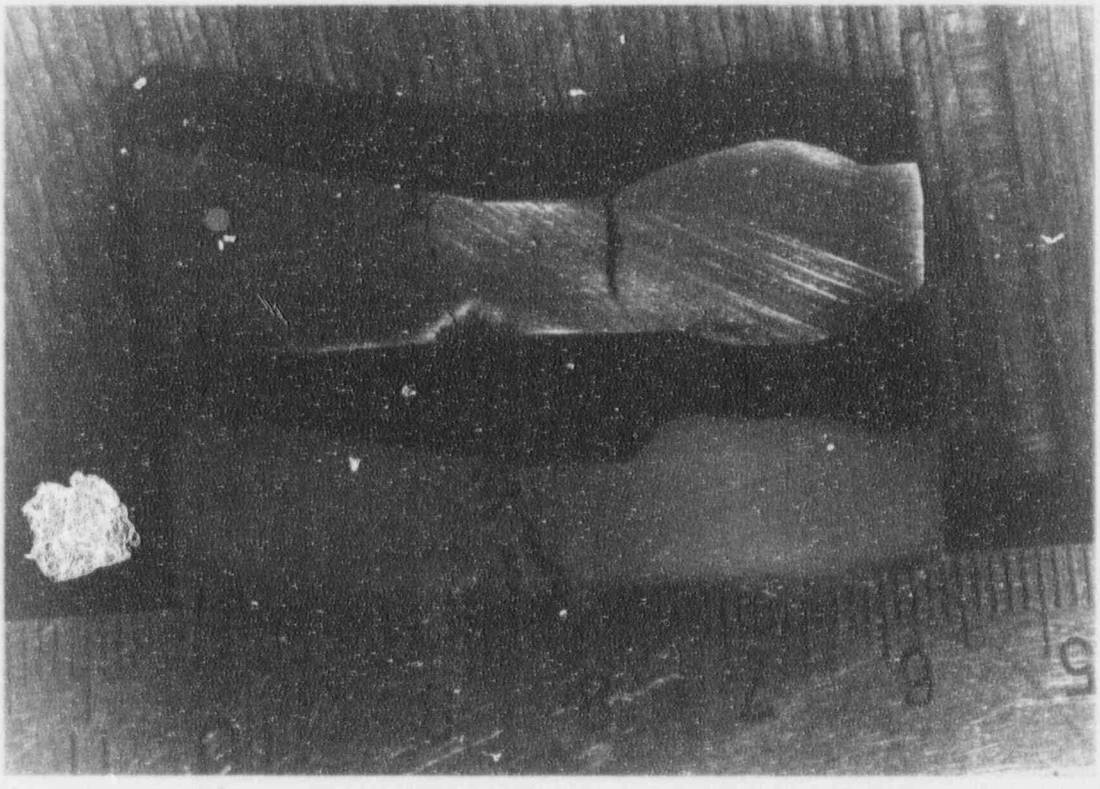
中国机械设备进出口总公司 CHINA NATIONAL MACHINERY AND EQUIPMENT IMPORT AND EXPORT CORP.

MILL TEST CERTIFICATE ASTM A-105

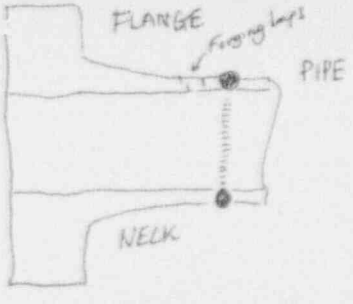
DESCRIPTION	CHEMICAL % C	Si	Mn	P	S	MECHANICAL Y.P	T.S	ELONG	R.A %	HB	HEAT #	QUANTITY
[illegible]	0.28	0.27	0.66	0.017	0.022	36	50	26	52	149	1224	1
[illegible]	0.23	0.24	0.68	0.014	0.022	35.7	51	26	58	145	1226	1
[illegible]	0.27	0.25	0.67	0.019	0.043	36.5	50	27	53	148	1230	1
[illegible]	0.32	0.25	0.70	0.017	0.022	36.8	51.9	28	59	156	06	1

INSULATING TEMPERATURE: [illegible]
DURATION OF TEMPERATURE: 1.5 h
COOLING METHOD: AIR
DATE OF INSPECTION: MAY 14 1991
JUNE 13 '91
INSPECTED BY:

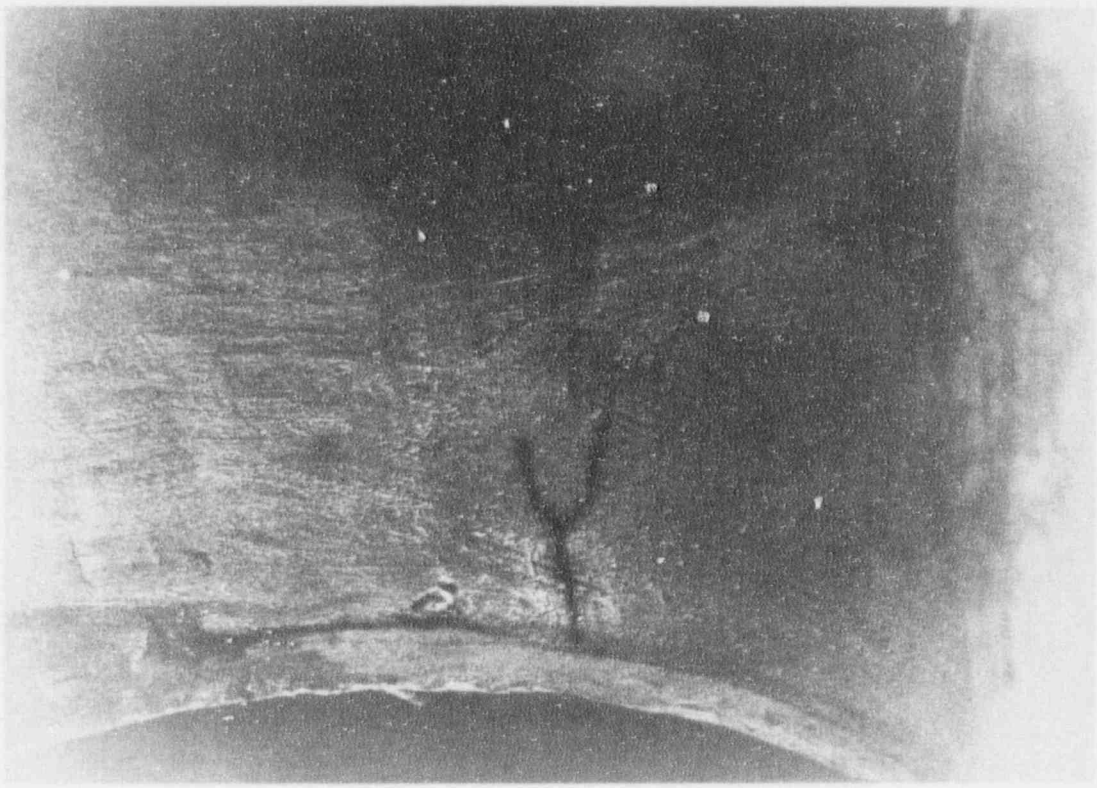




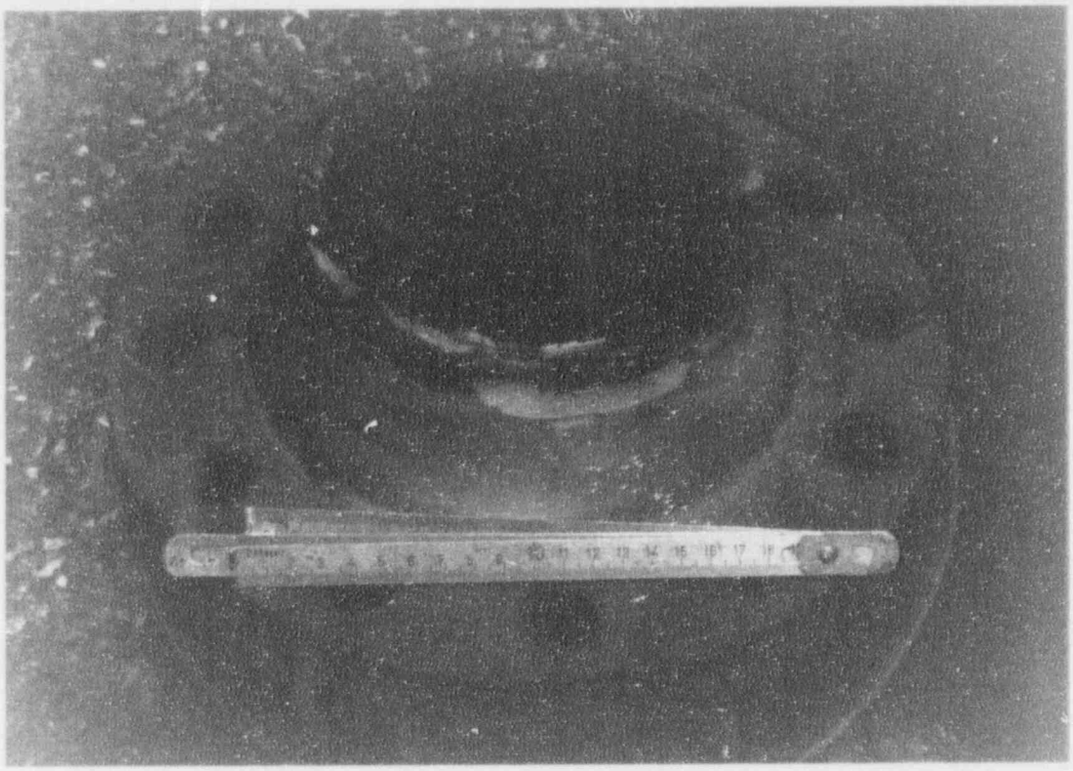
8" Weld Neck Flange

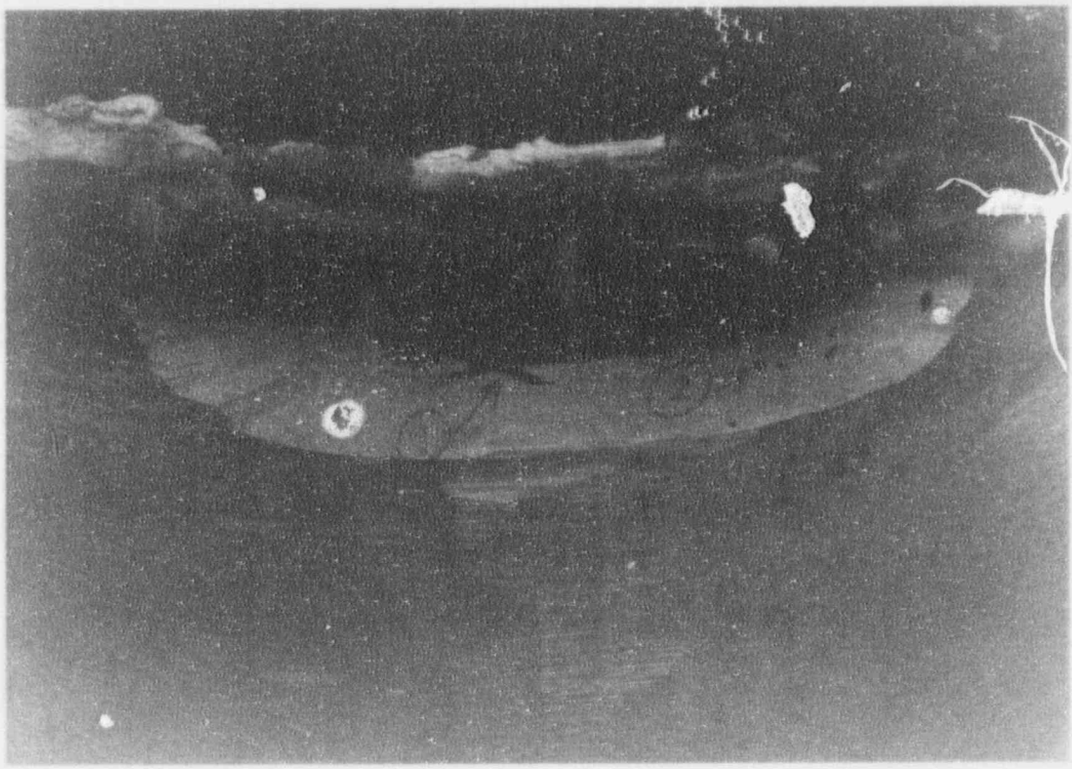


MARKING: 4" STD A 234 WPB (D) CHINA



4" Tee Joint





6" Weld Neck Flange

① Crack-like feature
② Porous-like feature

MILL REPORTS

Since ANSI B 16.5 and A 105 require heat number identification to appear on each flange, the following photographs and copies of mill reports can be used to identify products in the field.

Each mill test report has been annotated to identify where it or the product associated with it fails to comply with either ANSI B 16.5 or ASTM A 105. The photographs are included to illustrate various types of defects found.

MILL REPORT NO. 1

BC AK2

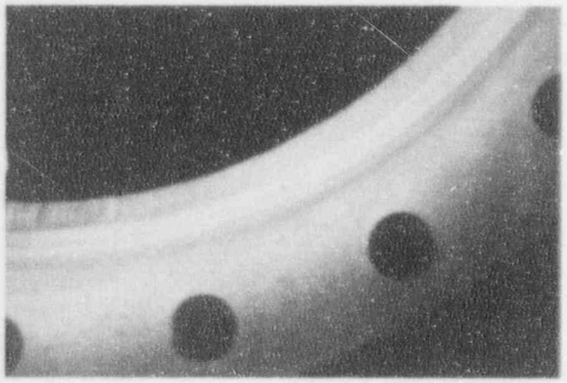
MILL TEST— CERTIFICATE

Cracks in Face

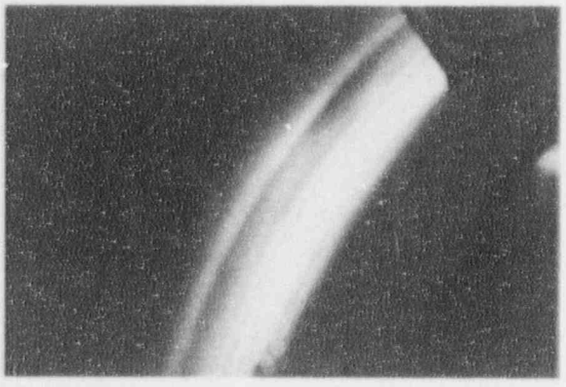
48 Flanges

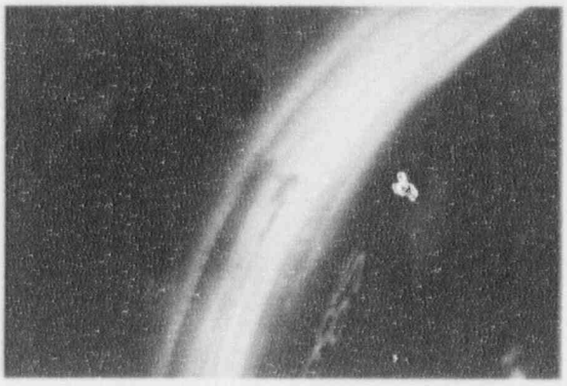
Province of SHANXI

DING XIANG NAN XI LI

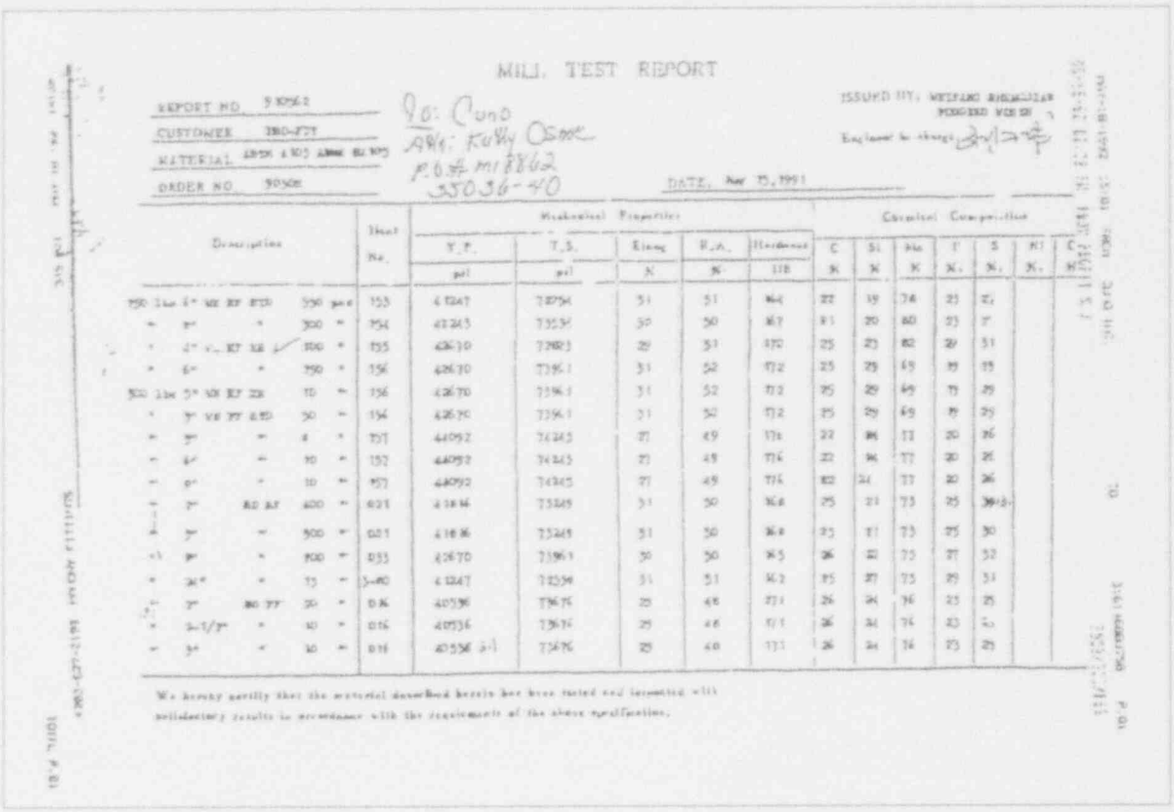


1. *The signature on this report is not the flange manufacturer. It is reported to be a trading company representative.*
2. *The sum of the chromium and molybdenum is .35% Maximum permitted by A-105 is .32%*
3. *Flange exhibits inclusions.*
4. *Tian Gong (trading co.) representative reported that Tai Gong is not the producing mill.*
5. *The trading company reported that Ding Xiang Flange Company did not use A-105 but instead used 25MN to produce all of its flanges (117-139 ions).*





MILL REPORT NO. 2



MILL TEST REPORT

REPORT NO. 5 X9562

CUSTOMER [illegible]

MATERIAL [illegible]

ORDER NO. 90506

Re: Cond
Attn: Kelly Osoc
P.O.# mi7862
35036-40

ISSUED BY: WELDING FABRICATION FORGING WORKS

Engineer in charge: [signature]

DATE: Nov 15, 1991

Description	Heat No.	Mechanical Properties Y.P. psi	T.S. psi	Elong %	R.A. %	Hardness HB	Chemical Composition C %	Si %	Mn %	P %	S %	Ni %	Cr %
750 lbs 6" WE BY 8730 350 pcs	153	41247	73754	31	51	144	22	19	74	23	32		
" 8" " 300 "	154	42345	73539	30	50	167	21	20	80	23	37		
" 4" x 12" BY 328 100 "	155	42630	73983	29	51	170	25	23	82	29	31		
" 6" " 350 "	156	42630	73961	31	52	172	25	25	69	35	35		
500 lbs 5" WE BY 228 10 "	156	42630	73961	31	52	172	25	29	69	35	35		
" 5" WE BY 8730 50 "	156	42630	73961	31	52	172	25	29	69	35	35		
" 3" " 4 "	151	44092	74345	31	49	174	22	26	72	20	26		
" 6" " 10 "	152	44092	74345	31	49	174	22	26	72	20	26		
" 8" " 10 "	157	44092	74345	31	49	174	22	24	72	20	26		
" 3" AD BY 600 "	021	41836	73569	31	50	168	25	21	73	25	39		
" 3" " 500 "	021	41836	73569	31	50	168	25	21	73	25	30		
" 8" " 500 "	033	42670	73961	30	50	165	26	22	73	27	32		
" 24" " 75 "	5-40	41247	73539	31	51	162	25	27	73	29	31		
" 3" AD BY 20 "	016	40536	73674	29	48	171	26	24	74	23	25		
" 3-1/2" " 10 "	016	40536	73674	29	48	171	26	24	74	23	25		
" 3" " 10 "	016	40536 5-1	73674	29	48	171	26	24	74	23	25		

We hereby certify that the material described herein has been tested and inspected with satisfactory results in accordance with the requirements of the above specification.

1. *Unspecified elements not listed as required by paragraphs 6.2 and 16.2 of ASTM A-105.*

2. *No record of normalizing as required by 16.2.*

no photos available

Mill Report No. 3

首钢机械工程总公司
SHOU GANG MACHINERY ENGINEERING CO.

材料 试验 报告
MATERIAL TEST REPORTS

CONTRACT: (90)OE1439m   P.O.NO. 10936

MANUFACTURER: SHAN DONG

CUSTOMER: [illegible] VALVE CORPORATION

ADDRESS: [illegible] NORTH WEST [illegible] AVENUE PORTLAND OREGON 97201.

MATERIAL: A105

CONCLUSION OF INSPECTION: OK

INSPECTED DATE: Sep. 10, 1990.

NAME OF PART: FLANGES

CHECKED BY: [illegible]

HEAT NO	C %	Si %	Mn %	P %	S %	T.S	T.P	ELONG %	R.A %	HB	LOT NO OF HEAT TREATMENT	SPECIFICATION	PART W/W KG	PART QTY PCS
1-366	0.24	0.27	0.60	0.026	0.015	56.5	33.6	25.4	53.0	165		16" 150# W/N RF		360
1-406	0.27	0.25	0.80	0.017	0.022	65.6	46.8	26.[illegible]	50.2	159		18" 150# S/O RF		150
1-405	0.24	0.23	0.75	0.021	0.018	55.4	37.4	30.0	52.0	170		20" 150# S/O RF(FF)		210
2-284	0.25	0.26	0.78	0.017	0.026	55.3	35.9	31.0	51.0	168		[illegible]		470
2-309	0.23	0.26	0.78	0.025	0.030	60.3	37.6	28.0	50.0	170		24" 150# S/O RF		200

HEAT TREATMENT DATA: NORMALIZING TEMPERATURE; MAINTAINING TIME OF TEMPERATURE

This MTR is certify [illegible] ASTM A105 and ANSI B16.5.

OTHERS,

SHOUGANG MACHINERY ENGINEERING CO. FOR EXAMINATION ONLY

1. *Unspecified elements not listed as required by paragraphs 6.2 and 16.2 of ASTM A-105.*

2. *Independent laboratory tests do not confirm the test results of this material test report.*

3. *Flanges produced to heat 1-406 are marked A-105N. This test report does not indicate normalization.*

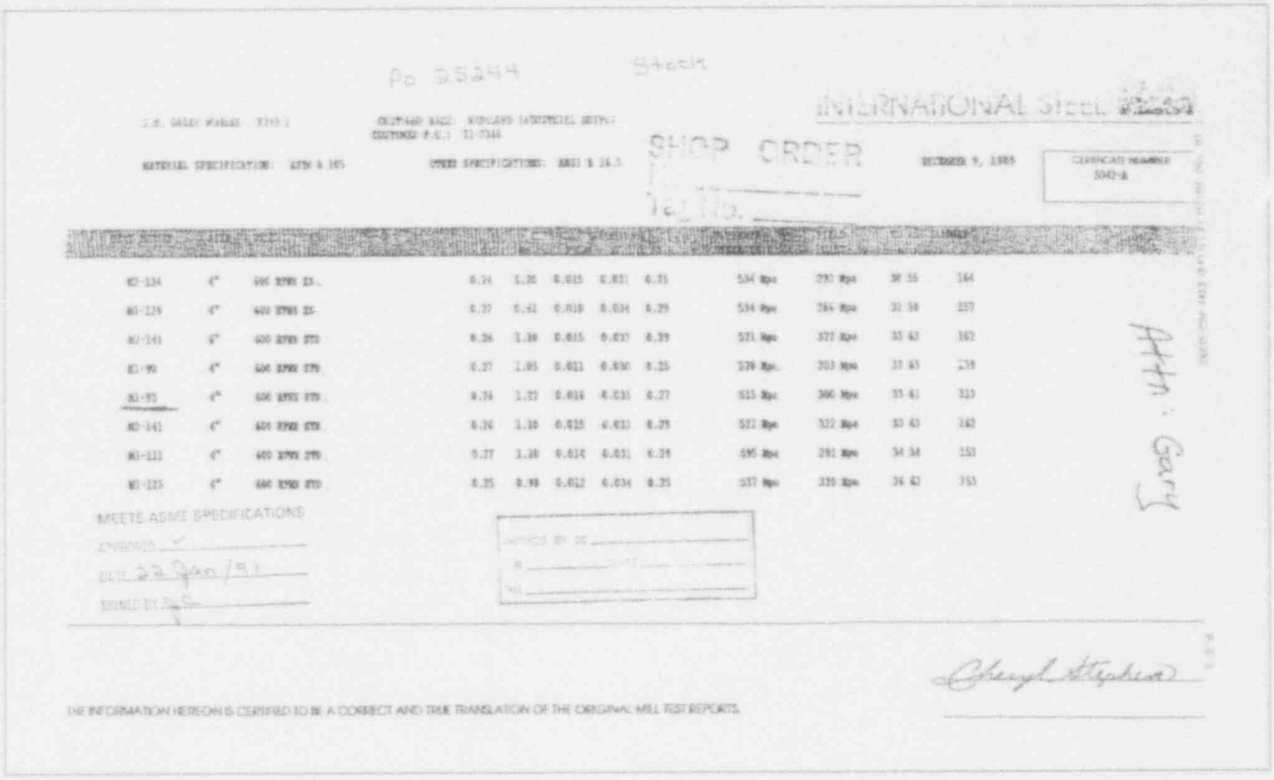
4. *Heat 1-406 flanges have had voids filled with steel rods and then welded over (slugged welds).*

no photos available

MILL REPORTS NO. 4 (A-E)

1. *Do not identify unspecified elements.*

2. *Do not indicate normalizing.*



Po 32344 Stock

INTERNATIONAL STEEL

SHOP ORDER

Tag No.

MATERIAL SPECIFICATION: ASTM A 105 OTHER SPECIFICATIONS: ANSI B 16.5 DECEMBER 9, 1993 CERTIFICATE NUMBER 5043-A

80-134	4"	600 B781 23	0.24	1.20	0.015	0.031	0.35	534 Mpa	293 Mpa	30 55	164
80-126	4"	600 B781 25	0.27	0.61	0.010	0.034	0.29	534 Mpa	284 Mpa	31 58	207
80-141	4"	600 B781 270	0.26	1.30	0.015	0.037	0.39	521 Mpa	322 Mpa	33 63	163
80-90	4"	600 B781 279	0.27	1.05	0.011	0.030	0.25	539 Mpa	303 Mpa	37 63	239
80-95	4"	600 B781 279	0.24	1.32	0.016	0.031	0.27	515 Mpa	300 Mpa	35 61	213
80-141	4"	600 B782 270	0.26	1.30	0.015	0.031	0.29	521 Mpa	322 Mpa	33 63	163
80-111	4"	600 B793 279	0.27	1.30	0.014	0.031	0.29	595 Mpa	291 Mpa	34 54	153
80-125	4"	600 B793 270	0.25	0.98	0.012	0.034	0.25	557 Mpa	339 Mpa	36 62	353

MEETS ASME SPECIFICATIONS

APPROVED ✓

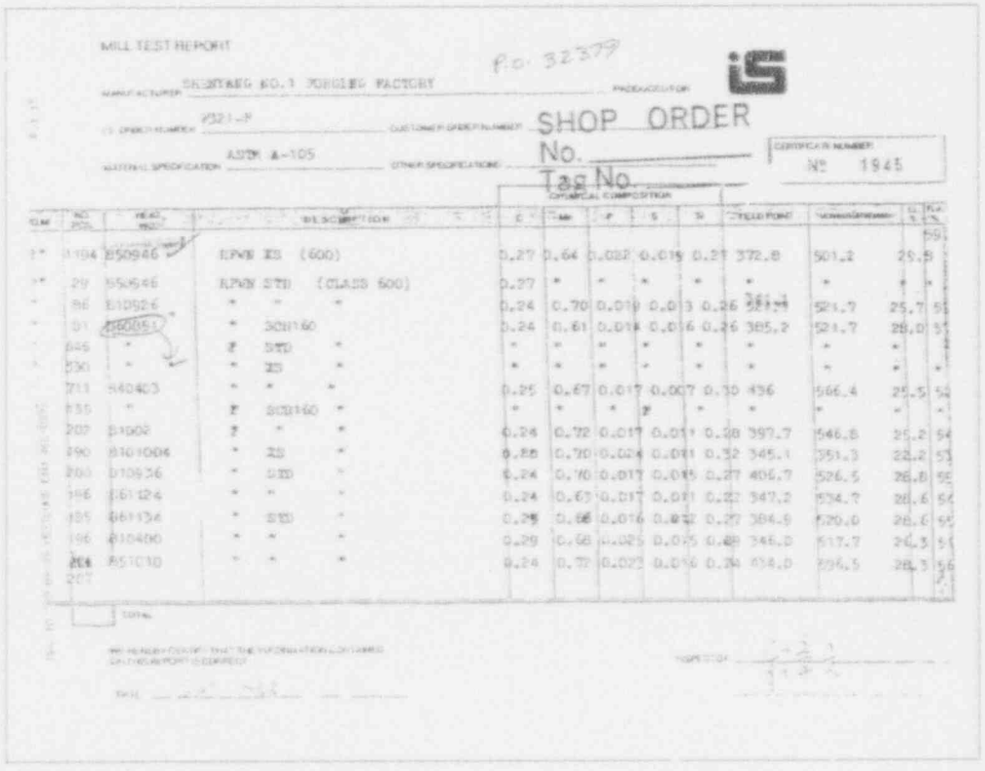
DATE 23 Dec / 93

SIGNED BY

Attn: Gary

THE INFORMATION HEREON IS CERTIFIED TO BE A CORRECT AND TRUE TRANSLATION OF THE ORIGINAL MILL TEST REPORTS.

A



MILL TEST REPORT

P.O. 32379

MANUFACTURER: SKEIN & BEG NO. 1 FORGING FACTORY PRODUCER:

SHOP ORDER No.

Tag No.

MATERIAL SPECIFICATION: ASTM A-105 OTHER SPECIFICATIONS:

CERTIFICATE NUMBER: № 1945

ITEM	NO. PCS.	HEAT NO.	DESCRIPTION	CHEMICAL COMPOSITION C	Mn	P	S	Si	YIELD POINT	TENSILE STRENGTH	ELONG. %	R.A. %
1**	8194	850946	ERNE ES (600)	0.27	0.64	0.022	0.015	0.21	372.8	501.2	29.5	59
2**	29	550646	ERNE 270 (CLASS 600)	0.27	"	"	"	"	"	"	"	"
3	96	810926	" " "	0.24	0.70	0.019	0.013	0.26	361.1	521.7	25.7	55
4	91	880061	" 3011160	0.24	0.61	0.018	0.016	0.26	385.2	521.7	28.0	55
5	845	"	" 270 "	"	"	"	"	"	"	"	"	"
6	830	"	" 23 "	"	"	"	"	"	"	"	"	"
7	711	840403	" " "	0.25	0.67	0.017	0.007	0.30	436	566.4	29.5	52
8	835	"	" 8031160 "	"	"	"	"	"	"	"	"	"
9	207	81902	" " "	0.24	0.72	0.017	0.011	0.28	387.7	546.8	25.2	54
10	890	8101006	" 23 "	0.28	0.70	0.024	0.011	0.32	345.1	551.3	22.2	53
11	200	810636	" 270 "	0.24	0.70	0.017	0.015	0.27	406.7	526.5	26.8	55
12	196	861124	" " "	0.24	0.63	0.017	0.011	0.22	347.2	534.7	28.6	56
13	195	861134	" 270 "	0.25	0.66	0.016	0.012	0.25	384.9	520.0	28.6	55
14	196	810480	" " "	0.29	0.68	0.025	0.015	0.28	346.0	517.7	24.3	51
15	204	851010	" " "	0.24	0.72	0.023	0.016	0.24	454.0	596.5	28.3	56
16	207											

TOTAL

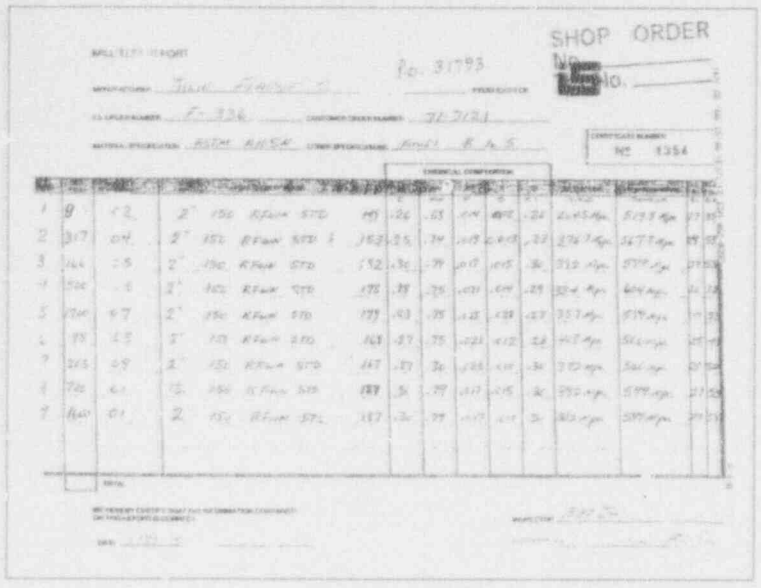
WE HEREBY CERTIFY THAT THE INFORMATION CONTAINED IN THIS REPORT IS CORRECT.

DATE

INSPECTOR

B

MILL REPORTS NO. 4



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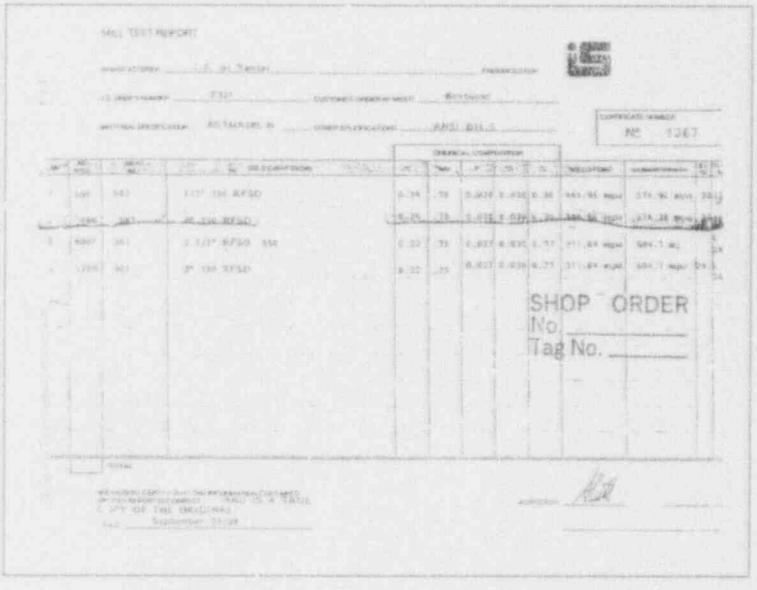

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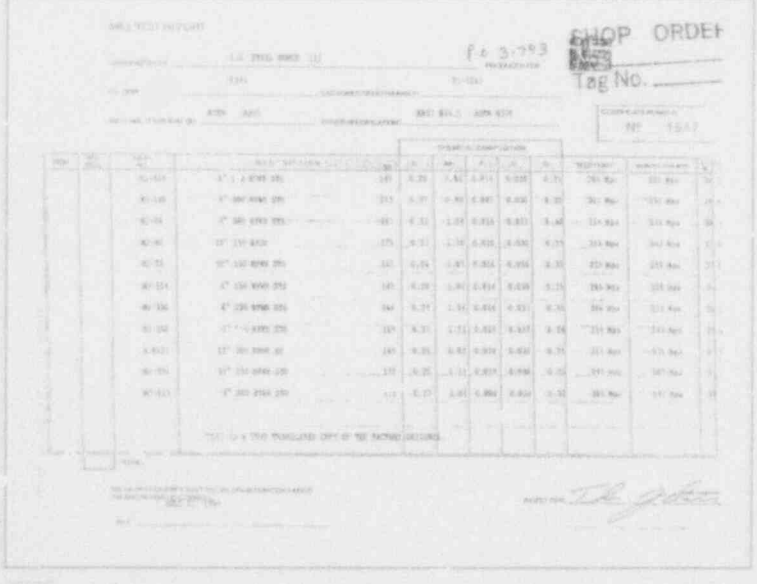


E

no photos available

MARKINGS, DESCRIPTIONS & PHOTOGRAPHS

Flanges with the following markings have been reported to the National Board as problematic. This information should prove useful since flanges from the same heat should carry markings identical to these.

DSI 4 300 RF B16 A-105N STD.345 CHINA

Cracked in heat affect zone

- Hardness at fracture edge into the hub, range from over 500 to over 260 BHN.
- Chemical analysis was as follows C -.38, Mn -.82, P -.028, S -.037, Si -.030, Ni -.40, Cr -.40, Mo -.15, Cu -.47
- The microstructure of the flange forging indicates an improper heat treatment after forging and certainly did not depict a normalized structure as would be expected from the "N" stamp on the forging.

B-16.5 072 LEO STD TMI 454 CHINA

- Cracking with inclusions. Cracks ground to .375" and increased in size.

LEO 4" 150 RFWN STD B-16 A-105 TB-511 CHINA

(TWO FOUND)

- Had been repaired by welding and had not been stress relieved or stamped per ASTM.

4" 150 N B-16 A-105 DZ44 GJ CHINA

- Cracked in the weld neck and had inclusions in two locations.

4" 300 STD A-105 57 CHINA

- Weld neck cracked while welding.

A-105 LEO 6 150 RFWN STD B-16

- Numerous inclusions in face.
- Inclusions in flange wall.

4 300 STD B-16 A-105 N W/N 58 CHINA

- Deformed bolt hole.
- Chip in the raised face.
- Gouges in the weld neck.

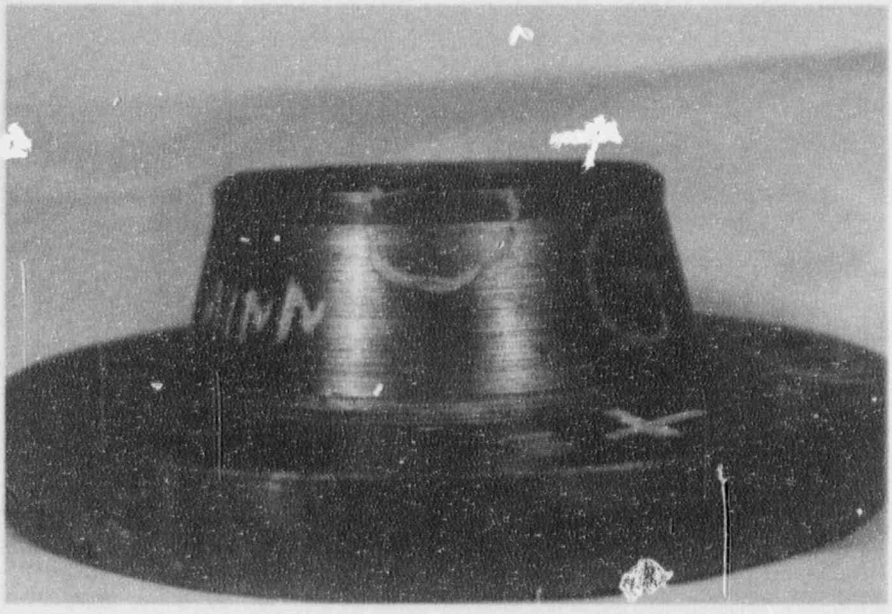
QD CHINA 6 150 A105 90-610 B16.5

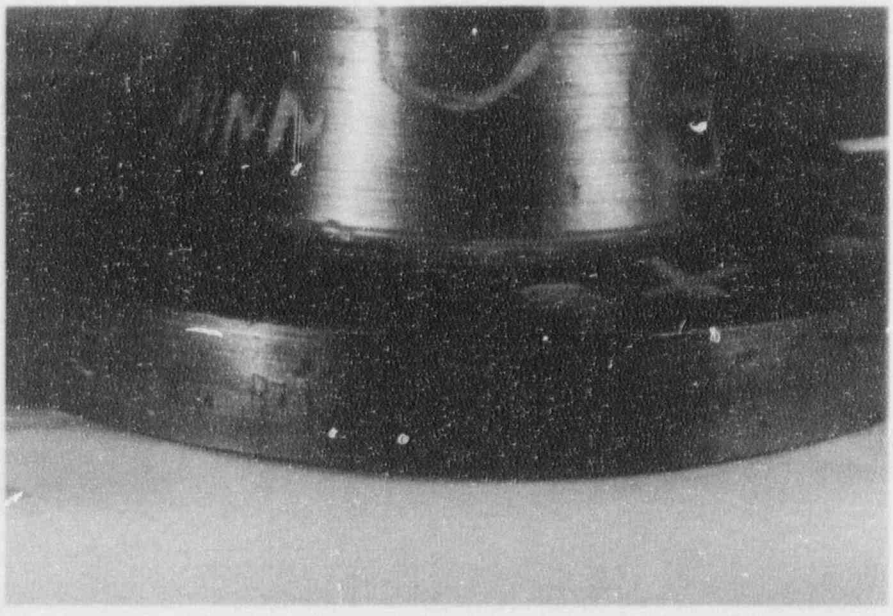
- [6] is in error. This blind flange is 8" size.
- Flange leaked in approximately 16 separate places.
- Flange showed evidence of extensive welding.
- Weld repairs were not identified with a letter "W" as required by A105.

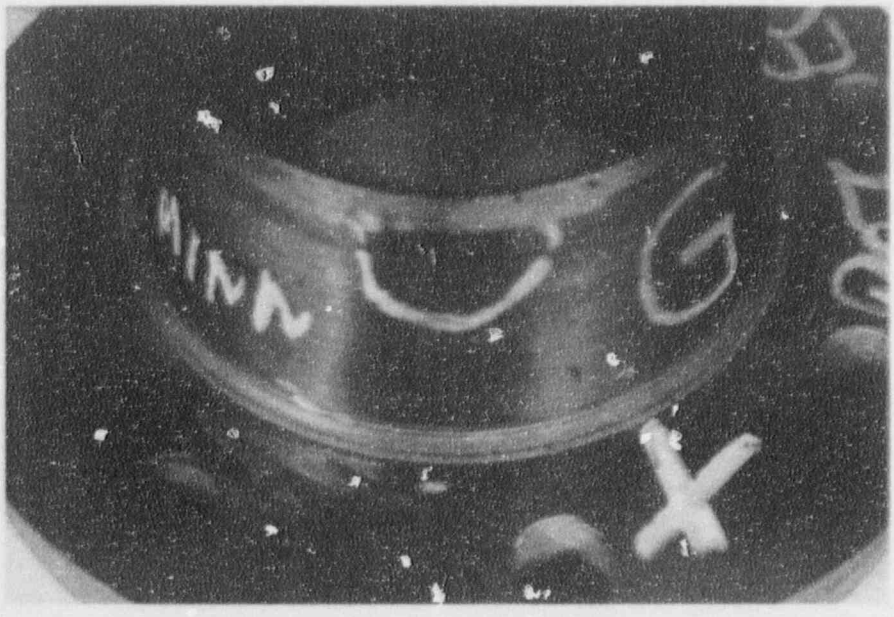
18 2 150 RFSO B16 A105 109MI 292 CHINA

- radial crack from bore to bolt hole – visible from both sides – found during hydro.

We have reason to believe one facility, as a result of mill test reviews, has rejected 5,000 China flanges, 3,000 of which had already been welded on pipe spools. Subsequent tests at an independent laboratory revealed that chemistry was out of spec on more than 50% of 31 heats. In addition, the macroetch revealed a number of the flanges had not been normalized although the letter "N" was stamped on the flange per ASTM.

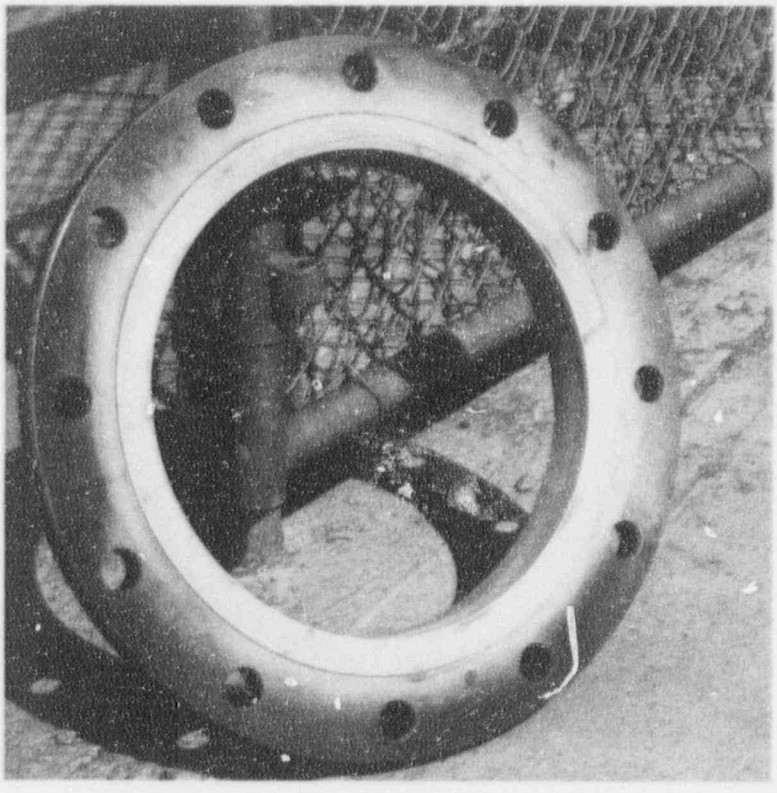




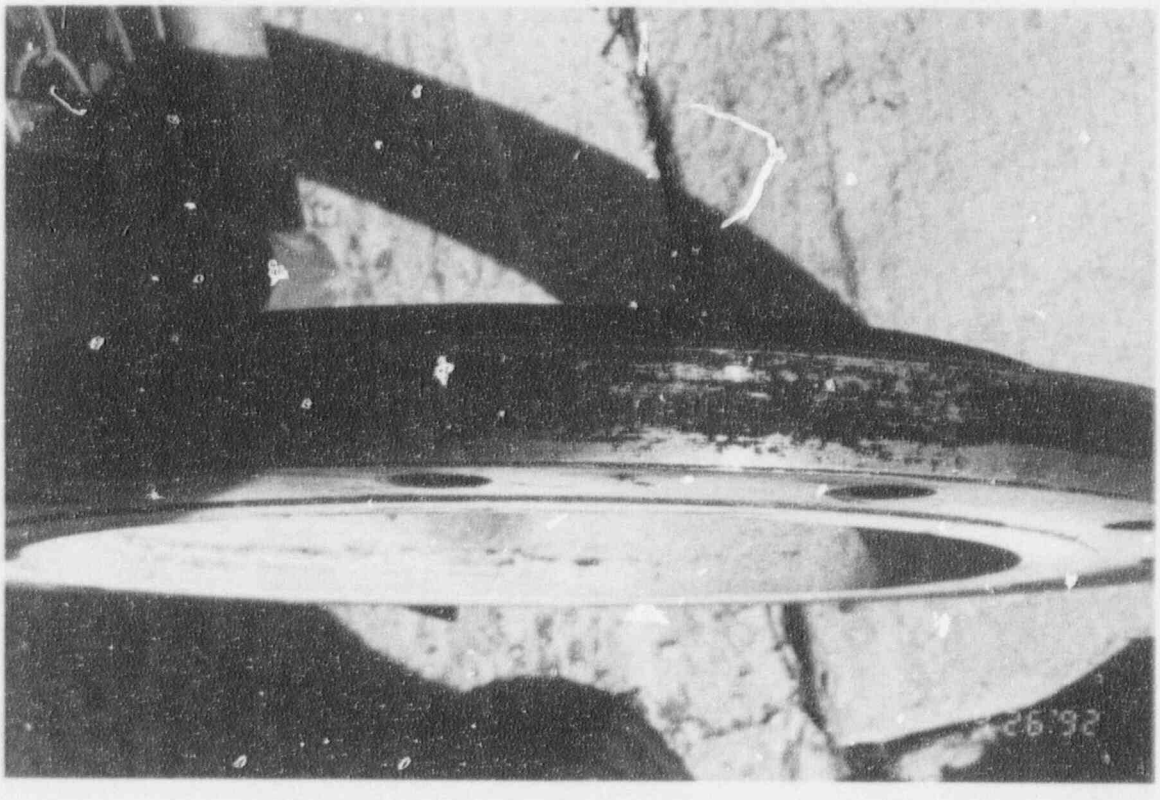


Flange exhibits laps or seams to an edge depth of approximately 50% of wall thickness.

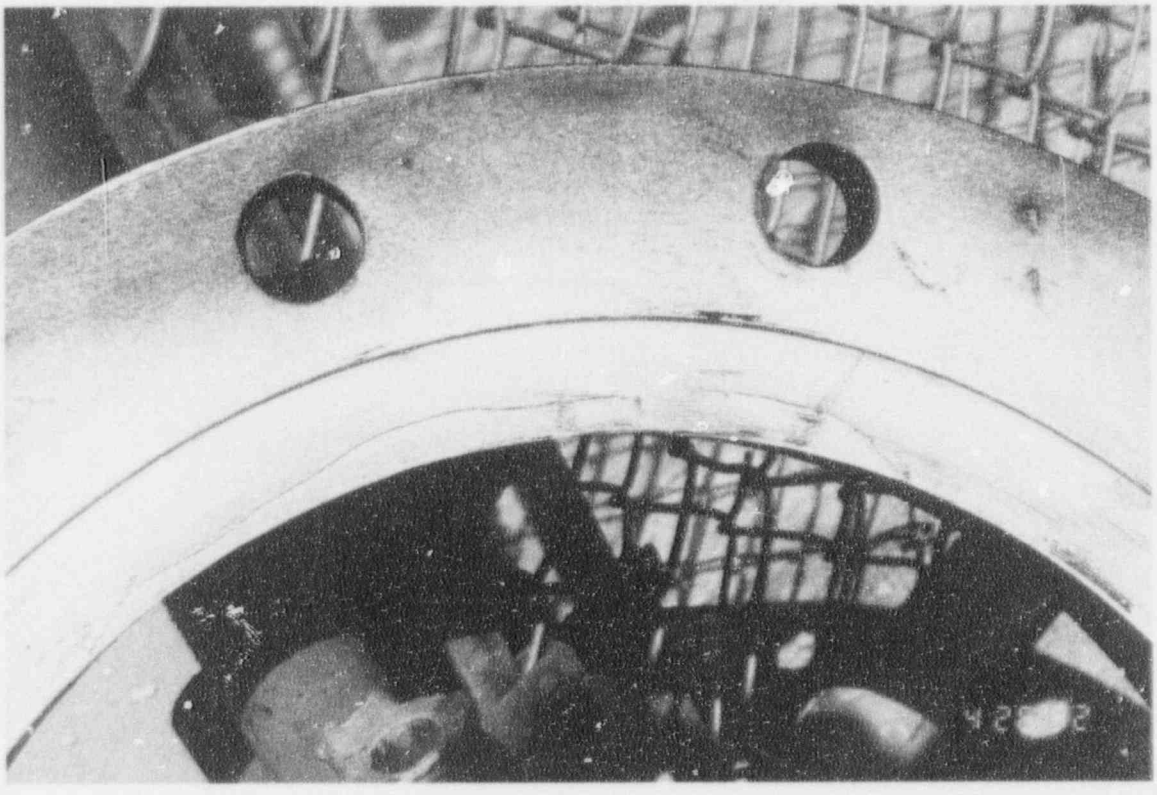
The following four photographs are of a 14" slip-on flange found in Alberta, Canada. This flange is identified with the following markings:



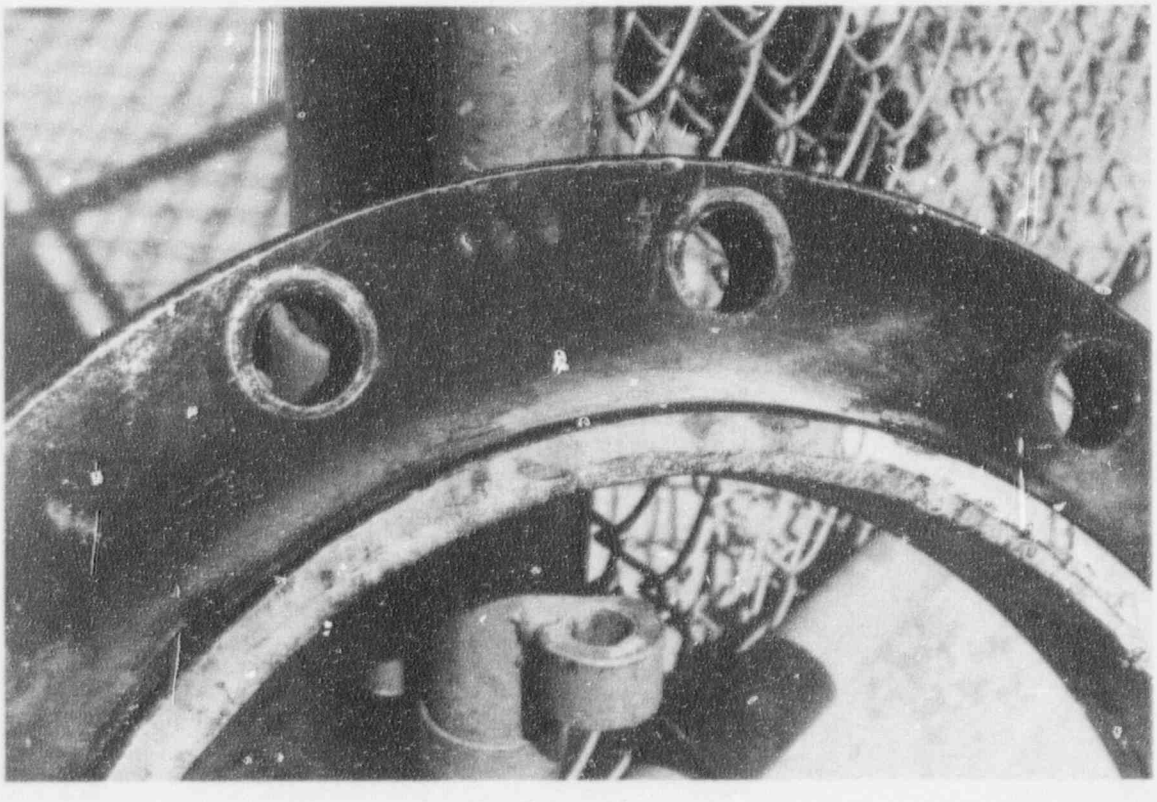
Full flange



SXM A105 B16.5 150 SO RF 14 B913725 CHINA



Gasket side



Other side

LETTER OF RESPONSE FROM CBPVI

BPVI **CENTRE OF BOILER & PRESSURE VESSEL INSPECTION & RESEARCH OF THE MINISTRY OF LABOUR, P. R. C.**

FACSIMILE TRANSMISSION:

TO: Mr. John D. Mcloughlin
NBBI

FAX NO: 614 888-0750

ATTENTION:

FROM: Wang Hanmuo
Director of CBPVI

DATE SENT: Aug. 31, 1993

NO. OF PAGES (inc. over-sheet) 1

PLEASE ADVISE AS SOON AS POSSIBLE IF ALL PAGES ARE NOT RECEIVED

Dear Mr.Mcloughlin,

I have read your letter to Mr.Zhang Lianhai (CBPVI's vice Director) on Aug. 6th,1992 as well as the copy of your letter to Mr. Zheng Youmei (the State Council of P.R.C.). For the importance of the matter, Mr.Zhang Lianhai has reported me all the details about it, and I also have got the information about the discussion between you and our Liao Ning Province delegation just in U.S.. As the director of CBPVI, I'd like to inform you something about the quality of the flange made in China.

How to result the problem of the quality of the flange made in China? Thank for your and our great efforts, The State Inport and Export Commodities Inspection and testing Bureau of P.R.C. has issued a order about it. The main points of the order is as follow:

In order to ensure the quality, since Jan.1st,1993, all the flange, elbow, tube for boiler and pressure vessel made in China for export must be compelled to be inspected and tested by CBPVI or some other inspective units according to the international standards or the standards of the imported countries. Would you be so kind to inform these to your coleagues as well as the companies concerned in your convenience, to add the clause about this mandatory inspection in their contracts concerned, and to make sure the inspective marks on the commodities concerned.

I am looking forward to hearing from you soon!

With my best regards,

Your sincerely

王汉谋

Wang Hanmuo
Director of CBPVI

8# Ji Chang Nan [illegible]
Tel. (01) 4666[illegible]
Dong Zhi Men Wai Niu Wang Miao
FAX (01) 4666503, (01) 4666596
Beijing 100027
Cable: BEIJING 6936

page 1

THE NATIONAL BOARD OF BOILER
AND PRESSURE VESSEL INSPECTORS
1055 CRUPPER AVENUE
COLUMBUS, OHIO 43229-1183

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