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COUNTRY PAPER FROM SAUDI ARABIA

SPECIAL CORROSION PROBLEM AND THE REPAIR AT SAFCO*

by

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UREA REACTOR

INTRODUCTION

Saudi Arabian fertilizer Company has a 600 ton single train ammonia plant and 1,000 ton single train urea plant alongwith other required facilities. The plant was originally built on turn-key basis by CHEMICO - USA and was put in commission early 1970.

The urea autoclave was designed and constructed by Messrs. Mitsubishi Heavy Industries - Japan. This vessel is designed for a pressure of 4,000 psig at 400°F, operating pressure and temperature are 3200 psig and 384°F respectively. The general arrangement and design of the vessel is as shown in the attachment-I of this report. The construction comprises of multilayer shell in carbon steel with forged top and bottom. The inside cylindrical section of the vessel is lined with 16 mm thick SS.316-L plate. The top and bottom heads do not have the liner but have a 1/4" weld overlay in SS-316-L. The over all height is 90 feet and ID is 5 feet. The internal construction of the autoclave comprises of 3 feed inlets at the bottom with distributor dome for proper mixing. There are 19 trays in the vessel with 4 ft. spacing. The vessel is made of 16 cylinders welded together to make a long vessel. Each cylinder has 2 weep holes through the multilayer shell. These weep holes are to indicate a failure of the liner in the cylindrical section.

OPERATING HISTORY AND FAILURE

Until August 1978, there had been no major difficulties or failures experienced with this vessel. Regular inspection of the reactor was carried out in each annual plant turnaround.

On 10th August 1978, the autoclave developed a leak through the bottom forging. The urea plant was shutdown and the vessel was opened for inspection. Examination of the failure revealed that wide area around bottom distributor was severly eroded/corroded. The extent of damaged area is shown in the attachment-II. At one location, the metal was completely corroded and while in service it developed a small rupture. At the point of failure, the opening was 1.5" long and about 0.2" wide. There were no visible bulges or deformities on the outside surface of the autoclave bottom. The material loss in the corroded area varied from 0.25" to 3" at certain locations. Generally, the loss was about 2" at most places.

REPAIR PROCEDURE

Several alternatives were considered for repair. The manufacturers were also contacted. Safco's recommendations for repair procedure were as follows-

1. Remove damaged S.S. overlay.

2. Grind any sharp contours for preparation to deposit weld metal.

3. Build up all cavities by manual metal arc using E-7016 electrode. Continue to build up until correct wall thickness is reached all over. After each bead of weld deposit, care be taken to remove all slag inclusion. At the end of carbon steel welding, the entire surface should be ground out smoothly in preparation of dye-penetrant inspection. Subsequent to dye-penetrant inspection of the carbon steel weld, the entire surface is to be deposited with one layer of E309 - 4 mm electrode. After this overlay, the surface is ground to remove all inclusions and surface defects. Post weld heat treatment to the repaired area is to be conducted to relieve the metal of all weld stresses. The heat treatment procedure is shown in appendix-III. After the post weld heat treatment, deposit the entire surface with E-316L-4mm electrode in 2 layers. Include also the unaffected areas of the bottom head for the final overlay.

4. Reassemble the bottom distributor.

5. Ultrasonically check the repaired area thoroughly for any weld defects.

6. Hydro-test the reactor to full test pressure of 5,000 psig. The rate of pressure rise, the holding time and rate of pressure drop during depressurizing are shown in the appendix-II.

The repair work was started based on Safco's repair procedure. The manufacturers recommendation received later was basically same as has been adopted by Safco. The only point of variance being Mitsubishi had recommended an initial preheat of 400°F to remove defused hydrogen and subsequently to continuously maintain a preheat of 400°F. Safco had considered preheating but decided that it is not practical without the use of air cooled suits. Since these were not available, preheating was not done. However, it was felt that continuous weld operation and high ambient temperatures will maintain a high metal temperature of say 150°F overall and about 200°F at points close to welding operation.

CAUSES OF FAILURE

The failure of the bottom of urea reactor is attributed to the gradual thinning out of the S.S. overlay over a period of time. The thinning of weld overlay was due to high velocity of the fluid entering the vessel and deterioration of S.S. 316 L weld deposit. Another factor which could have contributed is the oxygen content in the CO_2 feed to the reactor. It is possible that the oxygen content was actually lower than indicated because of faulty instrumentation.

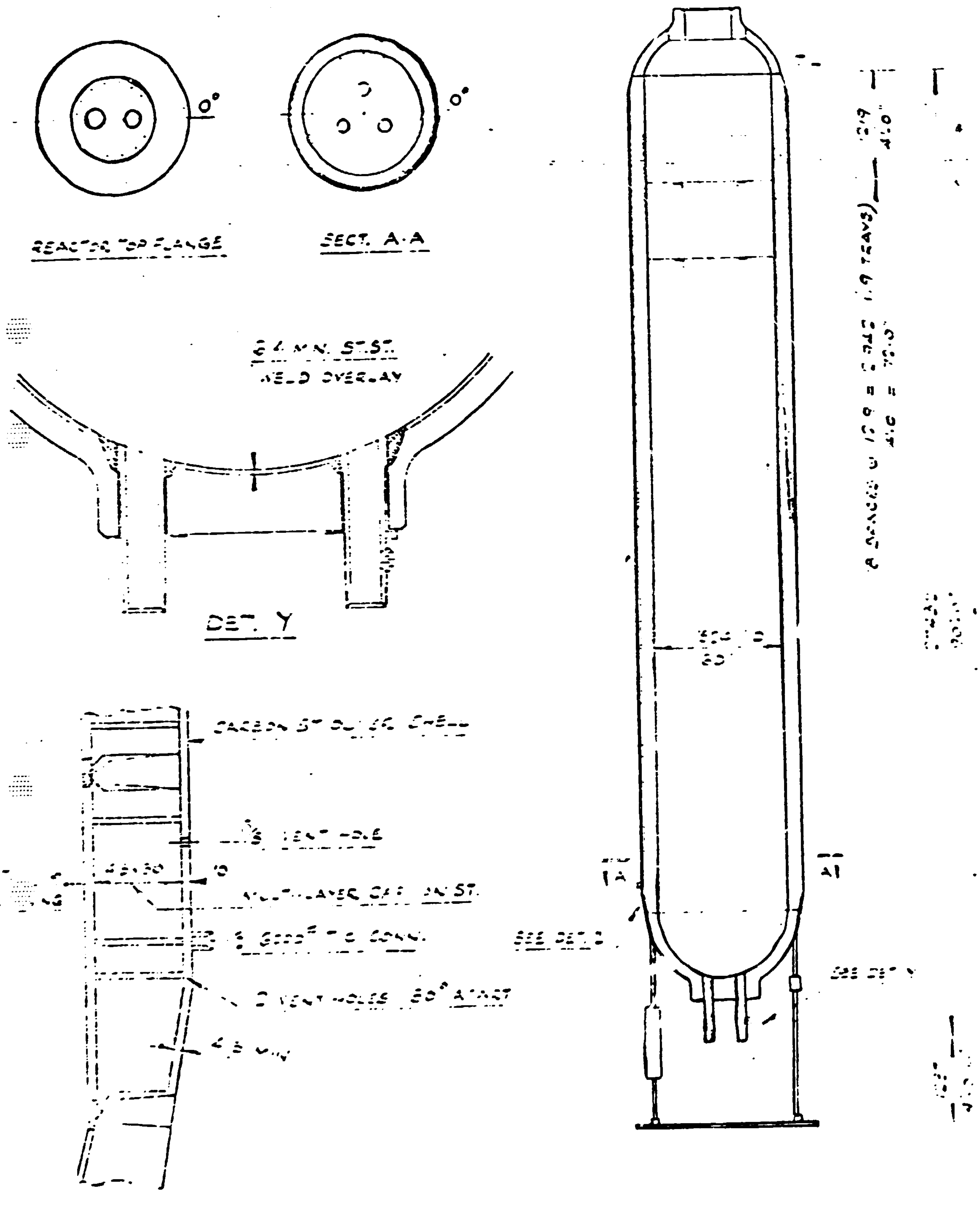
It has been found that SS-316-L weld overlay is susceptible to urea attack over a period of service. A new electrode by the trade name of Thermanit 19/15 H has been developed and is claimed to be better than E-316-L. The manufacturer of the autoclave is now recommending use of this improved electrode.

CONCLUSION

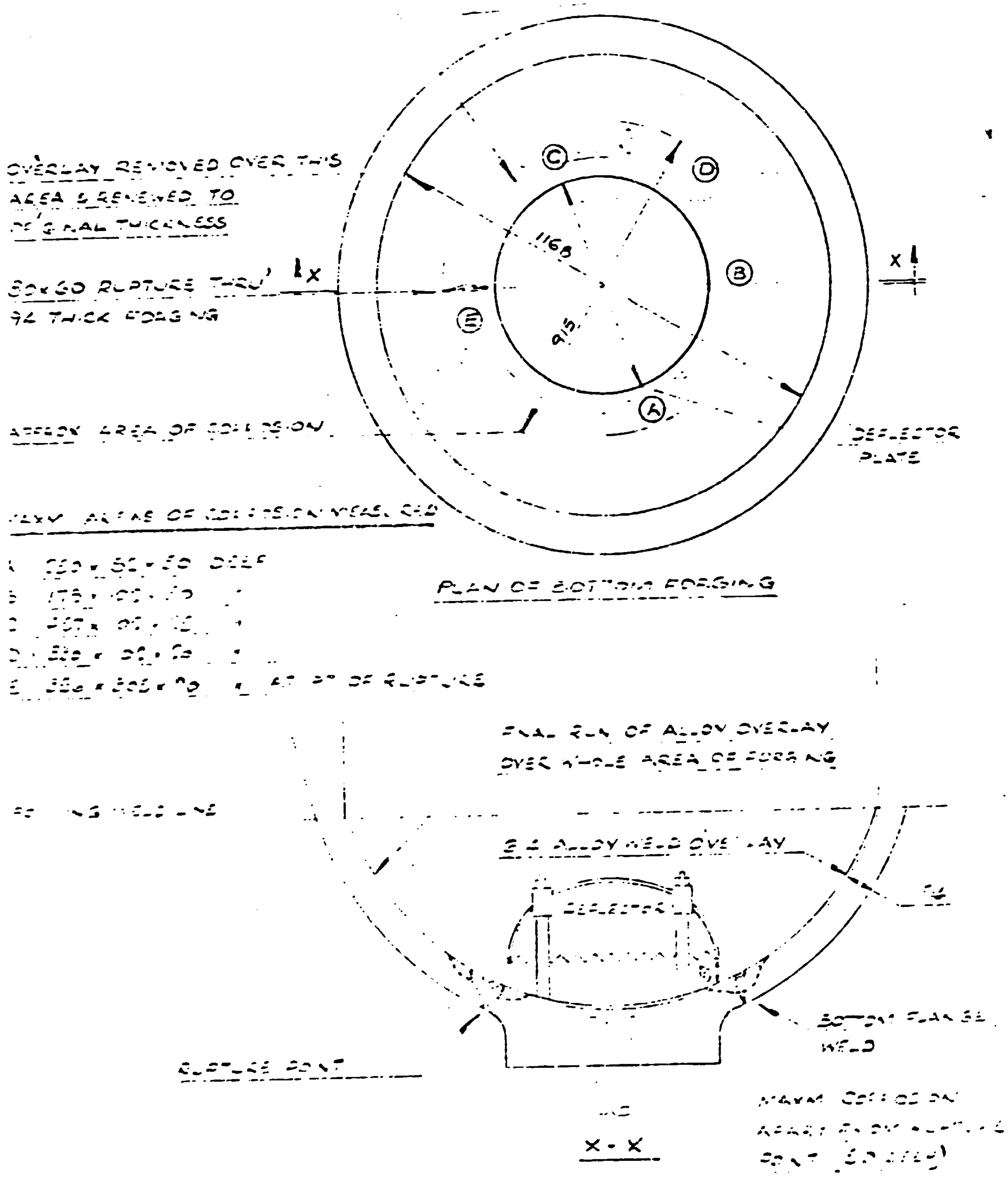
We have compared the performance of our autoclave with that of others and found that the vessel has given satisfactory service as can be expected. The failure experienced in August 1978 could have been averted if we had ascertained the proper thickness of the weld overlay on the bottom at the time of inspection during May 1978 turnaround. The repairs carried out by Safco were referred to an independent metallurgical consultant who has endorsed our approach and method of repair. The repairs were carried out with utmost care and at the fastest speed consistent with the quality required for the job. The entire Safco manpower was geared up to ensure that no time was lost in the decision making process or availability of material or manpower.

During the entire period the urea autoclave was down for repairs, the ammonia plant was kept operating normally, storing the production in the ammonia tank. At the conclusion of the repair work, the ammonia inventory reached the maximum of the storage capacity. This ammonia inventory, however was consumed before the end of the year 1978 achieving a record production of over 260,000 tons of urea.

ATTACHMENT 1



S.A.F.Co. 60" I.D. UREA REACTOR



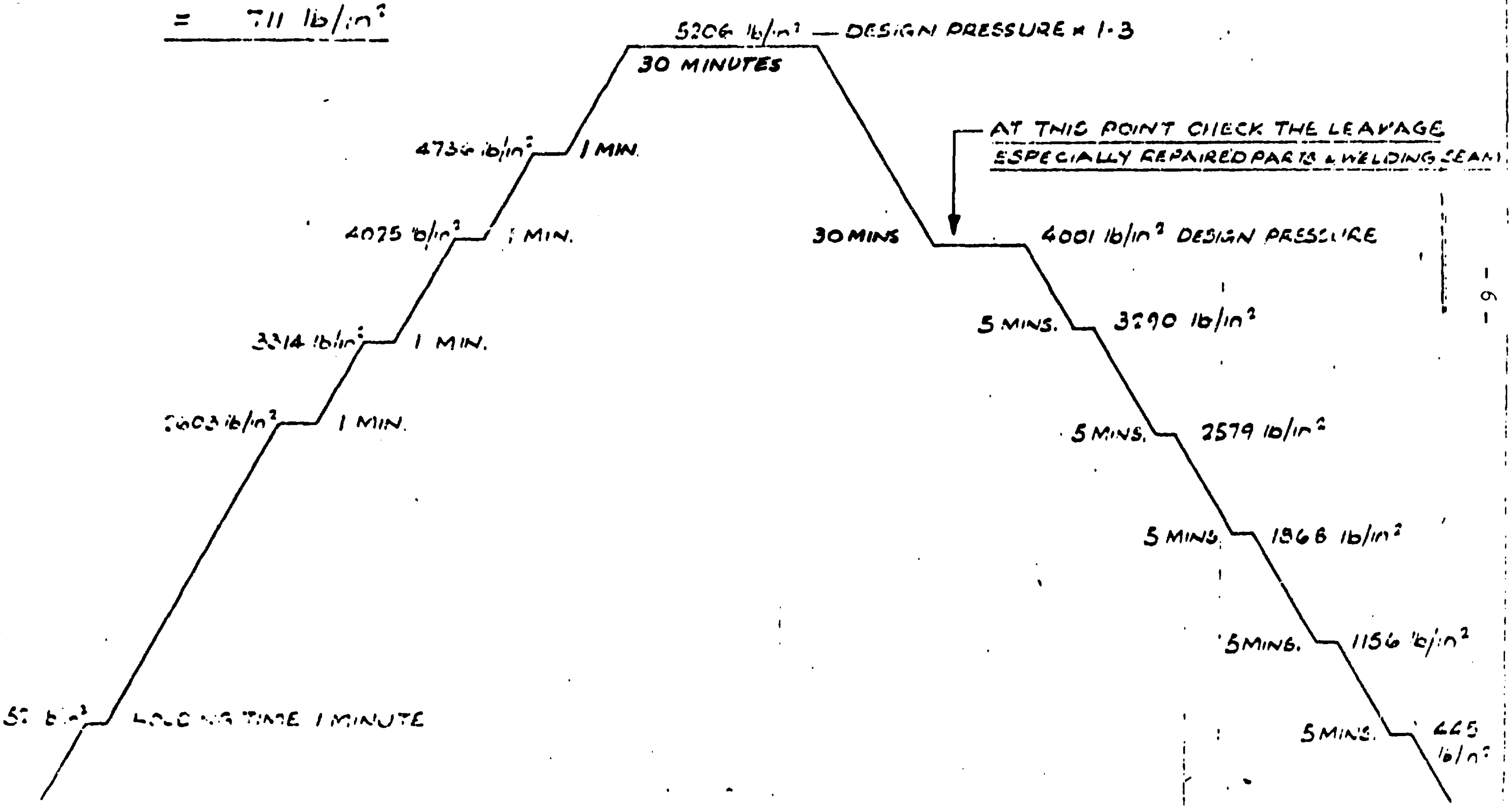
CORROSION/EROSION AREAS OF UREA REACTOR BOTTOM FORGING AT SAFCO

MHI'S RECOMMENDATION OF HYDRAULIC TEST FOR UREA REACTOR

APPENDIX 2

INCREASING & DECREASING RATE

= 711 lb/in²



Appendix-III

STRESS RELIEVING OF UREA REACTOR

The bottom head of the urea reactor was stress relieved after repairs on 20.8.78. Heating was done by using 22 pads of Cooper heat make flexible pad heaters of size 16" x 6.75" each with an output of 3.25 KW. 16 pads were used on the outside and 6 on the inside. The pads on the outside were secured to the head by welding S.S. studs on the head and using S.S. flats curved to suit the curvature of the head. They were further secured by S.S. bands. The 6 pads inside were positioned and held by refractory bricks.

For close monitoring of temperature, 9 thermocouples uniformly distributed, 6 on the outside, 3 on the inside were used. The effective heating area and the monitoring area of pads and thermocouples were clearly marked in a sketch and each lead tagged to facilitate close control on stress relieving.

Kawool was used for insulating all the furfaces, All the manholes and nozzles were boxed up with Kawool packing to prevent heat losses. The following procedure was used for stress relieving:

Rate of heating	Upto 600°F -	Any rate but not less than 3 hours
	600°F to 1150°F -	At the rate of 100°F/hr.
Soaking	Soaking temperature	: 1150°F
	Soaking time	: 8 hrs.
Rate of cooling	1150 to 600°F	at the rate of 100°F/hour.
	600 to 200°F	any rate - insulation removed
	at 200°F = Vac-All was used for further cooling.	

Actual total time taken for stress relieving operation was as follows:

Preparation work	24 hours
Heating and cooling	36 hours
	60 hours