



**TOGETHER**  
*for a sustainable future*

## OCCASION

This publication has been made available to the public on the occasion of the 50<sup>th</sup> anniversary of the United Nations Industrial Development Organisation.



**TOGETHER**  
*for a sustainable future*

## DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

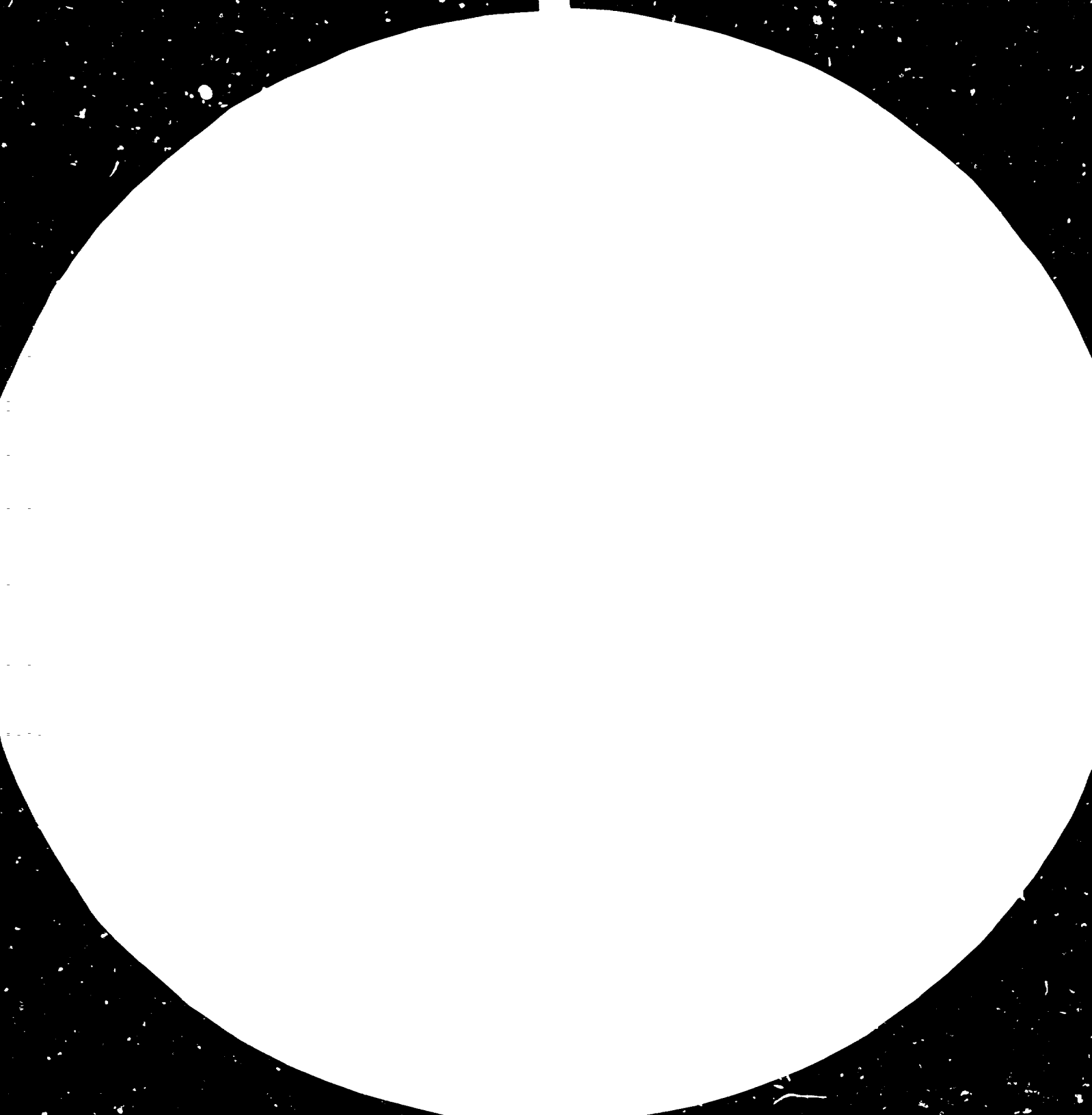
## FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

## CONTACT

Please contact [publications@unido.org](mailto:publications@unido.org) for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at [www.unido.org](http://www.unido.org)



5  
2.8

3.2



3.6



4.0



MITRE CORPORATION, BETHESDA, MD 20815 (301) 344-7300

5000 NORTH CENTRAL EXPRESSWAY, CHICAGO, ILL 60630 (312) 490-6000

RESTRICTED

12803

DP/ID/SER.A/459  
21 March 1983  
English

LEATHER AND LEATHER PRODUCTS  
INDUSTRIES DEVELOPMENT

DP/URT/78/010

UNITED REPUBLIC OF TANZANIA.

Technical report: The boiler maintenance course

Prepared for the Government of the United Republic of Tanzania  
by the United Nations Industrial Development Organization,  
acting as executing agency for the United Nations Development Programme

Based on the work of A. Kapitaniak, expert in steam boilers

928

United Nations Industrial Development Organization  
Vienna

V.83-53660

Explanatory notes

TLAI is the Tanzania Leather Associated Industries Corporation.

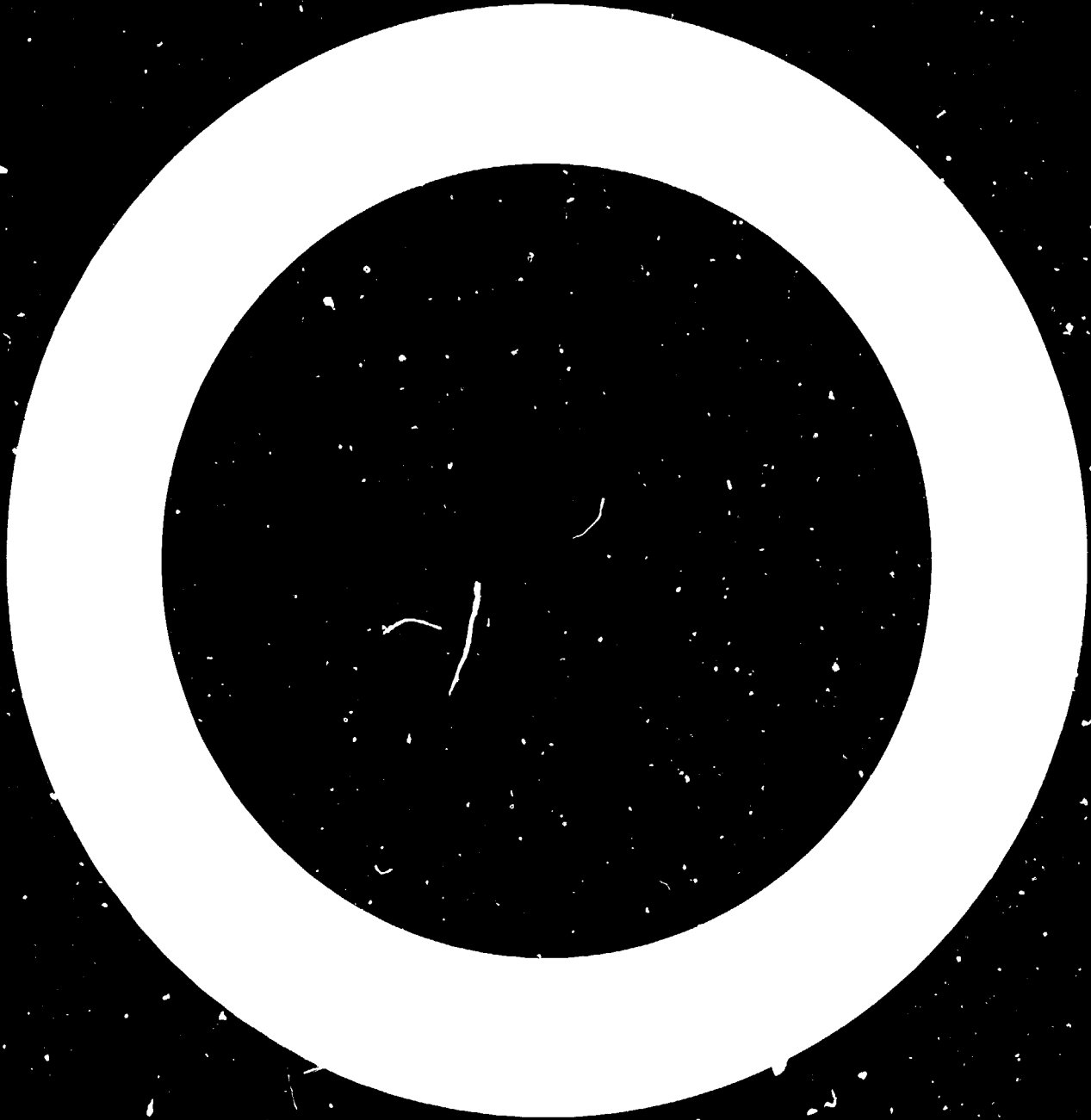
Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization (UNIDO).

ABSTRACT

One of the problems facing the various industrial plants in the United Republic of Tanzania is the poor maintenance standard of the boiler-house equipment. This has been especially noticeable in the operations of factories under the control of the Tanzania Leather Associated Industries Corporation (TLAI) that have been assisted through the project "Leather and leather products industries development" (DP/URT/78/010). The poor maintenance standards of steam boilers causes frequent stops in production, which leads to low capacity utilization and certain quality problems. Similar problems were observed in other industries in the United Republic of Tanzania.

To improve the capabilities of TLAI and other factories, it was proposed that a boiler-maintenance course be given in the country. Thus, the Ministry of Industries, in agreement with TLAI, requested the assistance of a boiler engineer to conduct such a course in January 1982. An expert was sent to the United Republic of Tanzania by the United Nations Development Organization (UNIDO), acting as executing agency for the United Nations Development Programme (UNDP), from 31 October to 20 December 1982.

During the first part of his mission (1-5 November 1982), the expert visited plants in Dar-es-Salaam to observe operations and maintenance in boiler houses. From 8 November to 10 December the expert conducted the course in boiler maintenance for participants from TLAI, the National Textiles Corporation and the National Chemicals Industries. The course included both classroom and in-plant activities.



CONTENTS

<u>Chapter</u>	<u>Page</u>
INTRODUCTION .....	6
I. FACTORY VISITS .....	7
Morogoro Tanneries .....	7
Tanzania Shoe Company (BORA) .....	11
Other factories .....	12
II. THE BOILER MAINTENANCE COURSE .....	14
III. FINDINGS AND RECOMMENDATIONS .....	15

Annexes

I. Counterpart and UNIDO staff .....	17
II. Participants in the boiler maintenance course .....	18
III. Lectures delivered during the boiler maintenance course .....	19
IV. Proposed course on operation and maintenance of boilers .....	20



## INTRODUCTION

One of the problems facing the various industrial plants in the United Republic of Tanzania is the poor maintenance standard of the boiler-house equipment. This has been especially noticeable in the operations of factories under the control of the Tanzania Leather Associated Industries Corporation (TLAI) that has been assisted through the project "Leather and leather products industries development" (DP/URT/78/010). The poor maintenance standards of steam boilers causes frequent stops in production, which leads to low capacity utilization and certain quality problems. Similar problems were observed in other industries in the United Republic of Tanzania.

To improve the capabilities of TLAJ and other factories, it was proposed that a boiler-maintenance course be given in the country. Thus, the Ministry of Industries, in agreement with TLAJ, requested the assistance of a boiler engineer to conduct such a course in January 1982. An expert was sent to the United Republic of Tanzania by the United Nations Development Organization (UNIDO), acting as executing agency for the United Nations Development Programme (UNDP), from 31 October to 20 December 1982.

The boiler-maintenance course was to cover such areas as boiler operations, routine maintenance and overhauling, mounting and control system maintenance and overhauling, water treatment, heat exchangers and steam installation and repairs. The course was expanded to cover such additional subjects as essential notions; definitions in steam-boiler practice; generation and properties of steam; basic reactions of combustion in package boilers; daily and shift maintenance; measurement equipment; operation, service and maintenance of oil-burner; protection of boilers off load; and maintenance planning, safety and reliability.

Prior to conducting the course, the expert visited a number of factories in the country to assess the state of boiler maintenance and to make recommendations for improvements.

The list of counterpart and UNIDC staff is given in annex I.

## I. FACTORY VISITS

The majority of the boiler houses visited are equipped with package boilers with oil burners that produce saturated steam. The boiler capacities range from 1,500 to 6,000 kg/h, working pressure is 5 to 15 bar and feed-water temperature is below 100°C. Fuel oil, and occasionally light oil (diesel oil), is used. Only one boiler house had vertical-shell boilers, and two factories had water-tube boilers with super-heaters that were designed for fuel oil and for coal (stoking equipment was in trial assembly).

The package boiler consists of one furnace tube and two flue-gas passes with many small smoke tubes fixed in front and back of the tube plates. The boilers are of welded construction and equipped with normal devices: safety valves (occasionally only one), pressure gauges, drain cocks, check valves, water-level gauges, vent cocks, main stop-valves and feed-water pumps (in some cases only one). Because the burners are fully or partially automatic, the boilers are often fitted with controls that limit the pressure. These devices act on the burner (start or stop) and on the feed-water pump.

The oil burners are designed mainly as compact units (atomizer, fan, oil pump, oil heater, combustion head and control devices in one casing) with pressure-jet atomizers (with one, two or even four nozzles). There are a few burners with air-pressure atomizers, rotary burners and non-compact burners fixed at front door with separated fans. The oil burners are controlled from a junction panel. Package boilers require treated water.

Descriptions of equipment and maintenance procedures at the factories visited are given below, along with recommendations.

### Morogoro Tanneries

#### Equipment

The works uses two package boilers, type UK-4, which supply saturated steam to some of the process equipment. The designed steam-flow rate of each boiler is 4,000 kg/h at a working pressure of up to 13 bar. The boilers are made in the German Democratic Republic and are fitted in non-compact oil burners delivered from Bulgaria. The boiler house is equipped with two feed-water pumps, fuel-oil pumps, a water-treatment unit, water and oil storage tanks and an oil heater. Feed-water filling and burner operations are semi-automatic. The boiler fitting is typical for package boilers, but the boiler house does not have any measuring instruments that would be useful to improve operations.

#### Maintenance and operation

The following observations were made:

- (a) The boiler house looks dirty;
- (b) There are visible leaks in steam pipes, fittings and manholes;
- (c) The water-treatment unit is operated without technical supervision;

(d) The combustion head of the burner and furnace tube slags after one week of operation;

(e) There are no instruction and maintenance manuals in the operator's room;

(f) There are no daily work sheets with scheduled actual working parameters of the boilers;

(g) The combustion process is not good (see (d));

(h) There seems to be no co-operation between boiler staff and the fairly well-equipped chemical laboratory, which can cause uncontrolled water treatment and corrosion during off load of the boilers;

(i) There are some corrosion failures and deposits on pipes and fittings jointed to water-level devices;

(j) The safety valves are well maintained.

### Recommendations

#### Water treatment

Better collaboration should be established between the boiler staff and the chemical laboratory. Based on periodical feed-water and boiler-water analysis, the chemical staff should advise on quantities and types of chemicals for the water-treatment unit, bearing in mind locally available chemicals. The expert suggested the following requirements:

#### Required characteristics of feed water

<u>Characteristic</u>	<u>Amount per litre</u>
Hardness	1 mg CaO (or 2.4 mg CaSO <sub>4</sub> , or 0.7 mg Ca, or 2.0 mg CaCl <sub>2</sub> , or 1.8 mg CaCO <sub>3</sub> )(corresponds to 0.1 German degrees)
pH	greater than 7
Alkalinity	1.2 milliequivalents
Suspended matter	below 10 mg
Oxygen content	0.05 mg
Oil impurities	up to 3 mg

The salt content of the water can be expressed in terms of its electrical conductivity. It should not be greater than 7500 S/cm. (A conductivity of 1 S/cm corresponds to a concentration of 0.6 mg/l of NaCl or 0.2 mg/l of NaOH.) The alkalinity should not be more than 5-20 milliequivalents per litre.

In order to prepare water treatment, it is essential to know:

- (a) Raw water analysis;
- (b) Requirements for feed and boiler water and, in addition, it would be good to analyse deposits (scales) on heating surfaces that come into contact with water;
- (c) Possibilities for purchasing chemicals (e.g., for removal of temporary hardness, slaked-lime  $\text{Ca}(\text{OH})_2$ ; for removal of permanent hardness, sodium carbonate  $\text{Na}_2\text{CO}_3$  or trisodium phosphate  $\text{Na}_3\text{PO}_4$ ; for softening, hydrazine  $\text{N}_2\text{H}_4$ ; for degassification and others).

Proper water treatment is the only way to restrict corrosion of the boiler, steam and feed systems and to prevent scale and deposit formation on heating surfaces.

#### Protection of boilers when not in use

If the boiler is not in operation for longer periods, it should be protected from corrosion. There are two possibilities - wet or dry maintenance. The expert recommended wet maintenance.

There should be a special tank for the protective solution. Trisodium phosphate  $\text{Na}_3\text{PO}_4$  is normally used. The chemicals are mixed with treated water to obtain a solution of 3g  $\text{Na}_3\text{PO}_4$  per litre of water. The solution tank should hold about 10 per cent more solution than the total volume of the boiler and piping network.

First, the boiler is drained, then filled with solution through open vent cocks using an additional pump (or feed-water pump). When solution flows out from vent cocks, the boiler should be checked to see if it is filled. All connections should then be closed. The concentration of the solution should be checked once a month.

An alkaline solution of hydrazine  $\text{N}_2\text{H}_4$  (150-200 mg  $\text{N}_2\text{H}_4/\text{m}^3$ ) could also be used. The pH value should be maintained in the range of 10-10.5. Because the reaction of oxygen and hydrazine is very slow at low temperatures, it is necessary to fill the boiler with solution while it is still hot. The water for the solution should be deaerated and demineralized.

#### Cleaning

The expert recommended using the acid method for cleaning. In principle, the choice of acid depends on the chemical composition of deposits; the expert said the following cleaning solution was used in his country for 100 litres of cleaning solution:

15 kg hydrochloric acid  $\text{HCl}$  (3-7% concentration, density 1.17 g)

1 kg hexamethylenetriamine (amino form) as inhibitor

85 kg cold (20°C) treated water

For 100 litres of passivation solution:

1.1 kg NaOH

0.5 kg Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>

0.6 kg Na<sub>3</sub>PO<sub>4</sub>

100 kg treated water (50°C)

or

1-2 kg ammonium citrate

(0.8-1.6 kg technical citric acid and 0.85-1.7 kg 25% ammonia)

1-2 kg sodium nitrite NaNO<sub>2</sub>

pH value 9.5-10.0.

For removal of scale corrosion the alkali boil-out process is used. A solution of NaOH, 6-10 kg/m<sup>3</sup> of boiler volume (1.5 kg/m<sup>3</sup> Na<sub>2</sub>SO<sub>3</sub>, 10 kg/m<sup>3</sup> Na<sub>3</sub>PO<sub>4</sub>) can be used.

The solution is prepared in a tank and then the boiler is filled up to water level (visible in water-level gauge).

Boiling duration should be 24 hours at a pressure of 2 bar, 12 hours at 4 bar, and 24 hours at 70% of working pressure. The boiler should be fed and blown off following each stage.

#### Correcting the firing process

Because this oil burner is designed with "spiders" for the air swirler blades (adjusted by hand lever outside the main mounting plate), it is necessary to find the best position for the combustion process. Of course, all parts located in the combustion head, such as the vortex plate, atomizer and electrodes, should be cleaned and adjusted regularly during operation.

A gas analyser (e.g., Orsat apparatus) should be purchased or borrowed. An optimal analysis would show 11.5-12.5% CO<sub>2</sub>, 4.5-3.5% O<sub>2</sub> and nearly invisible smoke. The combustion head of the burner must be cleaned and adjusted regularly.

#### Daily work sheet for the boilers

The boiler houses did not have sufficient measuring devices, but, nevertheless, a daily work sheet for the boiler can be filled out, recording working pressure, feed-water pressure, fuel-oil pressure, fuel-oil temperature and water level. If the oil temperature is not known, the oil supplied to the burner could have a high viscosity, and this could lead to bed atomization.<sup>1/</sup>

---

1/ For a pressure-jet atomizer, the following required: viscosity lower than 3.1 Engler grade (22 cSt, 92.4 Redwood No. 1, 106 Universal) which requires oil heated to 80°-140°C, depending on the quality of fuel oil.

A sample work sheet is shown below.

DAILY WORK SHEET

Hour	Date _____		Steam boiler no. _____				Remarks
	Boiler		Burner				
	Pres- sure	Water level	Feed metre tempe- rature	Feed metre pres- sure	Oil pres- sure	Oil tempe- rature	
1							
2							
3							
4							
5							
6							
7							
8							

Maintenance

Maintenance and repair should be performed in accordance with the requirements given in the instruction and maintenance manual. These must be well known by all staff in the boiler house.

To improve the performance results of the boilers, it is necessary to mend some damaged measuring instruments and to equip each boiler with additional instruments.

Tanzania Shoe Company (BORA)

Equipment

The factory has three small package boilers, type mark 4, manufactured by Thompson Cochran Wee Chieftain. The designed steam-flow rate of each boiler is 1,200 kg/h, working pressure 7-10 bar and feed-water temperature 100°C. The boilers are fitted in semi-compact oil burners with pressure-jet atomizers. Feed-water filling and burner operation are semi-automatic, with a dual control device that receives start and stop signals according to four water levels, i.e., + 12.5 mm to normal level - the water pump operates off and on; 50 mm below normal level (low level) - in this position burner circuit

is broken by a dual control; and 76 mm below normal (extra low level) - in this position a bell rings and the burner is turned off. Each boiler works with one feed-water pump and is equipped with normal fittings. For measuring there are only steam-pressure, oil-pressure and water-level gauges. The boiler house is equipped with one open feed-water storage tank and one oil tank. The water treatment is very simple - every 24 hours two litres of solution are put into an open tank.

The supplier has provided a well-prepared operational and maintenance manual, with some guidelines and requirements for auxiliary equipment.

#### Maintenance and operations

The expert made the following observations:

(a) The boiler house is dirty, the roof is leaking and rain falls on boilers and, worse, on the electric elements of burners (e.g., high-voltage transformer, 10,000 V for ignition electrodes). Steam-pipe isolation is partially broken, there are some leakages in the steam system, and the boiler operators have no flashlight for inspections (according to European requirements);

(b) One of the boilers is shut down because the control panel is broken. If this boiler stays empty without corrosion protection, it will be damaged in a short time;

(c) The water-storage tank should be closed and fitted with a level gauge. At present water is in permanent contact with the outside air, and all impurities that have been accumulated on the roof of the boiler house are drained directly into the water-storage tank;

(d) The boiler water visible in the water-level gauges is sometimes dirty.

#### Recommendations

The recommendations made to the Morogoro Tanneries are also valid for BORA. In addition, the feed-water system should be modified, and the storage tank and water-treatment units must be closed. Chemical supervision is needed (see the recommendations in chapter III). Leakages in the roof, isolation and pipes should be repaired immediately.

#### Other factories

During practical work for participants at the boiler maintenance course, other factories were visited, namely:

Tip Soap Factory, Tanga

Sabuni Industries, Tanga

Tobacco factory, Morogoro

Moproco Industries, Morogoro

Texco Sunguratex, Dar-es-Salaam

Texco F.T.M. Urafiki, Dar-es-Salaam

Keko Pharmaceutical Industries, Dar-es-Salaam

Maintenance and operations

The Tip Soap Factory, Moproco Industries and Keko Pharmaceutical Industries are factories with sufficient or good maintenance and operating conditions. Sufficient maintenance was also observed at the tobacco factory, which worked with a rather old vertical-shell boiler and a modern water-tube boiler.

In general, the factories possess package boilers that are larger and more complicated than those in the leather industry, but the technical problems are different. The expert made the following observations at the tobacco factory:

- (a) All recommendations given in technical instructions are being followed;
- (b) They have maintenance and overhaul planning and sufficient preventive maintenance;
- (c) The measuring instruments are efficient (in some cases there is additional equipment, e.g., flue-gas thermocouples);
- (d) Water-treatment systems are under control, according to instructions;
- (e) Combustion processes are not controlled (they have no measuring instruments).

Overhaul activities in the Texco F.T.M. Urafiki boiler house are regular, in accordance to plan, but the state of the stacks is very bad. There are corrosion damages and smoke-filled ducts behind the two package boilers. This shows that the combustion process has been out of control for a long time.



## II. THE BOILER MAINTENANCE COURSE

The boiler maintenance course took place from 8 November to 14 December 1982. The 16 participants came from the leather (four), textile (eight) and chemical (four) industries. Four of the participants had less than 5 years experience in boiler operations, six had 5-10 years' and six had over 10 years' experience. The names, positions and affiliations of participants are given in annex II.

The course consisted of class work and lectures (40 hours, plus about 18 hours for homework) and plant training (36 hours). A list of the lectures given appears in annex III. The class work aimed at giving the participants essential information on proper maintenance and operation. Because a great part of the audience was unacquainted with such basics as the characteristics of boiler operation, definitions used in operation, combustion etc., the expert extended the programme to questions not strictly related to maintenance. During plant work the participants verified their skills in maintenance, pointed out bad maintenance, operation and organization in the boiler houses and learned to give advice on technical matters and working conditions.

The expert found the practical skills of all the participants very good, and all participants completed the course satisfactorily.

### III. FINDINGS AND RECOMMENDATIONS<sup>2/</sup>

#### Findings

1. Maintenance and operation of steam boilers in the United Republic of Tanzania is of lower standard than in industrialized countries. This is caused by:

- (a) Lack of equipment for maintenance and repair;
- (b) Shortage of spare parts;
- (c) Insufficient training of boiler staff at all levels;
- (d) Scarcity or complete lack of measuring instruments and other devices needed to improve operations;
- (e) Insufficient boiler inspections and unprecise requirements in the technical supervision code.

2. The standard of maintenance and operations in TLAI boiler houses is the lowest of all factories visited. There seemed to be insufficient co-operation between management and boiler staff. More access to boiler technology from abroad was also necessary.

3. Although package boilers prevail in Tanzanian industries, these are of various designs, which makes the purchase of spare parts for burners, water pumps or smoke tubes that have different diameters and wall thickness difficult. This also hampers exchange or replacement of parts between factories.

4. Boilers that are fitted with only one feed-water pump instead of two are unreliable if the pump is not carefully maintained. Similarly, factories with only one boiler are likely to experience production stoppages.

5. Some factories have difficulties with water treatment, chemical cleaning or corrosion protection.

6. Owing to more pressing problems, thermal efficiency connected with boiler operation was not considered. However, boilers will soon have to be equipped with essential measuring devices and thermal testing will have to be carried out.

7. The majority of the participants were unfamiliar with activities for protection against corrosion, cleaning and boil-out process and planning and maintenance of fittings.

---

<sup>2/</sup> Findings and recommendations for individual factories visited are given in chapter I.

### Recommendations

1. A special chemical service should be established to advise on water treatment, chemical cleaning and corrosion protection during operation and off load of the boilers. The chemical service would also elaborate requirements for package boilers and existing or modernized equipment, train boiler staff in water treatment and supervise periodically water-treatment units and protection methods. Taking finance into consideration, two permanent posts - one chemical engineer and one technical or laboratory assistant - would be sufficient to advise boiler house staff in leather industries. The service could be based in the chemical laboratory at the Morogoro Tanneries (the expert was not able to visit all TLAI factories; therefore, this choice should be verified).
2. Spare parts should be ordered well in advance in order to speed up operations and shorten down time.
3. The management of all factories should pay more attention to daily boiler staff problems and strengthen internal inspection. It would be useful if the management of TLAI factories could visit the boiler house at Keko Pharmaceutical Industries Limited, which is a good example of proper operation.
4. To improve the economy of boiler operations (fuel saving, steam consumption per unit of final product etc.) the boilers should be equipped with additional measuring devices (flue gas-analysers and thermocouples or resistance thermometers and draught gauges).
5. Further training for chosen participants in boiler maintenance and operation would be very profitable for the factories. Two-month scholarships abroad might be provided for study in countries that produced package boilers used by Tanzania Pharmaceutical Industry Arusha, Kilimanjaro Textile Corporation Arusha and Morogoro Tanneries.
6. To further improve boiler operations, further training should be organized for new participants. The expert recommended a six-week course on improvement of boiler operations, maintenance and availability, an outline of which is presented in annex IV.

Annex I

COUNTERPART AND UNIDO/UNDP STAFF

Ministry of Industries

Mr. E. M. Hanti, Principal Secretary  
Mr. A. U. Milanzi, Training Officer

Industry

Mr. Chambaka, General Manager, Tanga Steel Rolling Mills  
Mr. W. Msagari, Personnel Officer, Tanga Steel Rolling Mills  
Mr. Salekule, Resident Director, Tanga Cement Company  
Mr. Treuber, Technical Manager, Tip Soap Industries, Tanga  
Mr. Kimweri, General Manager, Morogoro Tanneries  
Mr. Parri, General Manager, Morogoro Shoe Factory  
Mr. Malata, Tanzania Shoe Corporation, Dar-es-Salaam (UNIDO expert)  
Mr. K. Valambhia, Pharmacist/Director, Keko Pharmaceutical  
Industries Ltd.

UNIDO/UNDP

Mr. S. A. Henein, SIDFA, UNDP Office  
Mr. B. Svensson, Team Leader  
Mr. P. Buit, expert  
Mr. R. Chambers, expert  
Ms. Pereira, Administrative Officer, UNDP  
Mr. T. Krishnan, expert

Annex II

PARTICIPANTS IN THE BOILER MAINTENANCE

<u>Name</u>	<u>Occupation</u>	<u>Company</u>
Buddee Othman Dossa	Mechanical engineer	Tanzania Tanneries, Moshi
Mlao O. Mbwambo	Boiler foreman	Tanzania Pharmaceutical Industries Limited, Arusha
Clement K. Masele	Mechanical technician	Keko Pharmaceutical Industries, Dar-es-Salaam
Edward A. Njana	Boiler foreman	Sunguratex, Dar-es-Salaam
Edison E. Chando	Boiler mechanical supervisor	F.T.M. Ltd., Dar-es-Salaam
Edward Bartholemew	Boiler mechanic	F.T.M. Ltd., Dar-es-Salaam
Renatus Manumbu	Boiler attendant and technician	Sunguratex, Dar-es-Salaam
Stambul H. Kissanta	Boiler Instrument and electrical supervisor	Sabuni Industries, Tanga
Dunstan A. Kamtwela	Mechanical inspector	KILTEX, Arusha
Stanley Mpangala	Boiler supervisor	Morogoro Tanneries, Morogoro
Vincent Kimaro	In charge of boiler	Blankets Manufacture, Dar-es-Salaam
Sememba Said	Boiler mechanic	Tanzania Shoe Company, Dar-es-Salaam
Salimu A. Macs	Boiler mechanic	Tanzania Shoe Company, Dar-es-Salaam
Flavian De Kizy	Boiler technician	KILTEX Dar Mill, Dar-es-Salaam
Mafwimbo Magunda	Boiler technical foreman	Musoma Textile, Musoma
Yussuf Maleta	Boiler operator	Keko Pharmaceutical Industries, Dar-es-Salaam

Annex III

LECTURES DELIVERED DURING THE BOILER MAINTENANCE COURSE

Historical background on the development of steam generation and essential terms and definitions in boiler practice

Unit systems and dimensional equivalents used in boiler practice; generation and properties of steam; flow of 1 kg (1 lb) of water mass through the boiler's parts

Boiler types and their initial characteristics and classification

Fossil fuels in steam generation; the principles of combustion; basic reactions of combustion

Brief information on water treatment; introduction to maintenance; the boiler code; detailed requirements for package boilers

Maintenance planning and guidelines for maintenance activity connected with safe operation; maintenance of boiler fittings daily (or every shift)

The need for exact working instruction in operation and maintenance manuals; measurement equipment for small boilers

Major overhauling and routine repairs

Operation, service and maintenance of oil burners

Protection of boilers during down time; main causes of boilers deterioration; cleaning methods

Annex IV

PROPOSED COURSE ON OPERATION AND MAINTENANCE OF BOILERS

Date: May - June 1983

Duration: 6 weeks (theoretical work 3 weeks, plant work 3 weeks)

Location: Dar-es-Salaam and Arusha

The course will cover the following areas:

Theoretical work

Terms and definitions in boiler practice

Generation and properties of steam

Water requirements and water treatment

Liquid fuels

Oil burner operation, service and maintenance

Maintenance of fittings

Maintenance, cleaning methods and protection of boilers during down time

Overhauling, repairs and planning

Corrosion in flue-gas areas

Thermal balance and losses during boiler operation

Boiler operation

Main causes of boiler deterioration

Measuring devices

Improvement of operations

Plant work

Visits to boiler houses to learn to assess their technical state as regards maintenance, operation results, economy and overhauling

Training boiler operators and supervisors

Training to deal with boiler operation problems



