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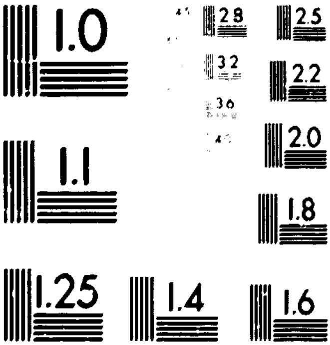

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ASSISTANCE TO THE GLASS INDUSTRY

DP/IRQ/78/001

IRAQ

Technical report: Quality control and glass technology

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

Based on the work of H.R. Persson, consultant in glass technology

United Nations Industrial Development Organization
Vienna

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Explanatory notes

The monetary unit in Iraq is the Iraqi dinar (ID). During the period covered by the report, the value of the dinar in relation to the United States dollar was $US 1 = ID 0.31.

The abbreviation LPG stands for liquified petroleum gas.

ABSTRACT

A consultant in glass technology was sent to Ramadi for the period 1 September to 21 October 1984 as part of the contribution of the United Nations Industrial Development Organization (UNIDO) to the United Nations Development Programme (UNDP) project "Assistance to the glass industry" (DP/IRQ/78/001) for which UNIDO acted as executing agency.

The purpose of the consultant's mission was to advise the glass factory at Ramadi on quality control of raw materials and glass products.

The consultant noted an improvement in the quality control of raw materials since his previous visit in 1983 and found that the old batch plant was working satisfactorily. The installation of three furnaces in the new glass container plant had been completed, and the factory now had a total of nine furnaces. Only six of them were in operation, one being rebuilt, and another two, new ones, not having been started yet due to the fact that the new batch plant was not performing as expected.

The output of the furnaces as compared to their capacity was found to be very low, resulting in a high oil consumption per tonne of glass produced.

The consultant also reviewed the quality control standards and procedures for the glass composition as well as for the final products.

His main recommendations include the following: most importantly a new batch plant should be built or the unsatisfactory one improved, preferably employing the same technology as the old, well-performing plant. The furnaces should be rendered more fuel-efficient by increasing their output and connecting more machines to each of them; their working life should be increased by various means such as selecting the proper refractory materials, carrying out regular maintenance etc.; and the possibility of substituting oil by natural gas for their heating should be seriously investigated.

In the area of quality control, the standards for raw materials should be continuously improved and existing ones enforced, and for the finished products the introduction of additional automatic inspection machines should be considered.

The consultant further recommends that the glass factory, in order to keep abreast with developments and research in glass technology and manufacture, should closely co-operate with the Technical Institute of Ramadi as well as seek to conclude a technical assistance agreement with an advanced glass company. Finally the glass factory should seek further assistance through a consultancy and short-term expert services in order not to jeopardize the achievements made under the present project.

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INTRODUCTION

As part of the project of the United Nations Development Programme (UNDP) "Assistance to the glass industry" (DP/IRQ/78/001) for which the United Nations Industrial Development Organization (UNIDO) is acting as executing agency, a consultant in glass technology was fielded for two months. The consultant arrived at Ramadi, his duty station, on 1 September and left on 21 October 1984. This was his third assignment to the project, which will end on 31 December 1984, as decided in the Tripartite Review Meeting held at Ramadi on 16 May 1983.

According to his job description (annex I), the consultant studied the quality control of raw materials and glass products. Since the inception of the project in 1979, there has been a marked improvement in the quality control of all phases of the production process. He noticed also some improvement in the quality of the glass products since his last assignment and was pleased to see that some of his advices and recommendations had been put into practice.

There were six furnaces in operation; furnace No. 4 was being rebuilt and will be in operation in early 1985. One of the three furnaces in the glass-container plant, supplied by an American company, had been started. The two other furnaces could not be put into operation because the attached batch plant was not performing satisfactorily. The batch plant had to be operated semi-manually and the batches were of poor quality. That batch plant will therefore have to be rebuilt. The other batch plant, which had been in operation for two years, and serves the six old furnaces, was performing well.

The consultant co-operated with the various production staff, especially regarding quality control of raw materials, batches and glass products. He took part in the daily discussions of different production problems, gave his advice and recommended ways to overcome the difficulties encountered.

The possibility of heating the furnaces with natural gas instead of heavy fuel oil was studied. Calculations showed that this could result in savings of approximately 40 per cent of the cost of heating. Contacts with other companies regarding fuel substitution were arranged.

Many of the problems encountered during an earlier mission of the consultant still existed, mainly due to the lack of skilled staff, spare parts and preventive maintenance. To enter a technical assistance agreement with an experienced glass manufacturer could be very beneficial for the factory.

The deputy resident representative and the programme officer of UNDP visited the glass factory. The Director General expressed his satisfaction with the assistance received from UNDP/UNIDO and requested further assistance to the project for 1985 through short-term expert services. The deputy resident representative explained that UNDP was not in a position to continue its assistance, but that a request for United Nations Volunteers could be considered. There would also be the possibility of receiving further assistance under a Trust Fund arrangement.

The consultant also gave two lectures on modern glass development, one at the glass factory and one at the Technical Institute of Ramadi.

The consultant enjoyed excellent co-operation with all staff concerned and would like to express his gratitude for this.

I. RECOMMENDATIONS

1. A new batch plant should be erected as soon as possible. The technology of the new plant should be similar to the one now used for furnaces No. 1-5 and the sheet-glass furnace. The advantage would be that existing skill and the same spare parts could be used.

2. The quality of raw materials should be continuously improved and no supplies of raw materials should be accepted that are not up to the required standards.

3. An effort should be made to render the furnaces more fuel-efficient. The number of furnaces should be decreased and their output as well as the number of machines fed by each furnace increased.

4. The composition of the container glass should be altered. A decrease of the Na_2O-content will reduce the cost of raw materials (less soda ash) and make it possible to run the machines at higher speeds.

5. The suppliers of furnaces should be asked to help increase the working life of a furnace from four to six years. It is important to choose carefully the proper refractory materials, to find optimal solutions for the ereccion of the furnaces, their firing and daily control, and to observe the general maintenance instructions from the supplier.

6. The management of the factory should continue to evaluate the possibility of substituting oil by natural gas for heating the furnaces and prepare for that change.

7. Should customers demand a higher quality of glass containers, the introduction of additional automatic inspection machines should be considered.

8. To keep abreast with latest technical research and development in glass manufacturing, the glass factory should try to reach a technical assistance agreement with an advanced glass company.

9. To further the training of the factory's technical personnel, co-operation with the Technical Institute of Ramadi should be enhanced.

10. Additional assistance by a consultant, for one to two months in 1985, should be sought. The consultant should help in production and quality control, in the preparatory work for the new batch plant, and in negotiating a technical assistance agreement.

11. In order not to jeopardize the achievements made under project DP/IRQ/78/001, which will end on 31 December 1984, the Ramadi glass factory should seek further assistance through short-term experts services, especially in the areas of maintenance of H-28 machines and maintenance of moulds.

II. ACTIVITIES

A. Quality control of raw materials

The quality control of the raw materials has improved since the visit of the consultant in 1983 thanks to very satisfactory work done in that area by the laboratory and the quality control department.

The sand is taken from a quarry at Rutba, about 300 km west of Ramadi. The different qualities of sand in that quarry have been inspected, and the glass factory has decided from which spots in the quarry the sand should be taken. The sand does not contain any brown conglomerates (a high percentage of iron oxide), as was the case in 1983.

When the sand trucks arrive at the glass factory the sand is inspected before it is accepted. In particular the grain size and presence of brown conglomerates are controlled. If the grain size or iron content are not in accordance with the agreed standard, the sand is not accepted.

The accepted sand is then sent to the ceramic factory (2 km away from the glass factory). In the ceramic plant the sand is screened and stones larger than 2 cm are removed.

At the glass factory the sand is divided into two different parts. One part of the sand is used for container glass and sheet glass, the other part for tableware. Sand to be used for tableware is washed which decreases the Fe_2O_3 content from about 0.08 per cent to about 0.05 per cent.

The limestone is taken from Abu Sfaia, about 45 km west of Ramadi. The stones arriving from the quarry should have a size of 20 to 25 cm. At the glass factory the limestone is checked regarding its size and colour. The Fe_2O_3 content should be less than 0.15 per cent.

Once the supply of limestone is accepted, it is sent to the storage place in the batch plant. Before being used as raw material for glass production it is crushed, milled and sieved. The grain size should be maximum 2.4 mm.

The source of the dolomite is in Rutba, located near the sand quarry. The personnel in the mine has been told from which spots the dolomite should be taken.

When the dolomite arrives at the glass factory, a sample is taken by the laboratory and in a quick chemical analysis the MgO and CaO content is checked. The total percentage of MgO and CaO should be at least 50 per cent, i.e. about 20 per cent MgO and 30 per cent CaO. If the dolomite as supplied is not of the specified quality, it is not accepted by the glass factory.

All the other raw materials, such as soda ash, alumina, sodium sulphate, sodium nitrate, carbon, selenium and cobalt are imported. Every new shipment is controlled regarding grain size and chemical composition.

B. Batch preparation

The new batch plant has been in operation for about two years, and the consultant co-operated closely with its manager. The batch plant functions quite satisfactorily and batches of good quality and homogeneity are being produced.

The equipment and the operation of the batch plant must be checked every day by competent personnel. Errors and defects can usually be adjusted quite easily if detected at an early stage. Great maintenance problems can occur if defective equipment is allowed to operate for some time.

The supervisors in the batch plant reported technical problems in the plant as soon as they were detected and the consultant found it very stimulating to take part in the dicussions and to give advice and recommendations on how to overcome the technical problems.

For some time the grain size of the dolomite had been too fine. This caused problems when weighing the dolomite and also difficulties in the melting process. To some extent the problem was solved by changing the sieves and by decreasing the number of steel balls in the mill. Further improvement was obtained by adjusting the feeding mechanism of the balance.

A good job was already done by the staff responsible, and conditions can be further improved after . ipt of some coarser sieves. Optimum conditions may be obtained by selecting a sieve having a maximum opening of 2.5 mm and by experimenting with the number of steel balls. The size of the balls will also have some influence on the grain size of the dolomite.

The sand washer and distributor has to be cleaned and maintained several times every year. Various possibilities for minimizing the time for that maintenance were discussed. Also, the sand fed into the washer contained many large, hard lumps of sand. These should be removed by screening.

After a proper maintenance had been carried out, the sand distributor worked satisfactorily. It is, however, difficult to obtain a correct and constant feeding of sand and water. Further investigation in that area is required.

The balances in the batch plant were checked and if necessary adjusted about once a month.

The weighing and mixing operation is fully automatic. All the weights of the different batches can be checked individually on the data print-outs and thus any irregularities in the batch processing easily detected. Usually such problems could be quickly solved by the skilled staff in the control room.

In general the batch plant worked quite satisfactorily and can be operated and maintained by the local staff.

Table 1 shows the composition of batches prepared in the batch plant.

Table 1. Composition of batches prepared in the batch plant, in kilograms

	Tableware (Furnaces 1, 2, 3)	Container (Furnace 5)	Sheet glass
Sand	605	600	596
Alumina	5.5	6.8	9
Limestone	156	154	12
Dolomite	-	-	155
Soda ash	195	208	199
Sulphate	4	4.3	15
Nitrate	6.5	-	-
Potash	15	-	-
Carbon	-	-	1
Selenium	2.5 grams	-	-
Cobalt	0.6 grams	-	-

The colour of the tableware products could be improved by adding approximately 250 grams of cerium to the batch.

C. Furnaces

There is a total of nine furnaces at Ramadi, but only six were in operation. The output of the different furnaces is detailed in table 2.

Table 2. Output of furnaces

Furnace number	Capacity (tonnes/day)	Output (tonnes/day)	Machine	Product
1	45	30.6	2MDP,H-24	Tableware
2	45	19.9	2MDP	Tableware
3	35	15.9	MDP,H-28	Tableware
5	45	31.2	2 IS6.SG	Containers
7	70	22.9	3 IS6.SG	Containers
Sheet	85	52.0	2 Fourcault	Sheet glass

Furnace No. 4 will be rebuilt and is expected to be operating as of January 1985.

Installation of furnaces Nos. 6, 7 and 8 in the new glass container plant was completed, and there were three I.S. machines having 6 sections at each furnace. However, furnaces Nos. 6 and 8 had not been started yet. Furnace

No. 7 had been in operation since December 1983, but only one machine out of three had been started. All three furnaces and nine machines in the new plant can not be started before the attached batch plant is improved or a completely new one built. It is not expected that a new batch plant can be in operation before 1987.

In general the furnaces have a good technical standard and are built by well-known furnace suppliers.

The maintenance and control of the furnaces is very good. Almost every day they are controlled by a qualified furnace engineer who works under Mr. Faik Al Ubaidi, who was, in the framework of this project, sent in 1981 on a fellowship to Europe for training in glass furnace operation.

The furnace engineer supplied data on the oil consumption of the furnaces which are given in table 3.

Table 3. Oil consumption of furnaces

Furnace number	Oil consumption	
	Litres/day	Litres/tonne of glass
1	9 360	306
2	8 208	412
3	7 200	453
5	9 648	309
7	8 640	377
Sheet glass	18 864	363

This consumption rate is very high. A more normal figure for a regenerative furnace having a capacity of 40 to 80 tonnes of glass per day would be about 200 litres of oil per tonne of glass.

There is no doubt that the main reason for the high oil consumption at Ramadi is the small output from each furnace as compared with the capacity (see table 2). This was pointed out in an earlier report by the consultant (DP/ID/SER.B/432) and it was also recommended in that report to decrease the number of furnaces and to increase the number of machines at each furnace. To be effective and economical the output of a furnace should not be less than 85 to 90 per cent of its capacity.

On the average, furnaces are used for four years. By selecting the best refractory materials, improving the working conditions and with good maintenance it is possible to extend their service life to about six years. All refractory materials are imported. An example of refractory materials used in a container-glass furnace is shown in table 4.

Table 4. Refractory materials for container-glass furnaces

Refractory material	Quantity (kg)
Alumina zirconia silicate (AZS)	92 000
AZS cement	3 600
Alumira	27 500
Alumina cement	1 500
Zircon	18 500
Zircon mortar	2 000
Zircon patch	1 000
Sillimanite	140 000
Sillimanite mortar	4 000
Silica	80 000
Silica insulation	20 000
Silica mortar	10 000
Basic refractories	260 000
Basic mortar	15 000
Bulk ceramic fibre	500
Ceramic board	200
Ceramic blanilet	600
Ceramic paper	50
Fire clay SK36	80 000
Fire clay SK34	35 000
Fire clay SK32	350 000
Fire clay mortar	45 000
Insulation B-3	40 000
Insulation mortar	5 000
Total	1 231 450

D. Glass composition

The glass melted in the different furnaces had the compositions shown in table 5.

Table 5. Chemical composition of glass melted in different furnaces (Percentage)

Component	Furnaces 1, 2, 3	Furnaces 5, 7	Sheet glass
SiO_2	72.5	72.4	72.1
R_2O_3 (Al_2O_3 and Fe_2O_3)	1.1	1.6	1.8
CaO	10.4	10.5	6.8
MgO	-	-	4.0
Na_2O	15.5	15.0	15.0
SO_3	0.5	0.5	0.3
Total	100.0	100.0	100.0

The chemical composition of the glass was checked daily in a Philips X-ray fluorescent analyser, type PW 1400, which is an efficient and safe method of chemical analysis.

The Na_2O-value in the standard composition for the glass in furnaces Nos. 1, 2 and 3 includes approximately 1 per cent of K_2O. At the time of visit of the consultant the company added some potash to the batch for tableware glass. Potash had for some time been available at the glass plant and instead of waisting it, it was used as a substitute for soda ash.

The R_2O_3-content indicated in table 5 includes aluminium oxide (Al_2O_3) and ferric oxide (Fe_2O_3). The Fe_2O_3-content alone was as follows:

	Percentage
Glass for tableware	0.06
Container glass, furnace No. 5	0.07
Container glass, furnace No. 7	0.12
Sheet glass	0.11

Physical testing of the glass, as a means of determining its chemical composition and some physical properties, was not carried out to a great extent.

Previously the density of the glass from each furnace had been measured. During the consultant's assignment only sheet glass was checked. Density measurements give a good and quick indication of any changes of the glass composition and it is advisable to test the density of the glass from each furnace daily.

Equipment for measuring some viscosity values of the glass is available, but is not used. These measurements are somewhat more difficult to carry out and nobody of the laboratory staff has sufficient time and skill to perform those tests.

The density of the glass can be calculated accurately by the Philips X-ray analyser. This is done at present for each chemical analysis of the glass. Similar calculations can also be made to determine some viscosity values of the glass. However, at this stage such calculations are not a necessity.

The homogeneity of the glass is not measured in the laboratory. The Swicker's method for testing ring sections is a quick and easy method to determine the homogeneity of the glass. In particular it would be useful to test the bottles and jars from furnaces Nos. 5 and 7.

E. Quality control of glass products

The quality control department, which is organized under the laboratory manager, has about 40 employees. They work in four teams, controlling the quality of the following products:

(a) From furnaces Nos. 1-4;

(b) From furnace No. 5;

(c) From furnace No. 7;

(d) Sheet glass.

All test results, particularly those for products from the machine at furnaces Nos. 5 and 7 are recorded. The quality control manager prepares a summary of test results for each day. These are then sent to the production department, the laboratory and to the Director General.

Tableware

The tableware products from furnaces Nos. 1-4 are inspected visually at the cold end of the lehrs. They are then packed in cartons or plastic crates. Some of the tableware products are transferred to a storage room, others to a decorating machine.

Afterwards there is a special quality control of the packed products. Of the tea tumblers a carton of 120 tumblers is taken every shift for a quality control. If 11 or more of the tumblers are rejected, all the tumblers made during the testing period must be re-inspected or rejected.

In addition to that special control, there is a quality control of the following properties: weight, grade of annealing, visual defects and thermal shock resistance at 60°C. This quality control is carried out four times every shift. For each product there is a standard specification according to which an article is accepted or rejected.

Jars

The jars made on the I.S. machines at furnace No. 5 are controlled visually at the cold end of the lehrs and by automatic inspection machines.

The flatness of the top ring surface is controlled by the inspection machines. The jar is sealed by a rubber tap and in order to keep a vacuum in the jar the top ring must have a flat surface. Jars which do not have a perfect top surface are rejected automatically by the machine.

Four times per shift the following properties are checked: weight, volume, diameter of top ring, grade of annealing and thermal shock resistance at 40°C. In addition the diameter of the top ring is controlled on six samples every hour.

Soft drink bottles

The I.S. machine which is in operation at furnace No. 7 produces bottles for soft drinks.

At the cold end of the lehr there is a visual inspection station and an automatic inspection machine. This machine is a choke tester which controls the internal diameter of the neck of the bottle.

Three times every shift bottles are taken from the lehr to the control department. They are checked regarding the following items:

(a) Thermal shock resistance at 40°C. Sixty four bottles are tested every time; a maximum of three bottles may break. If the breakage is higher all bottles produced during the testing period are rejected. The test is then repeated every hour and only if less than 5 per cent of the bottles break, the production is again accepted;

(b) Internal pressure. Six bottles (one from each mould) are tested. The minimum acceptable pressure is 20 kg/cm^2;

(c) Verticality test;

(d) Dimensional tests;

(e) Grade of annealing;

(f) Volume;

(g) Weight;

(h) Annealing after decoration.

Sheet glass

The following properties of sheet glass are controlled every shift: visual defects; thickness and interference with vision.

Every glass sheet is controlled by the cutter who rejects or accepts the sheets. They are sorted in one quality only.

F. The new glass container plant

Several problems had to be solved before the new glass container plant could be started. It was very soon realized, that the batch plant of the new glass plant did not have a sufficient capacity.

In the new plant there are three glass melting furnaces and nine glass forming machines having six sections for single gob operation. Each furnace has a capacity of about 70 tonnes of glass per day. One of the furnaces (No. 7) was started on 25 December 1983. Only one of the machines could be started since it was estimated that the capacity of the batch plant was satifactory for a maximum of two machines. It has not been tried to start a second glass forming machine. Instead it has been decided to improve the batch plant to such an extent that it can supply batch for all nine machines, i.e. 210 tonnes of glass per day.

At the time of the consultant's assignment the operation of the batch plant was semi-m•nual and quite primitive. It was experienced that the batches produced did not have a satisfactory homogeneity. The conditions in the furnace were of course improved, since only one third of the furnace capacity was utilized. However, it is obvious, that the operation of the batch plant must be further improved as soon as possible.

The homogeneity of the glass bottles produced was not always satisfactory, which was revealed particularly during thermal shock tests. Sometimes it was necessary to reject the bottle production for several days due to bad homogeneity of the glass.

The glass produced had the same composition as that of coming from furnace No. 5 and was used to produce soft drink bottles of a weight of 415 g and a volume of 271 ml, brim full. The speed of manufacturing was 38 bottles per minute.

The bottles were decorated in two colours by ACL (applied ceramic labels) in an automatic decorating machine.

G. The sheet glass plant

The sheet glass plant at Ramadi is based on the Fourcault technology. The plant has been described in previous reports by the consultant.

Since May 1984 two machines only have been in operation. It is estimated to stop the furnace for a rebuilding in September/October 1985 and to start it again in January 1986.

At present the output of the furnace is 52 tonnes of glass per day. Out of this approximately 35 tonnes are accepted and cut into glass sheets. This is an average figure for a Fourcault plant.

Problems with dolomite in the batch plant caused some production problems in the sheet glass plant. Once the difficulties in the batch plant were overcome, the production of sheet glass improved.

The speeds of draw are as follows:

3 mm glass - 63 m/hour

4 mm glass - 45 m/hour

6 mm glass - 24 m/hour

For every shift a staff member of the quality control department is assigned to inspect the glass. There is only one quality of sheet glass produced and the glass sheets are rated as acceptable or not acceptable.

Furthermore, three samples of glass are taken daily from each machine to determine its density. The standard density value is 2.4788. A deviation of maximum 0.0005 is accepted by the sheet glass management. Quite often there is a larger deviation and that may influence the production. When three machines are in operation the output from the furnace will be approximately 78 tonnes per day, of which about 53 tonnes will be acceptable.

For delivery to customers the sheet glass usually is neither wrapped in paper or protected by wooden frames. Breakage on trucks, therefore, is often 5 per cent or more.

Normally 150 people work in the sheet glass plant. During the assignment of the consultant there were 128, and less than half of them were Iraqis.

H. Visit from the UNDP office

On 1 October 1984 the deputy resident representative and the programme assistant of UNDP visited the Ramadi Glass Factory. In particular they met and had discussions with the Director General and the Deputy Director General. The Director General expressed his great appreciation for the work carried out by the consultant and other UNIDO experts. He mentioned that he would like to obtain further assistance from UNDP/UNIDO to the glass factory and the ceramic factory.

The deputy resident representative pointed out that the project DP/IRQ/78/001 would end on 31 December 1984, as decided at the Tripartite Review Meeting held at Ramadi on 16 May 1983. Since he understood the great appreciation of the UNDP/UNIDO assistance through the project, he indicated that the UNDP office could consider a request for United Nations Volunteers for maintenance and training purposes. He also explained that further assistance through UNDP was only possible if the Government was willing to accept such assistance under a Trust Fund arrangement. The Director General said he would be grateful if such an arrangement could be made.

A visit was also arranged to the ceramic factory which is part of the Public Enterprise of Glass and Ceramic Industries. Details of that visit are contained in annex II.

I. Use of natural gas for heating the furnaces

There is interest in Iraq in trying to use natural gas for industrial heating. Since the Ramadi glass factory is a large consumer of heavy fuel oil and liquified petroleum gas (LPG), the use of natural gas for heating the fur·aces could be a very economical proposition. Two staff members dealing with the supply of utilities at the plant have discussed the issue with the consultant and asked for his co-operation and advice. As a result the following analysis was prepared.

Calorific values:	Heavy fuel oil	10 200 kcal/kg
	LPG	21 605 kcal/m^3
	Natural gas	9 389 kcal/m^3
Prices:	Heavy fuel oil	5 fils/litre
	LPG	60 fils/kg
	Natural gas	ID 5.590/1 000 m^3

These values are approximate, but have been used when calculating the various costs for using the different types of fuels.

Based on the 1983 fuel consumption of the glass factory, the following calculation was made:

Fuel	Quantity	Kcal x 10^6	Price in ID
Oil	26 785 m^3	259 547	133 925
LPG	6 473 tonnes	245 353	388 380
Total		504 900	522 305
Natural gas	43.8 x 10^6 m^3	504 900	300 606
Savings			221 699

This shows that for 1983 there could have been savings of ID 221,699 if natural gas had been used instead of heavy fuel oil and LPG.

The output of glass in 1983 was 68,985 tons. When all nine furnaces at Ramadi glass factory will be in operation the output will increase to 144,175 tonnes per year. If it is assumed that the quantity of fuel will increase proportionately with the output of glass from the furnaces the following figures will be arrived at, when using all nine furnaces:

Fuel	Quantity	Kcal x 10^6	Price in ID
Oil	55 979 m^3	542 439	279 896
LPG	13 528 tonnes	512 775	811 694
Total		1 055 214	1 091 590
Natural gas	112 x 10^6 m^3	1 055 214	628 251
Savings			463 339

It will thus be approximately ID 46,000 cheaper (42%) to use natural gas than heavy fuel oil and LPG, when all nine furnaces are in operation.

A staff member and the consultant visited Taji Industrial Complex, Baghdad, on 9 October 1984, where there is a gas station for natural gas. The gas is received with a pressure of 60 bars. Before distributing the gas to the various industries, the pressure is reduced to 7 bars. The gas is also filtered at the gas station, and in winter time the gas is heated to 40°C. All industries in the complex were satisfied with the gas for heating purposes, according to the technical department at Taji.

At Ramadi there is a pipe line with natural gas about 1 km from the glass factory. The technical management of the glass factory is now studying the cost of connecting this pipe line to the glass factory. Enquiries have also been sent to different companies asking for a price of altering the heating of the furnaces to natural gas.

Details on the oil consumption of the various furnaces at Ramadi glass factory are given in table 3.

III. METHODS FOR IMPROVING THE QUALITY CONTROL OF RAW MATERIALS AND GLASS PRODUCTS

A. Raw materials

There is a tendency in the glass container industry to decrease the use of soda ash in the batch and to improve the melting conditions and the efficiency of the furnaces.

In order to succeed in these two respects it is most important to optimize the qualities of the raw materials. The standard specifications of raw materials are continuously being changed and improved. Changes of standard specifications and improvements of quality control of raw materials are published in technical journals and other literature on the glass industry. This literature should be studied by the glass technologists of the factory.

At present the control of raw materials is quite satisfactory. The glass factory has its own standard specifications, which have been discussed with the consultant at previous missions. Raw materials, particularly the local ones (sand, limestone and dolomite), are tested with respect to grain size and chemical composition. Raw materials outside the specifications are not accepted, which is a good system. It is, however, recommended, that the factory specifications for raw materials be compared once a year with new standard specifications published in the relevant literature.

The methods used for grain size analyses and chemical analyses are fully acceptable.

Continuous contacts should be established with the suppliers of raw materials and the quarries should be visited about once a year.

B. Batch preparation

There are two batch plants at Ramadi glass factory. One batch plant, an automatic one, supplied by a Belgian company, has been in operation for about two years. Batches for furnaces Nos. 1-5 and the sheet-glass furnace are prepared in that plant. It operates satisfactorily and the batches are of good quality. It is important, however, to have daily a qualified control of the plant and to maintain it according to the instructions.

The other batch plant, supplied by an American company, was intended for the glass plant having three furnaces. This plant has been found to perform unsatisfactorily and it supplies only one machine and not nine machines as originally planned for. It is therefore most important that a new batch plant is erected or, if possible, the original one improved to a satisfactory standard.

Since the factory is very satisfied with the Belgian batch plant, it would be advisable to use the same technology in the batch plant for the three new furnaces. The technical skill acquired by the personnel can thus be used in the second plant as well, and the possibility of using the same types of spare parts for the two plants would be an additional advantage. Various companies will be able to supply the required technology.

It should be emphasized that it is impossible to make glass of good quality if the batches fed into the furnaces are of poor quality. There should be a continuous control of the data print-outs and the laboratory should check the homogeneity of some batches by making chemical analyses.

C. Quality control of glass products

The quality of glass products, such as containers, tableware and sheet glass, is continuously being improved. Most of the quality control, especially regarding glass containers, is now carried out by automatic inspection machines at the end of the annealing lehr.

To some extent automatic inspection machines are also used at the Ramadi glass factory. At furnace No. 5, where ketchup paste jars are produced, the flatness of the top sealing surface is controlled on every jar by an automatic inspection machine. On the soft drink bottles produced at furnace No. 7, the internal diameter of the neck, the bore, is controlled automatically.

Glass containers are manufactured at increasingly higher speeds and the quality requirements raise at the same time. Therefore, visual inspection, as the only means of control, can no longer guarantee satisfactory results and automatic inspection becomes a necessity.

To obtain a satisfactory control of glass containers the following should be carried out:

(a) Visual inspection at the cold end of the lehr;

(b) Automatic inspection at the cold end of the lehr;

(c) Production control by the quality control department;

(d) Statistical quality control of the packed products by the quality control department.

All this is well known to the technical management of the glass factory and some of these controls are also carried out. However, more automatic inspection machines will be needed at Ramadi. To some extent this depends on the requirements of the customers, and it is therefore important to keep in touch with the customers in order to ascertain whether they are satisfied with the quality of the glass products.

A more comprehensive description of modern glass quality control is given in annex III.

As far as sheet glass is concerned, there is at present no sorting according to different qualities. All sheet glass supplied to the market has the same average quality, which is acceptable.

IV. FUTURE ACTIVITIES TO IMPROVE TECHNOLOGY AND OPERATING CONDITIONS

The Ramadi glass factory is in a favourable situation regarding future development of its glass production for the following reasons:

(a) Indigenous basic raw materials are available in Iraq;

(b) Technical skill and experience in glass manufacturing is available at Ramadi;

(c) If the glass factory were running its nine furnaces at full capacity, it would still not meet the market demand for glass products in Iraq;

(d) Oil and gas are available locally;

(e) A glass department is being started at the Technical Institute of Ramadi.

It is therefore concluded that the glass factory should increase its capacity in the future and improve the technology used.

To start with, a new batch plant should be built, using the available building. The investment cost for the new equipment will be about ID 200,000. However, some of the existing equipment can most probably be used. The furnaces should then be run at full capacities. There should be more machines at each furnace and the number of furnaces can then be decreased. Eventually the furnaces may be heated with natural gas.

The I.S. machines should be changed from single-gob to double-gob operation.

The finished products should increasingly be checked by automatic inspection machines.

Some co-operation between the glass factory and the Technical Institute at Ramadi should be established. The Technical Institute has a well-equipped glass technology department, including a mini plant in which batches can be prepared and glass melted, and equipment for the measurement of the properties of glass. All equipment is of a high and very satisfactory standard. From this point of view the Institute is ready to start technical courses in glass technology.

The Institute's problem is to find teachers for the glass department. One mechanical engineer from the glass factory was employed by the Institute in August 1984 and preparations are underway for the training of students in glass technology. It is planned to start courses in 1985.

The consultant delivered a lecture in glass technology to the technical and economic teachers at the Institute. Representatives of the management of the glass factory were also present at that lecture. At a meeting after the lecture a committee with representatives from the Institute and the glass factory was formed. That committee will discuss a possible co-operation between the two parties and make proposals of how the common goal of training students to become qualified glass technicians could be achieved.

It would be very beneficial for the glass factory if courses in glass technology could be started at the Technical Institute. The Institute could also assist the glass factory by testing some glass properties, using equipment that is available at the Institute but not at the glass factory.

Some students could then get a more advanced education at a university having a glass technology department.

There is continuous research and development work in the field of glass production. The Ramadi glass factory should make an effort to follow that development. The best way to keep abreast with new developments is to seek the co-operation of, and enter a technical assistance agreement with, an advanced glass company. This would enable Ramadi glass factory to produce more glass products of a higher quality and at a lower cost than at present.

Fourcault plants no longer produce sheet glass of the highest quality. Flat glass of better quality can be obtained by the Pittsburgh process and by the float-glass process. These are now being studied by the Ramadi glass factory in co-operation with partners in neighbouring countries.

A high-quality flat glass can be processed into a variety of advanced flat-glass products, some of which are presented in annex III.

Annex I

JOB DESCRIPTION

Post title: Consultant in glass technology

Duration: Two months

Duty station: Ramadi with travel within the country

Duties: The consultant will be attached to the Technical Manager of the company and will specifically be expected to:

(a) Review the presently applied quality control techniques and methods in the factory;

(b) Advise on how to improve the raw material and product quality control systems; introduce new methods and techniques;

(c) Make recommendations for future activities to improve the technology and operation of the factory.

Annex II

VISIT TO THE CERAMICS FACTORY

On 1 October 1984, following their visit to the glass factory, the Deputy Resident Representative and the programme officer of UNDP, Baghdad, visited also the Public Enterprise and Ceramic Industries, Ramadi. This factory was supplied by a Czechoslovak company.

The factory, which produces wall tiles, started to operate in 1980. The quality of the tiles produced is unsatisfactory, and the factory would therefore like to get technical assistance through UNIDO.

The Technical Manager of the ceramics factory will discuss the issue further with his Director General and an application for assistance may be made to the UNDP office.

Since the ceramic factory also intends to increase the capacity of the plant, UNIDO assistance in the evaluation of suitable equipment would be most valuable.

Annex III

QUALITY CONTROL

A. Raw materials and glass

When manufacturing glass it is important to keep all conditions as constant as possible. This requirement starts with the raw materials and applies to the batch composition, the melting conditions in the furnace, the output from the furnace, the speed of production machines, the annealing etc.

Being aware of the importance of constant conditions, one realizes the necessity of having complete control of all steps in the manufacturing process.

In every glass factory quality control is an important activity. The more automatic a plant is, the more important becomes quality control, and very sophisticated electronic equipment is now available for that purpose. In less modern plants, however, more orthodox control is still applied with some success. Regardless of which processes are used and what degree of automation there is, quality control will always be important and necessary.

Raw materials

The chemical composition of the raw materials has to be determined, and their moisture content must be known. No materials should be used before they have been controlled carefully in the work's laboratory. Every single shipment of raw material should be checked against standard specifications. If the quality of a raw material is found not to be within the specifications, that material should be rejected.

Batch

The balances and the weighing system must be controlled regularly, at least twice a year. The homogeneity of the batch can be controlled easily by dissolving a small portion of the batch in water and in hydrochloric acid. Many plants check the batch composition every day.

The cullet should be clean and of uniform size. The ratio batch/cullet should be kept as constant as possible, and the chemical composition of the cullet should be known.

Fuel

Many glass companies control supplies of fuel oil and gas in order to maintain constant temperatures and heating conditions in the melting furances.

Melting conditions

Modern furnaces are equipped with all necessary instruments and control devices enabling a close check of all conditions in the furnace.

The temperature is controlled at different places of the furnace and in the regenerators.

It is also important to keep the furnace atmosphere, the gas pressure, the fuel consumption and the glass level under control. A regular check of the refractory bricks should also be made.

Forming machines

All suppliers issue maintenance recommendations for their machines, which should be strictly followed. Local adjustments have to be made if the time required for the delivery of spare parts and materials is too long.

A specific programme for preventive maintenance should always be in force. This of course applies not only to machines and moulds but to all equipment and machinery used in the glass factory.

Glass composition

It is important to keep the glass composition constant. If this is not done the glass forming machines will not operate efficiently and it may also be difficult to maintain a satisfactory quality of the glass products.

Normally it is enough to carry out a full chemical analysis once or twice a month. The result from a chemcial analysis should always be compared with the results of the physical testings of the glass.

The batch composition should be changed only when absolutely necessary in order to keep the glass composition constant. Frequent alterations should be avoided.

Density

The density of glass can be measured very accurately (to one ten thousandth) by a sink-and-float method. A carefully selected glass sample is placed in a liquid in which it will float. When the liquid is heated its density decreases and the temperature at which the glass sinks is recorded. The density of the glass can then be calculated from that temperature.

Daily density measurements should be carried out on the glass from each furnace, density values being important indicators of any changes in the glass composition.

Viscosity

The viscosity of glass can be measured easily and quite accurately by observing the elongation of a filament of a glass fibre which is heated at a given rate. These measurements will give an indication of the softening point, the annealing point, the strain point, the relative gob temperature, the working range index and the relative machine speed. Some of these points can be found directly, others can be calculated.

Seeds and blisters

If the glass is not well melted it will contain seeds and bubbles. A daily check of this will give valuable information regarding the furnace. Seeds and blisters can be detected by looking at the glass with the naked eye. It is recommended, however, to use a specially designed seed-o-scope.

B. Quality control of glass containers (and to some extent of glass tableware)

Homogeneity

As it is very important that the glass has a satisfactory homogeneity, this should be controlled every day by cutting ring sections, of 1-2 cm height, from bottles according to the Swicker method. They should be immersed in monochlorobenzene or a similar liquid. The edges of the rings are viewed under a low-power polarizing microscope to determine the presence of glass cords. The homogeneity of the glass is then expressed according to a cord rating scale.

Weight and volume

Frequently bottles are weighed by the machine operator. If the weight of the bottles is not kept within specified limits, their volume will not be correct. The quality control laboratory should therefore check weight and volume of the containers every shift in order to ensure that customers' specifications regarding volume are met.

Dimensions

The dimensions of the containers should be checked frequently by the machine operator, by the inspectors and by the quality control department. Different go/no-go gauges are usually made for each container which enable operators to establish easily and quickly that the dimensions are within specified limits.

The diameter of a bottle, for instance, can be checked with a metal-ring gauge, while for the internal diameter of the bore of a bottle neck a bore gauge havig maximum and minimum dimensions can be used. Most glass plants use automatic inspection machines on the single-liner at the cold end of the lehr to test all those dimensions.

Annealing

The degree of annealing should be checked several times during a shift. The containers are then viewed in a polariscope and compared against standard strain discs. Strain in a glass container may be due to an inaccurate annealing temperature curve in the lehr or to non-homogeneity of the glass.

Thermal endurance

Bottles and jars are often required to withstand certain thermal shocks in the customers' plants. It is therefore necessary to specify their maximum and minimum thermal shock resistance. A study of thermal shock behaviour also constitutes valuable information for the glass manufacturer regarding the quality of the containers.

In a thermal shock test, a number of bottles are immersed in a hot water bath and then transferred to a cold water bath. The percentage of breakage and the temperature of the baths are recorded.

Impact test

In this test the bottles are struck by a swinging pendulum to determine the wall strength of a bottle, which is sometimes required by customers. Impact tests give useful information to the glass manufacturer regarding strength and design of a bottle.

By cutting bottles, the thickness of the glass wall can be measured directly.

Vertical load

When capping bottles in the bottling plants there is usually a load applied to the bottle. It is therefore useful to test some bottles for vertical load in the glass plant. The load is usually applied by hydraulic means and measured by a pressure gauge.

Internal bursting pressure

This is an important test for bottles which will be used for carbonated beverages and other liquids stored under pressure.

For the test the bottles are filled with water and then put inside an increment pressure tester. The bottles are sealed at the top and the pressure inside the bottle is increased in a series of increments until it bursts. The internal pressure test gives useful information to the glass manufacturer regarding the general quality of bottles.

Inspection and quality levels

At the cold end of the annealing lehr every bottle must be inspected for defects and impurities. The inspectors should be skilled workmen who can quickly pick out defective items. The trend is to use increasingly automatic inspection machines for that type of work.

When testing containers for defects and measuring their quality level, only a small percentage of the total amount of bottles produced can be treated by the quality control department. For every dimension and quality requirement some tolerances are established, because not all bottles are identical regarding dimensions and physical characteristics. In many cases the customers specify the sampling technique to be used and indicate their acceptable range of tolerance for each defect.

Defects can be classifed in groups of acceptable quality levels (AQL). Normally defects are classified in the following three groups:

Critical defects	AQL = 0.0-0.1%
Major defects	AQL = 0.0-1.0%
Minor defects	AQL = 0.0-6.0%

Critical defects are such defects that render the use of the container dangerous. Glass fragments in the container like spikes or bird cages are critical defects for containers for food and beverages. Such defects normally have a zero acceptance level. If containers with critical defects are found, the total lot of containers should be rejected and re-inspected.

Major defects may render the container unsuitable for its purpose. Thin walls, warped or dipped sealing surfaces, insufficient thermal or mechanical strength and annealing strain are typical major defects of a container.

Minor defects do not affect the functional performance of a container. Such defects are surface blemishes, mould marks, seeds and blisters etc.

<u>Automatic inspection</u>

The following items may be checked up to 100 per cent by machines installed at the cold end of the lehr:

Dimensions

Resistance to vertical load

Bore diameter

Finish leakage

Impact strength

Cracks and checks

These inspection machines automatically reject containers that are not up to standard.

Quality control departments normally use the following testing equipment:

Increment pressure tester

Polariscope

Thermal shock machine

Vertical load tester

Impact tester

Seed-o-scope

Side wall distribution analyser

Manual thickness gauge

Petrological microscope for stone identification

Polarizing microscope for control of glass homogeneity in ring sections

Volume comparator

Sampling of glass containers

Most important in quality control is to know how many containers have to be examined in order to obtain a sufficient statistical basis for the evaluation of a given lot of containers. The most satisfactory method is, of course, to examine all containers, which is done in the visual inspection and when inspection is carried out by automatic inspection machines at a single-liner.

For inspection by the quality control laboratory, containers are sampled according to statistical methods and the number of samples to be tested are taken from statistical tables. These tables also give the number of containers that have to pass a certain test in order to satisfy the requirements of the specified AQL.

Tables for inspection by attributes (MIL, STD, I05D or the British Standard BS 6001) are often used in the glass industry.

The sampling method according to ASTM C 224-78 for items coming off a continuous production lehr is detailed in the following table.

Table 6. Sampling method

Type of test or examination	Minimum number of samples	Time schedule	Minimum number of samples per lot
Annealing	3	Every 3 hours or less	20
Internal pressure	1 round	Every 3 hours or less	50
Thermal shock	1 round	Variable	50
Visible characteristics	Not applicable	Not applicable	
Dimensions	1 round	Variable	50

For the annealing test the three bottles shall represent the centre and both sides of the lehr.

A round refers to one container from each end of the forming machine.

The time schedule for thermal shock and dimensional characteristics varies with the type of bottles produced.

For a pass test it is normal to take 50 containers randomly selected from the lot to be tested.

C. Qualities of flat glass

Homogeneity and purity standards for flat glass are normally higher then for container glass.

Flat glass products can be classified as follows:

- Clear sheet glass
- Polished plate glass
- Float glass
- Rolled glass (cast glass)
  - Rough cast glass
  - Figured rolled glass
  - Cathedral glass
  - Wired glass
  - Rolled opel glass
- Hand-blown sheet glass (antique glass)
- Heat-absorbing glass
- Light- and heat-reflecting glass
- Processed glass
  - Toughened glass
  - Laminated glass
  - Sealed insulating glass units
  - Cladding glass
  - Sand-blasted glass
  - Acid-etched glass
  - Metallized glass (mirrors)
  - Bent glass
  - Edge-worked and bevelled glass

Sheet glass is usually produced according to the Fourcault or the Pittsburgh process. Float glass is a superior quality of flat glass, not classified as sheet glass.

Most countries distinguish three or four kinds of sheet glass for which the following quality requirements apply.

Special selected quality

This quality is used for pictures, cabinet work etc. where a superfine sheet glass is required. The glass should only have very few and small imperfections, such as few seeds of up to 1.6 mm in the central area and not exceeding 3.2 mm in other areas.

Selected glazing quality

It is used for glazing work requiring a selected sheet above the ordinary glazing quality. Permitted are a few seeds and an occasional large seed, not more than 6 mm long, and faint strings or lines in the central area. In general, the central area of a pane shall be practically free from defects and there shall be no perceptible interference with vision when looking through the glass at an angle not less than 45° to the surface of the glass.

Ordinary glazing quality

The ordinary quality is used for general glazing purposes in factories, for housing estates etc. More defects are permitted than in the second quality, such as blisters of up to 12 mm in the central area and surface defects that do not perceptibly interfere with normal vision. The outer area may contain blisters not exceeding 20 mm in length and there should be no perceptible interference with vision when looking through the glass at an angle of 90° to the surface of the glass.

Horticultural glass

This is an inferior quality, available in limited sizes for horticultural purposes. This glass may have more defects than the other qualities, but it shall not contain any stones which may cause spontaneous breakage.