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English

CEMENT RESEARCH AND DEVELOPMENT CENTRE

DP/TUR/72/034

TURKEY

Technical report: Application of new appropriate energy-saving technologies in the Turkish cement industry (phase II).

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

Based on the work of Harald C. Boeck, cement expert

United Nations Industrial Development Organization
Vienna

id.79-5507

Explanatory notes

References to tons (t) are to metric tons.

References to dollars ($) are to United States dollars.

Besides the common abbreviations, symbols and terms, the following abbreviations have been used in this report:

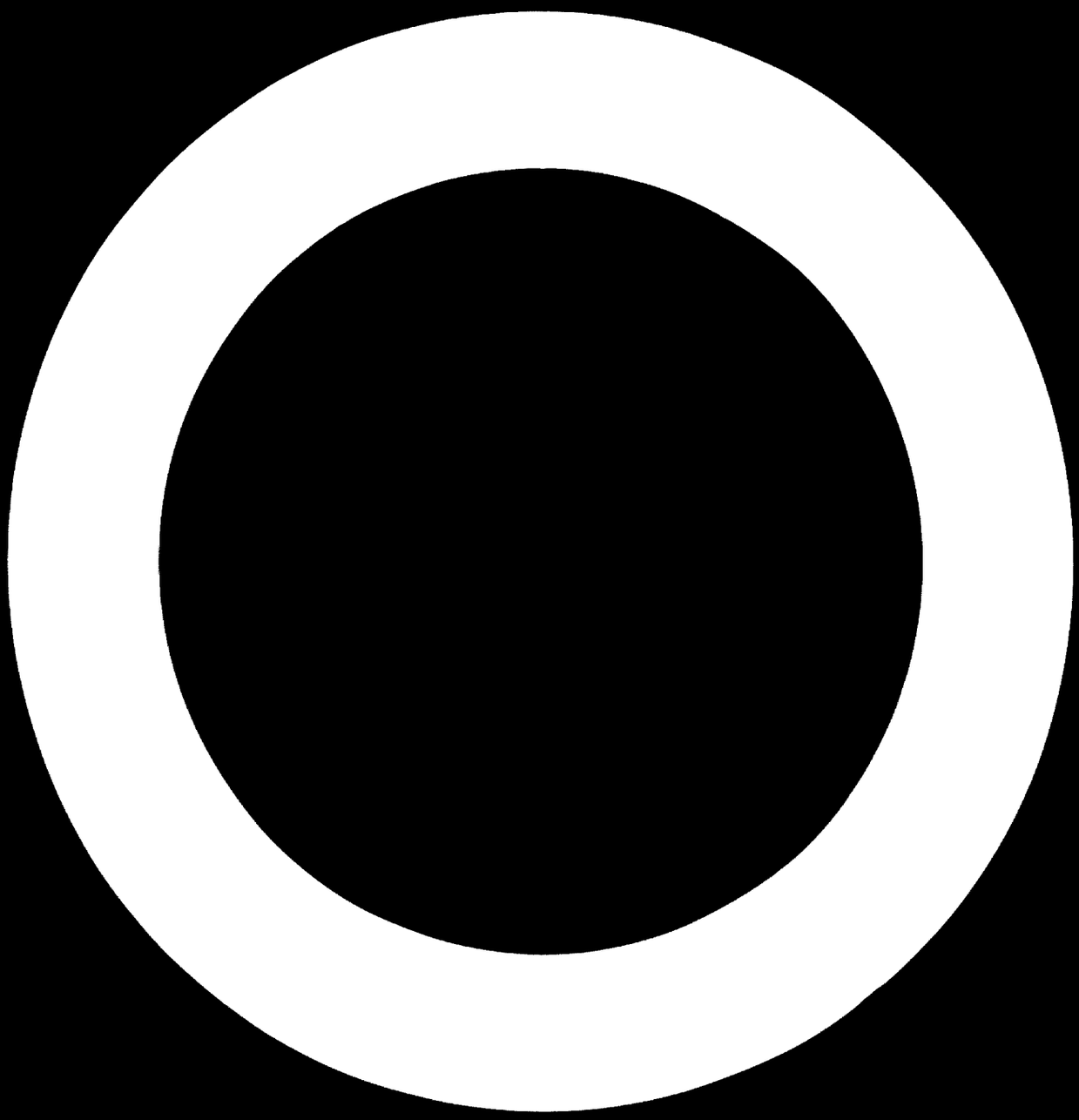
ÇISAN	Türkiye Çimento Sanayii T.A.S. (Turkish Cement Industries Company - TCIC)
CRDC	Cement Research and Development Centre
t/a	tons per annum
t/d	tons per day

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

ABSTRACT

At the request of the Government of Turkey to the United Nations Development Programme (UNDP), an expert in cement production was sent on a six-month mission to advise the Turkish cement industry on the latest technology, in particular, on trends in energy-saving equipment. This mission was a follow-up on a previous one which took place from November 1976 to March 1977 and was part of the overall project "Cement Development and Research Centre" (DP/TUR/72/0 that the United Nations Industrial Development Organization (UNIDO) is carrying out as executing agency for UNDP. The mission began on 28 September 1978 and ended in March 1979.

The present high price for fuel oil in Turkey constitutes a serious problem for the cement industry. The expert therefore recommends as one of the most important measures to be adopted to use coal or lignite instead of oil as the main fuel for the production of cement. The planned construction of seven new cement plants should be postponed or rather limited to one or two plants for the time being and existing plants modernized instead. Further recommendations to save energy include the following: precalcining systems should be introduced into new, large plants and existing Lepol kilns should be equipped with simpler precalciners; all existing plants should receive prehomogen - zation equipment; the quarrying system should be improved, the crusher placed at the quarry and the material transported to the plant site by conveyor belts.



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INTRODUCTION

At the request of the Government of Turkey to the United Nations Development Programme (UNDP), an expert in cement production was sent on a six-month mission, beginning on 28 September 1978 and ending in March 1979. He was assigned to the Cement Research and Development Centre (CRDC) of the Turkish Cement Manufacturers' Association (TCMA) at Ankara. This mission was part of the overall project "Cement Development and Research Centre" (DP/TUR/72/034) that the United Nations Industrial Development Organization (UNIDO) is carrying out as executing agency for UNDP. During the mission the expert has been on detail from Ankara to Ethiopia, Jordan, Kuwait and the Syrian Arab Republic for about two and a half months.

The aim of the mission was mainly to follow-up on the previous mission[1] (November 1976 to March 1977) concerning the application of low-energy equipment for the seven newly planned cement plants. For convenience the expert's previous recommendations are given in annex II.

Due to the severe economic situation in Turkey the Turkish Cement Industries Company (TCIC), in Turkish Türkiye Çimento Sanayii T.A.S. (ÇISAN), which represents the public sector, is facing many problems in their 15 cement plants. Turkey has a total of 35 cement plants and the 15 government-owned plants are mostly located in areas where cement demand is low and which are less attractive for the private sector. However, ÇISAN plans to put up seven new cement plants, each with a capacity of 550,000 t/a in order to meet the projected demand. In 1978 the total cement production in Turkey was close to 16 million.

As the cost of new cement plants is skyrocking, ÇISAN will probably have to seek alternative solutions in order to increase their cement production. This report contains some pertinent proposals. However, in any case large sums will have to be invested in order to save energy. CRDC could play an important role in this effort and therefore the Centre should be put into operation as soon as possible.

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1 See job description in annex I.

I. SUMMARY OF FINDINGS AND RECOMMENDATIONS

In April 1979 the cement price rose from LT 300 to LT 1,125 per ton, ex-factory. At that time the exchange rate for the United States dollar was LT 26.50 for $US 1. On 12 June 1979 the lira has been devaluated by 43% the exchange rate being now LT 47.10 for $US 1. This means that the price of cement will be close to LT 2,000/t. The average daily wage in Turkey is about LT 200.

With an international fuel-oil price on the spot market of more than $US 30/ barrel (159 litres) which equals to about $US 200/t it is now a must for Turkey to switch over from fuel oil to coal or lignite for the production of cement. This is a serious problem which could lead to the conclusion that Turkey should not produce cement at all but import it from nearby oil producing countries.

However, there is no reason to be so pessimistic and thus the following recommendations are given, which should help to improve the situation:

1. Search for cheap transportation, e.g. a powerful railway network.

2. Utilize coal or lignite as fuel for cement production.

3. Produce lignite dust and charred lignite at the lignite deposit. Charred lignite gives a high flame temperature in the burning zone of the kiln and lignite dust can be used in the precalciners.

4. Develop mixed cement types as recommended by Mr. Bel, cement consultant.[2]

5. Equip new, large plants with a precalcining system for the utilization of lignite dust.

6. Introduce simple precalcining systems for existing Lepol kilns which will bring about 10% increase in production.

7. Postpone the construction of new cement plants e.g. plan the erection of one or two instead of seven new plants, giving high priority to low-energy equipment.

8. Improve existing plants e.g. by means of introducing prehomogenization.

9. Improve the quarrying system. If the quarrying is subcontracted to companies with poor equipment, this results in excess consumption of fuel because most contractors will take the easily accessible, soft and moist raw materials.

2/ See document ID/ [illegible] of 15 January [illegible].

10. Place the crusher at the quarry and use a long-distance rubber-belt conveyor for the transportation of the limestone/marl from the quarry to the plant site.

11. Introduce bulk transportation of cement and teach people to buy bulk cement in small quantities. The cement could be dispensed into empty oil drums (200 litres) or heavy bags which can be recycled.

12. Develop local manufacture of modern low-energy equipment e.g. vertical roller mills, diaphragms for cement mills etc.

13. Involve CRDC in applied research and create a good relationship between the cement plants and CRDC.

14. The Concrete Section at CRDC should be put into operation as soon as possible. Considerable savings in energy can be done in the building industries.

15. Purchase a no-break generating plant for CRDC without further delay.

II. ENERGY CONSERVATION AND/OR SAVING ON FOREIGN CURRENCY EXPENDITURES

Quarrying

Great attention should be paid to the quarry system used in each cement plant. Most problems existing in a cement plant can be related to a poor quarrying system.

A major innovation in quarry equipment was the development of the hydraulic crawler drill for blast-hole drilling. Compared with the conventional pneumatic crawler drill the new equipment has many advantages as can be seen from the following table.

Comparison between pneumatic and hydraulic crawler drill

	Unit	Pneumatic	Hydraulic
Bit diameter	mm	63.5	63.5
Drilling time for 18.3 m (60 ft)	min	35	23 (52% faster)
Penetration	mm/min	520	810
Fuel consumption	litre/h	50	30
Specific consumption	litre/m	1.32	0.51 (260% saving)

Source: Atlas Copco and Montabert.

The total investment cost for crawler drill and compressor is roughly the same for both systems, i.e. about $US 140,000. For the hydraulic crawler drill only a small compressor of about 5 m^3/min (180 ft^3/min) is needed for flushing and the noise level is considerably lower than that of the conventional pneumatic drills.

It is well known that a great deal of SIDAM's cement plants suffer from too high a moisture content in the raw materials resulting in a reduced capacity. This problem could probably be solved by changing the quarry system. It might be better to invest in a more modern quarry system rather than to install a dryer in the raw materials processing system.

Crushing, transportation and prehomogenizing

It is obvious that the crusher will have to be located as close as possible to the quarry face. The crusher could be of the conventional stationary type or a mobile or semi-mobile crusher. The investment costs are lower for the latter, mainly due to the high cost of civil work for the conventional stationary crusher. Semi-mobile crushers are therefore becoming very popular.

The crushed raw materials should be transported by means of rubber-belt conveyors; transportation by truck should be limited as much as possible due to the higher fuel consumption and the high cost of spare parts which will have to be imported.

Prehomogenizing is a real must and should take place either at the quarry or, more conveniently, at the plant site. Reference is made to a previous report on the subject by Mr. Le Bel (DP/ID/SER.A.139). It should be mentioned here that circular prehomogenizing plants are becoming more and more popular because of the low investment cost and the possibility of continuous reclaiming.

Raw meal preparation

If the raw mill would receive prehomogenized raw materials with a maximum variation in the $CaCO_3$ content of $\pm 1\%$ and a moisture content not exceeding 1%, any plant manager would be very happy. Unfortunately, these conditions rarely exist in Turkish cement plants and therefore a considerable amount of energy could be saved by improving the raw meal preparation. A study should be carried out, plant by plant, in order to establish how the above-mentioned target can be met. A feasibility study will have to be prepared since considerable investment for new equipment could be involved, such as: a predrying plant; a prehomogenizing plant; a vertical roller mill plant existing raw mills could be converted to cement or coal mills eventually in connection with a precalcining installation. Such complex modification call for proper consultancy services, especially where the local manufacture of equipment will be involved.

Homogenizing

The final target for homogenizing of the raw meal before the kiln is to obtain a variation of the calcium carbonate content not exceeding $\pm 0.2\%$. Below eight homogenizing factors, F_0 to F_7, are given:

Quarry (with selective quarrying)	F_0 = 1 to 1.5
Intermediate storage	F_1 = 1 to 1.5
Crushing	F_2 = 1 to 1.5
Blending beds	F_3 = 4 to 10
Intermediate storage	F_4 = 1 to 1.5
Raw grinding	F_5 = 1 to 2
Continuous homogenization	F_6 = 3 to 6
Batchwise homogenization	F_7 = 5 to 30

In most Turkish cement plants the well-known but now old-fashioned batchwise homogenization is applied and with this system, if it is in excellent condition, it should be possible to obtain a homogenization factor of more than 1 to 30, which is satisfactory. However, this is pure wishful thinking as such perfect conditions do not exist in reality.

The specific power consumption for batchwise homogenization is about 1.65 kWh/t as compared to the latest multi-stream silo which consumes about 0.14 kWh/t. Also investment costs for the latter is considerably lower than for batch-homogenization silos. In other words, the trend is to do the major homogenizing job before the raw mill and apply low-cost and low-energy silos before the kiln.

The raw meal will have to be transported mechanically and not pneumatically as the latter transport system is energy-intensive. For horizontal transport air-slides or rubber-belt and screw conveyors should be used. For vertical transportation belt buket elevators are preferable which are available with a capacity of up to 1,000 m^3/h and with a total centre-to-centre distance of up to 100 m. The capital expenditure for mechanical equipment and the operating and maintenance costs are low and the same applies to the energy consumption.

Precalcining

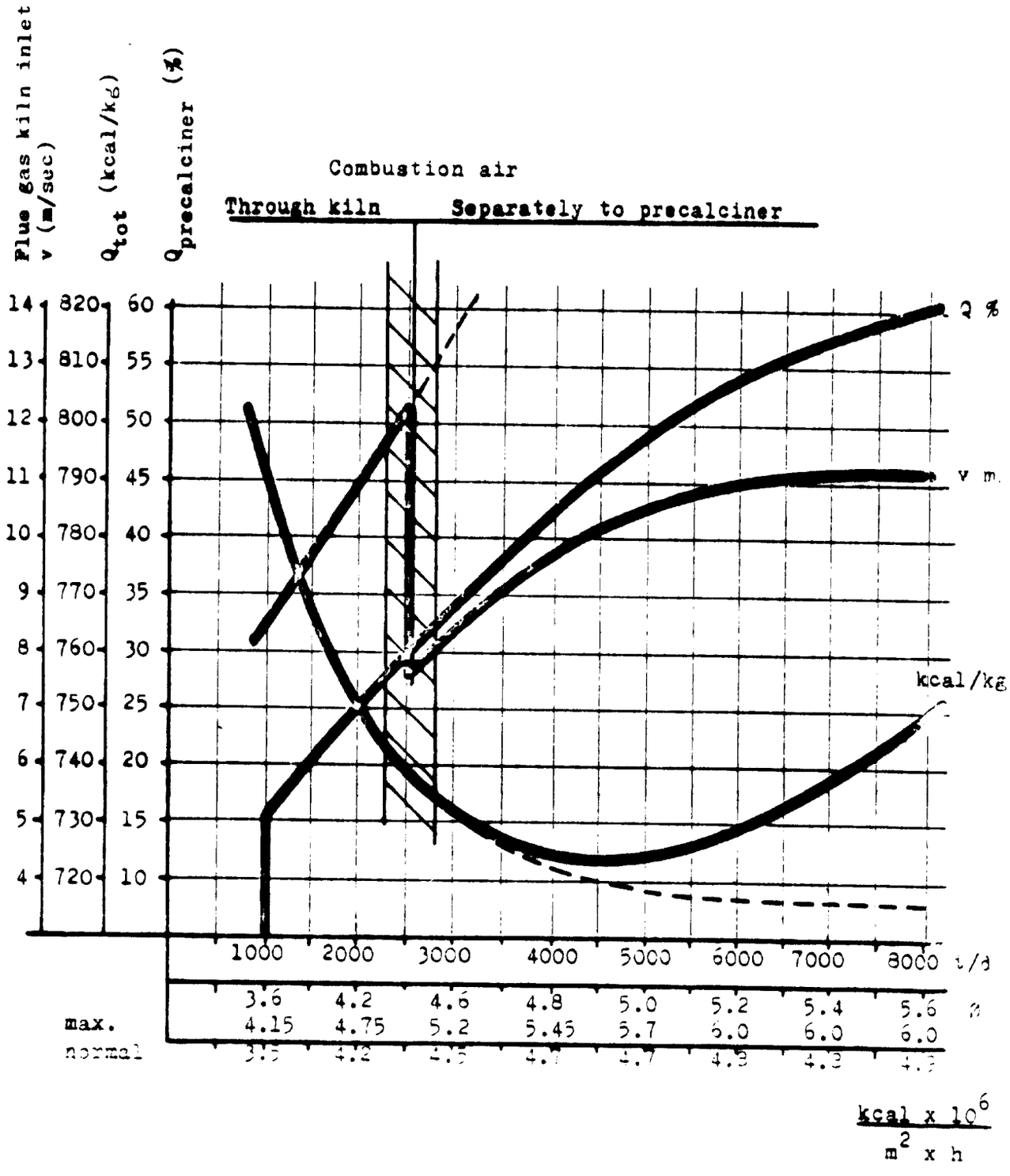
Due to the very high cost of fuel oil and the presense of huge deposits of coal and lignite in Turkey, precalciners for the cement kilns would be very interesting for ÇISAN. Theoretically, no energy is saved by using precalciners: the consumption of fuel is even slightly higher, except for kiln sizes exceeding 4,000 t/day. In practice, however, there are savings due to a higher run-factor of the kiln and because low-calorific fuel such as lignite can be used for the flameless pyroprocess in the precalciner.

The following graph can be used to determine which size of precalciner is the most appropriate for a given kiln size. As can be seen, the most suitable kiln size for the use of a precalciner is in the range of 4,000-5,000 t/d. Nevertheless, it might be advantageous for ÇISAN to install precalciners in smaller-scale plants in order to be able to utilize lignite as fuel: the lignite would have to be very cheap in that case.

To equip existing kilns with precalciners is somewhat problematic and relatively expensive. In each case a detailed feasibility study would have to be carried out. To install the precalciner is simple and inexpensive, but to adapt the rest of the plant may not be economically feasible.

Manufacturers of precalcining systems are given in annex III. The expert would like to stress that it is extremely important for Turkey to gradually replace fuel oil by coal and/or lignite as the main fuel used in the cement industry. The Government should give high priority to the development and the exploitation of the coal and lignite deposits. Although this will involve rather big investments for the installations for mining, drying, charring and transport, it is necessary and will pay in the end.

Determination of suitable size of precalciner for a given kiln size
with combustion air through the kiln or separately to the precalciner



Source: Humboldt Wedag

Pyroprocessing

In spite of the introduction of precalciners it will never be possible to use only low-calorific fuel for cement production. Some research work should therefore be urgently undertaken on how to develop a high flame temperature with the lowest possible calorific value. One solution would probably be to char the lignite.

Annex IV shows a flow diagram of a lignite-dust pyroprocessing installation produced in the Federal Republic of Germany.

Since both, the raw materials and the local coal or lignite have a high moisture content, the coal/lignite will probably have to be dried at the deposit.

Cement grinding and additives

An interesting innovation in the field of clinker grinding is the new COMBIDAN mill developed by a Danish manufacturer. It is claimed that the new type of mill can save about 19% of energy (5.1 kWh/t) in open-circuit grinding of Portland cement. This is a remarkable improvement which should be of great interest to ÇISAN because a large number of existing cement mills could be converted to the new COMBIDAN type.

The use of additives could play an important role in the effort to save energy in the Turkish cement industry and should definitely be considered. (See also DP/ID/SER.A/139.) This way a considerable increase of the production capacity could be achieved by means of moderate investments; the above-mentioned alternatives should therefore be considered before big capital investments in new cement plants are being made.

Bulk cement transport

The increasing cost of paper bags for cement will make it more and more advantageous to switch over to bulk cement transport.

In annex V two types of containers are shown, one for truck transport and one for railway transport. These containers can be applied to all kind of trucks and railway wagons, thus constituting a very flexible system.

For unloading compressed air with a pressure of 1.0 to 2 atü is needed.

The containers can be manufactured locally. The life of such containers is at least 10 years.

III. RECOMMENDATIONS RELATING TO THE CEMENT RESEARCH AND DEVELOPMENT CENTRE (CRDC)

The CRDC project has now reached the stage where 6,520 m^2 of building surface are ready for the installation of the equipment.

The CRDC consists of four main sections:

Process Control Equipment Section
Raw Materials Investigation Section
Cement Laboratory Section
Concrete Section

Part A of the equipment for the Raw Materials Investigation Section is in operation and cement tests and raw material investigations for the new cement plant located close to the CRDC are being carried out. Part B (the rest) of the equipment is ready for shipment from the Federal Republic of Germany.

However, a severe problem will have to be solved as soon as possible: in order to protect the electronic equipment, an emergency no-break generating plant will have to be installed. The shipment of part B will most probably be subject to the prior installation of such a plant.

The CRDC can provide the Turkish cement industry with valuable services by:

a. Putting the Raw Materials Investigation Section into full operation as soon as possible;

b. Focusing on quarry problems e.g. drilling equipment, blast-hole drilling patterns, explosives, all kind of additives etc.;

c. Introducing homogenizing systems for raw materials before the raw mill;

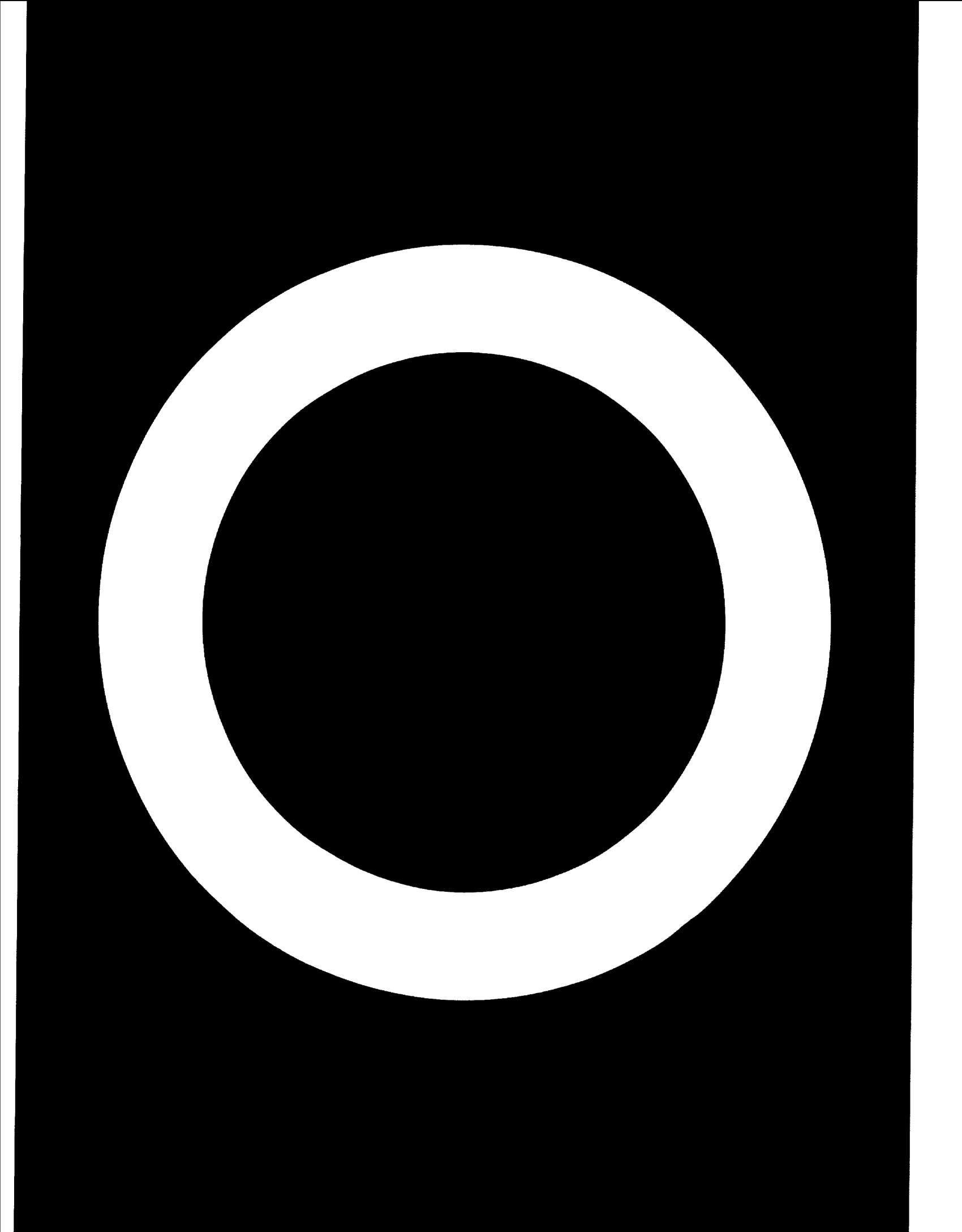
d. Making investigations on coal lignite firing systems;

e. Researching on drying and milling of coal and lignite and the enrichment of low-calorific fuels by charring etc.;

f. Making investigations on raw materials for mixed cement;

g. Speeding up the opening of the Concrete Section; considerable energy savings could be achieved in the building sector;

h. Creating and maintaining good relations with the cement plants.



Annex I

JOB DESCRIPTION

POST TITLE	Expert in cement technology
DURATION	Six months with possibility of extension
DATE REQUIRED	1 January 1978
DUTY STATION	Ankara
DUTIES	The expert, in close co-operation with his counterpart and with the project co-ordinator, will participate in seminars and provide technical consultancy to solve problems in cement technology from the quarry to the packing plant. In addition he will make brief reports for documentation of the seminars. Specifically, the following topics will be stressed in order to decrease energy consumption: - Quarrying and quarry equipment - Mobile crusher/stationary crusher - Transport of raw materials - Prehomogenization of raw materials. On-line analysis - Low-energy mills - Kiln systems. Preheaters and precalciners - Firing systems using low-calorific fuel - Clinker storage systems - Clinker grinding systems - Finished cement transport and storage - Bagged and bulk cement
QUALIFICATIONS	Industrial engineer with extensive experience in cement technology
LANGUAGE	English
BACKGROUND INFORMATION	The first cement plant in Turkey was set up at Darica, Istanbul in 1911 with an annual capacity of 30,000 tons. This plant was expanded in 1913. Other factories and expansions followed in the period from 1922 to 1960 where the installed capacity passed 2 million annual tons. Participating in the development and planning a role of growing importance since its establishment in 1950, the Turkish Cement Industry Corporation has now a dominating position in the Cement Industry. The accelerated

development of the cement industry is illustrated by the rapid doubling of both production and consumption from about 2 million tons in 1960, 4 million was reached in 1966 and 8 million in 1972. The rapid growth of the cement industry in the past and projected growth in the future combined with the introduction of large and sophisticated plants with modern process control equipment has not enabled the cement industry to train sufficient personnel to maintain and use the principles of modern production control in the factories.

Process and plants are designed abroad and the factories are erected and commissioned under the supervision of foreign experts.

When local personnel continue operation after the guaranteed performance has been reached and plants taken over, a deteriorating performance has been experienced.

The result has been large and incidental variations in production, increasing both fuel consumption and wear on equipment.

Consequently, it has been decided to request UNIDO assistance to improve the situation.

Annex II

RECOMMENDATIONS MADE IN PREVIOUS REPORT[a]

1. Turkish Cement Industries Company TCIC should follow the development of the push-car kiln closely. The clinker production of existing plants could be increased by replacing the present raw mills by vertical roller mills of the appropriate capacity. The former raw mills could be converted into cement mills. Thus, capacity could be improved and flexibility increased at low cost.

2. As a means of transport, the rubber-belt conveyor should be preferred wherever possible in spite of the high initial investment costs.

3. Preblending plant should be applied at existing cement plants to increase production capacity and improve clinker quality. It should be included in all new cement plants.

4. To utilize Turkey's huge deposits of lignite, the use of separate pre-calciners where lignite can easily be used as fuel should be considered.

5. A study should be carried out on how to store large amounts of clinker at lowest possible costs.

6. Delivery of cement in paper bags should be reduced in favour of bulk transport since the cost of paper bags is considerable.

7. For the 11 cement plants that have been planned but not yet contracted for, the supplier should be free to design a low-energy plant. Alternatively, an independent consulting company could be asked to undertake the plant layout and to select the equipment, giving special regard to equipment that could be manufactured locally.

8. For the 11 new cement plants, continuous homogenizing with the homogenizing compartment should be considered.

9. The best existing plants should be modernized, which could be done in a short span of time and with low annual investment costs per ton.

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[a] Document DP/TR/SER.A/[illegible], dated [illegible] June [illegible].

Annex III

MANUFACTURERS OF PRECALCINING SYSTEMS

AUSTRALIA

Sorresen's Pty. Ltd.
Consulting Engineers
Suite 108 Edgecliff Centre
Edgecliff NSW 2027

Phone: (02) 32 0476

PBP (pellet-bed-precalciner)
Applicable for semi-wet/dry process only
Maximum capacity 1,500 t/d

DENMARK

F.L. Smidth and Co. A/S
77 Vigerslev Alle
DK-2500 Valby, Copenhagen

Phone: +45 1 30 11 66
Cable: folasmidth copenhagen
Telex: 270 40 flsco dk

Precalcining system with separate precalciner

Precalcining system for low-alkali cement

Integral calcining system

FEDERAL REPUBLIC OF GERMANY

KHD Industrieanlagen AG
Humboldt Wedag
P.O. Box 91 04 04
D-5000 Cologne 91

Phone: (02 21) 8 23-1
Cable: humboldtwedag köln
Telex: 8 873 221

Pyroclon R (regular)
Separate combustion air

Pyroclon S (special)
Combustion air through the kiln

Polysius AG
Graf-Galen-Strasse 17
D-4720 Beckum

Phone: (0 25 25) 711
Telex: 89 131 polbk

Prepol AS
(Combustion air separate)

Prepol AT
(Combustion air through the kiln)

JAPAN

IHI Ishikawajima-Harima
Heavy Industries Co., Ltd.
Shin Ohtemachi Bldg., 2-chome,
2-1 Ohtemachi, Chiyoda-ku
Tokyo 100

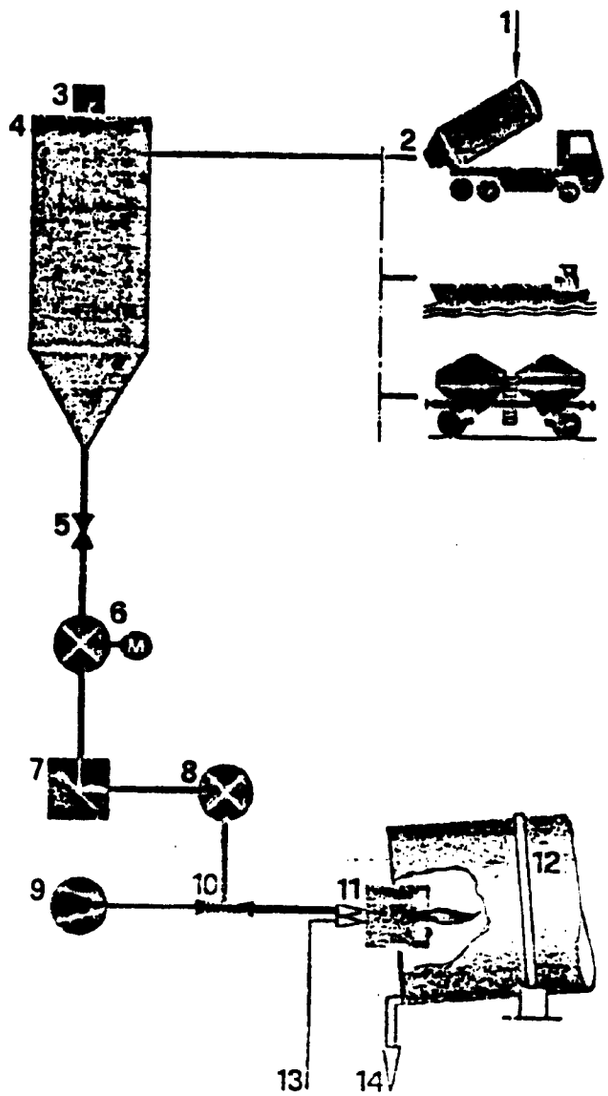
Cable: ihico tokyo
Telex: J22232 IHICO J22232

IHI-SF
Suspension preheater with flash furnace

Kawasaki Heavy Industries Ltd. 4-1 Hamamatsy-cho 2-chome (World Trade Center Bldg.) Minato-ku, Tokyo Cable: kawasakiheavy tokyo Telex: J22672	RSP-system (reinforced suspension preheater Developed together with Onoda Cement Co. KSV and NKSV (Kawasaki spouted bed and vortex chamber-system and new KSV)
Mitsubishi Mining and Cement Co., Ltd. 5-1, Marunouchi 1-chome, Chiyoda-ku Tokyo Phone: (03) 211-7411 Cable: bishiminecement tokyo	**MFC-system** (Mitsubishi fluidized calciner system)
Onoda Cement Co., Ltd. No. 1-7, Toyosu 1-chome, Koto-ku Tokyo **Cable: onoseme tokyo** **Telex: J252-3945**	RSP-system developed together with Kawasaki
Kobe Steel Tekko bldg. 1-chome Marunouchi, Chiyoda-ku Tokyo **Phone: (03) 218-7111** **Telex: 222-3601 kobstl j**	DD-furnace (Dual combustion and denitration furnace)

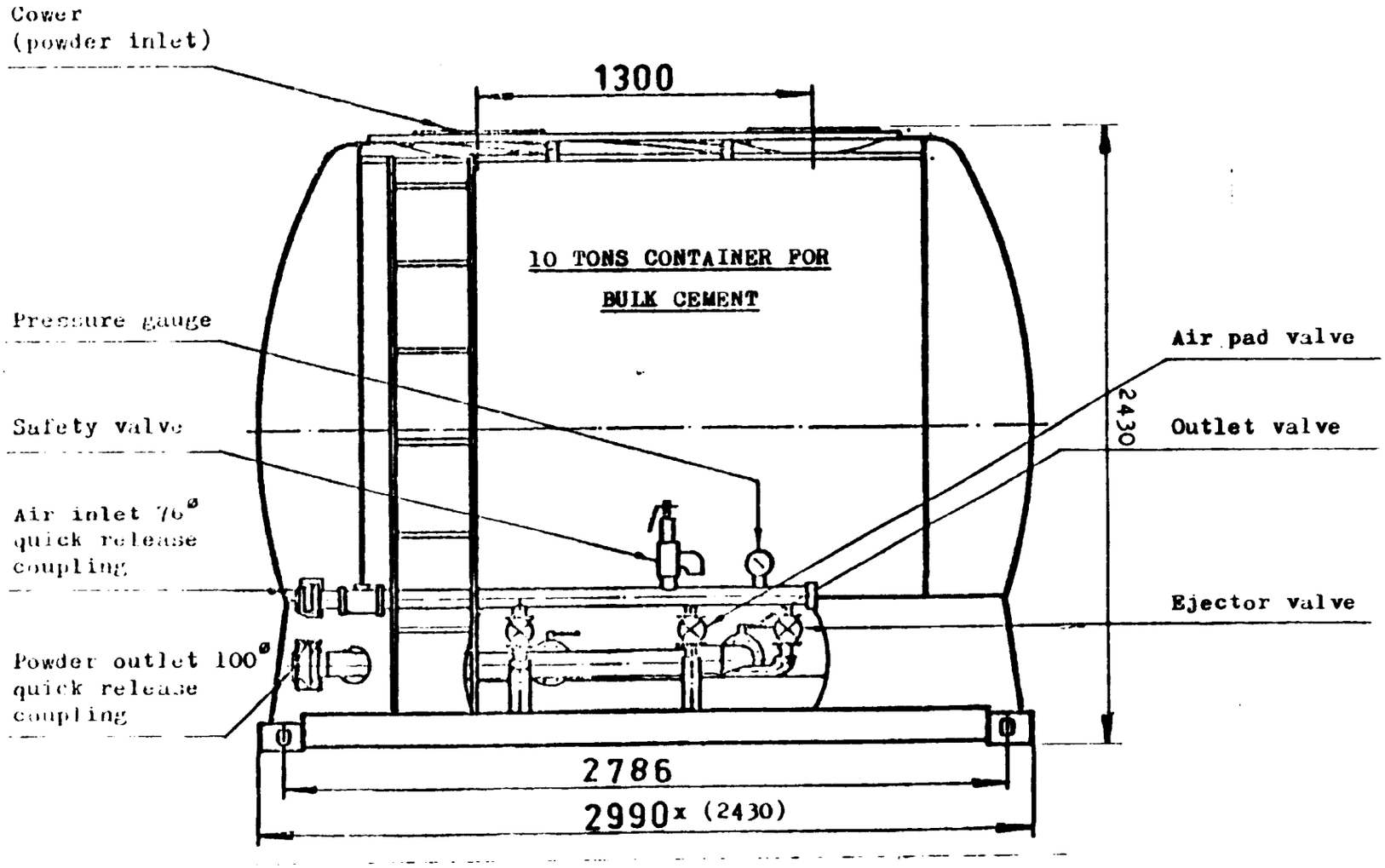
Annex IV

FLOW DIAGRAM OF A LIGNITE-DUST PYROPROCESSING INSTALLATION



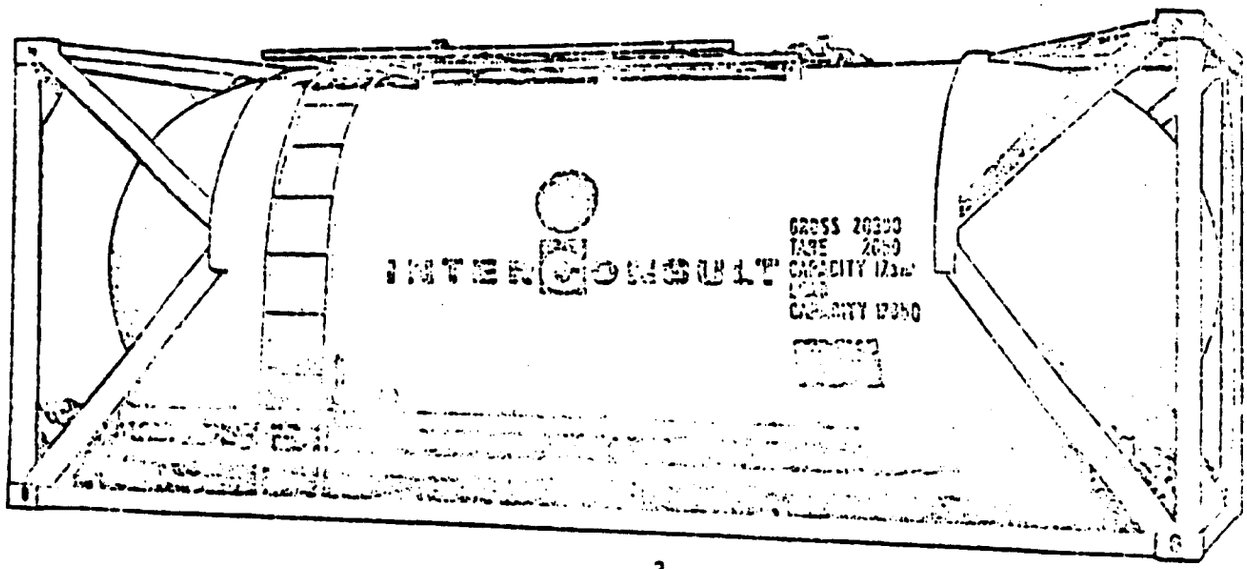
1. Compressed air
2. Lignite dust
3. Dedusting of silo
4. Silo
5. Valve
6. Rotary sluice
7. Measuring device
8. Rotary sluice
9. Fan
10. Injector
11. Burner
12. Rotary kiln
13. Additive fuel, gas or fuel oil
14. Cement clinker or lime

A. Ten-tons truck container for bulk cement

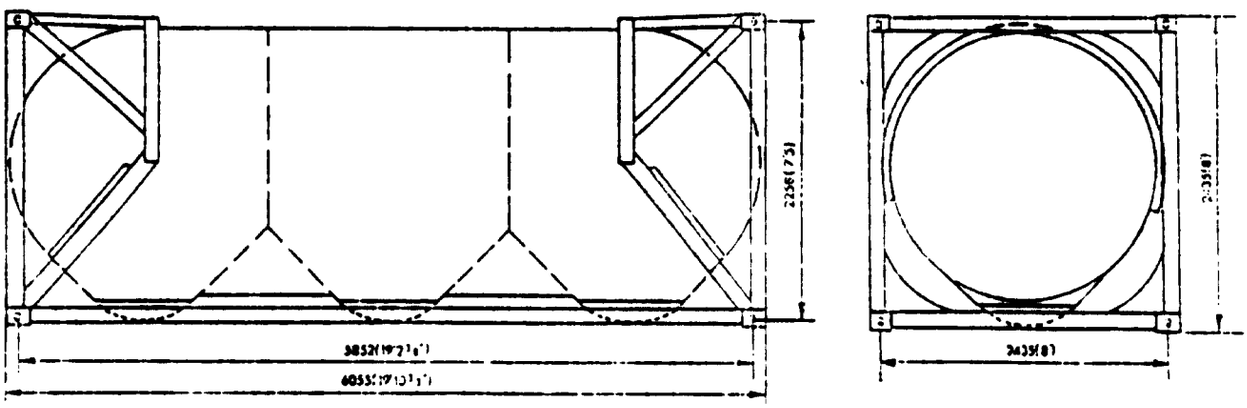


Volume	approx.	9.8 m^3
Tare	"	1,930 kgs
Total weight	"	10,200 kgs

3. 20' x 8' x 8' railway container for bulk cement or lignite dust



Volume	17.3 m^3
Total Weight	20,300 kgs
Tara	2,650 kgs
Load capacity	17,650 kgs



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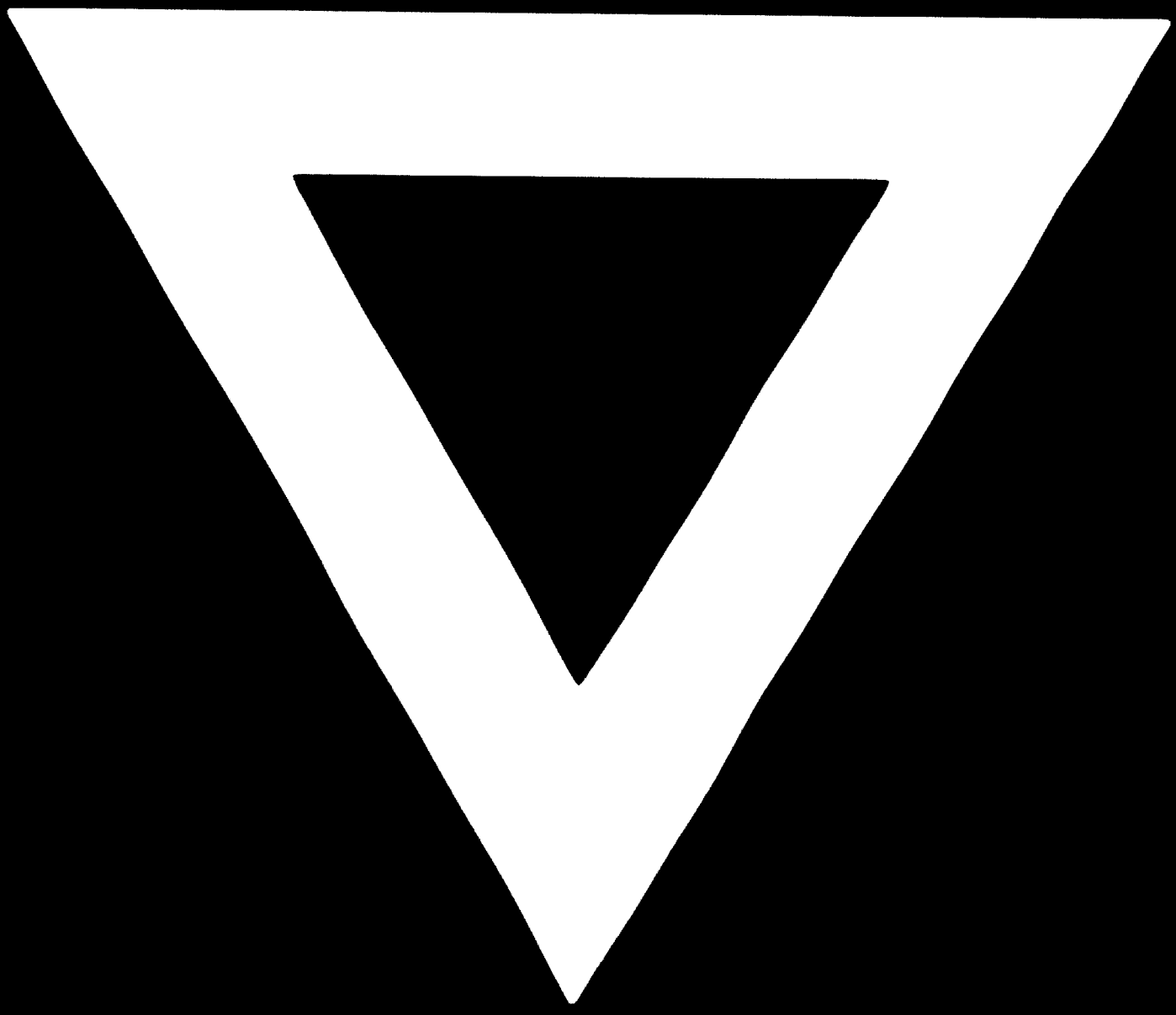

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