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ASSISTANCE TO THE PLASTICS INDUSTRY: PRODUCTION OF POLYVINYL ACETATE BY POLYMERIZATION OF VINYL ACETATE

SI/JOR/78/018

JORDAN

TERMINAL REPORT

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

United Nations Industrial Development Organization

U.78-1408

United Nations Development Programme

ASSISTANCE TO THE PLASTICS INDUSTRY: PRODUCTION OF POLYVINYL ACETATE BY POLYMERIZATION OF VINYL ACETATE

IS/JOR/73/018

Project findings and recommendations

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

Based on the work of R. Strauss, expert in plastics technology

United Nations Industrial Development Organization
Vienna, 1976

Explanatory notes

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

The monetary unit in Jordan is the dinar (JD). During the period covered by the report, July 1975, the value of the JD in relation to the United States dollar was $US 1 = JD 0.312.

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SUMMARY

This is the terminal report of the projeot "Assistanoe to the Plastios Industry" (IS/JOR/73/018). The mission was undertaken by a three-man team chosen to work at Amman, Jordan, under the direction of the local National Planning Council. The team was to assist and supervise all aspeots of the first polyvinyl-acetate emulsion polymerization plant in Jordan. The work covered by the assignment followed on the over-all factory design and layout, including installation of the steam boiler, air compressors and cooling-water services. The team supervised on site the final stages of the installation and tested and commissioned the plant. The full range of products was then manufactured successfully to demonstrate the various production techniques and operational procedures. The assignment also covered advice on local raw materials and chemioal purchases, the training of local operators and laboratory technicians, and recommendations, in consultation with local management, for the longer-term operation of the factory.

The three members of the team are listed in annex I. R. Straus was in over-all charge of the project including design. N.D. Bews supervised the commissioning, the operator and chemist training, the raw material checks and the laboratory work. B.R.P. de Silva organized the detailed plant specifications and supervised the actual installation and testing of equipment; he also helped to commission the plant and performed the detailed engineering checks.

The objectives of the project were successfully aohieved, the plant was started up within one day of the target date and it is now in successful operation. The few troubles that were experienced in testing and commissioning allowed some useful operator training and provided local trouble-shooting experienoe.

INTRODUCTION

This is the report of the project "Assistance to the Plastics Industry" (IS/JOR/73/018). The project was designed more specifically to aid in the production of polyvinyl acetate by polymerization of vinyl acetate. The assistance was requested by the United Nations Development Programme (UNDP) Resident Representative in Jordan on 5 June 1973 following a request from the Government of Jordan. It was approved by the United Nations Industrial Development Organization (UNIDO) as executing agency under the programme for Special Industrial Services (SIS) on 1 August 1973. The UNDP final contribution amounted to $11,200.

The revised Project Document called for the assignment of three experts to work as a team. The main tasks of the assignment were completed in July and August 1975. According to the job description, the team was:

(a) To assist in the supervision of the erection and start-up of a polymerization plant for the production of polyvinyl acetate using suspension or emulsion polymerization techniques;

(b) To advise on the selection of additives such as plasticizers during polymerization, as well as on resin formulations and other processing techniques for use as paints, adhesives, sealants and resin for leather treatment;

(c) To train local counterparts in the production and use of polyvinyl acetate for various applications;

(d) To recommend in consultation with the local authorities a future programme of work which may require UNDP/UNIDO assistance.

Jordan Polymers & Intermediate Chemicals Company (Jopolymer) had requested help with the project, which was based on a licensee agreement with Vinyl Products Limited of Carshalton, England, the leading producers of resin emulsions in the United Kingdom. Knowledge of the current market situation and of imports into Jordan of these emulsions allowed an evaluation of the product range and plant capacity required and an estimate of the future prospects for local manufacture.

The two major marketing outlets in Jordan for resin emulsions are the paint and adhesives industries. It was decided, therefore, to start the plant with a few general products covering a broad range of applications

within these markets. The three grades chosen for the paint industry are all copolymers based on a cellulosic stabilizing system. Two of these are among the top-selling emulsions in the United Kingdom, mainly owing to their high flexibility. A wide variety of paint types can be based on these emulsions, and both are already proven in tropical climates. The third paint grade is in fact a special product, which was developed specifically for a major United Kingdom paint company with a number of licensee paint factories in the Middle East, including Jordan. The manufacture of this grade for the local licensees will provide a firm production base load for the plant.

To cover the adhesive field, two grades were chosen that are suitable (with some minor modification) for several types of application such as wood glues, packaging adhesives and general household adhesives. Both grades are vinyl acetate homopolymers stabilized with polyvinyl alcohol. Two other established outlets for resin emulsions are in the textile industry and paper coating. These industries are not yet well developed in Jordan and require only a small annual tonnage. They are therefore best served for the time being by imports of the special grades although the plant is capable of making such products when the local market warrants such an extension of its range.

I. FINDINGS

Location of site and factory layout

The site chosen was near Zarka, about 18 km from Amman. It is well situated in terms of accessibility, being close to the new main highway between the two cities. The site location and layout were planned to allow for transport access, drainage of effluent and rain-water, optimum services availability, storage of raw materials and finished products, and particularly to allow for the future expansion of all buildings, especially the plant. The layout is shown on the attached site plan (figure I). The four main buildings consist of the office/laboratory block, the main production building, the raw material, engineering and finished goods stores (this also houses the electrical switch room) and the boiler house, in which the air compressor is located. A recirculating cooling water system is used for which an induced draught-cooling tower was installed.

Electricity is obtained from a new transformer located approximately 500 metres from the site and water is supplied from a local well also situated close to the site.

The main production building is shown in the attached photograph (figure II) and has a steel framework serving a dual purpose:

(a) To act as the main building frame;

(b) To support the main items of plant (such as the production vessels and heat exchanger).

This building houses a 3-ton reactor and auxiliaries and is designed to allow for the future installation of a further 5-ton unit when the market requirement justifies the increased capacity.

State of installation at commencement of assignment visit (24/6/75)

The office building had been completed, the production building steelwork had been erected, but the roof and wall claddings had yet to be commenced.

The steel chequerplate first and second floor stagings had been installed and painting of the steelwork was in progress. However, the effluent drains and the drain covers had still to be laid.

The reactor, heat exchanger, blenders and other large vessels had been installed in the production building. Most of the larger diameter stainless steel and mild-steel piping had been assembled with the valves and fittings in position, but most of the small-bore pipework was still outstanding. The main instrument panel was located on the first floor but the instruments had not yet been mounted, although most of the other instrumentation local to the equipment had been completed. All the electrical work inside the production building was still outstanding.

The building housing the stores was completed and the underground storage tanks for inflammable liquid were in position. The installations for the steam, air and water supply were generally completed except for the electrical services and the cable ducts. The transformer was still awaited and the total electrical installation was less advanced than was hoped and therefore was clearly on the critical path for the installation programme. The 4-inch main water pipe supplying water to the site had still to be laid. The whole site had been fenced in and some of the internal roadways were partly cleared though concreting was still required. The quality of the local workmanship in all areas was sound and of a sufficiently high standard.

Installation completion and commissioning

The team felt it to be of the utmost importance to work closely with all the local personnel. This included direct physical involvement in the completion and checking of the installation, tightening pipework etc., in conjunction with the various contractors on site, as well as detailed discussions with all members of the local team in planning, setting of target dates (and methods of achieving these) on a day-to-day basis.

The future operators also helped with mechanical assembly and testing during the final plant installation and commissioning, which gave them an excellent opportunity to absorb some of the engineering knowledge of the plant they were later to operate. By working physically with the local personnel in completing each item in turn, the team helped to create an excellent sense of motivation and commitment and contributed largely to the successful, punctual start-up of the plant.

At this point it is pertinent to refer to the preliminary report issued in the form of a letter dated 24 July 1975 and attached as annex II. This can be read in conjunction with the information given below.

The information is set out in detail since it is considered a useful basis for similar operations in other countries. It is hoped that it will illustrate the advantages of local know-how in addition to the technical expertise and of the close and friendly co-operation between the UNIDO personnel and the factory management, as well as local contractors, which led to the successful completion of this project. Emphasis is also placed on the problem-solving experience during the installation period and the inherent motivational advantages of a plant start-up procedure under the combined supervision of local personnel and UNIDO experts.

With the arrival of UNIDO personnel on site meetings were held with the contractors and the factory management to assess the work outstanding, to draw up a programme and to estimate a possible start-up date. Responsibilities were clearly defined and equipment still needed was listed. Arrangements were made for this to be pursued immediately so that bottle-necks could be avoided. Regular meetings were organized to control progress of the work and to smooth out any operation that had been held up owing to external factors.

Civil work

Priority was given to the completion of the painting and brickwork around the production building and also to the completion of the drains and the clearance of rubbish from this area. Subsequent priorities for the civil work were listed to ensure that these should be done in accordance with the plant requirement and to avoid interference with other contractors.

Mechanical work

The future plant operators were available to help the mechanical contractors complete the installation of pipework. This proved a decided advantage since it gave the operators an opportunity to become familiar with the equipment from an engineering point of view as well as from the operational aspect. Under supervision they completed the assembly of all agitators and

the fixing and bolting down of the vessels in the correct position. At the same time they finished the welding and installation of the remainder of the mild steel pipework and the final few items of stainless steel connexions. In both cases target dates were set.

Electrical work

It was apparent that the electrical installation would prove a bottle-neck in the plant commissioning and it therefore was given the greatest priority. Most of the electrical equipment in the production building was flame-proof. The local contractor's electricians were unfamiliar with the handling of this type of equipment; however, they proved themselves adept at learning the correct procedures for cable terminations etc., and the subsequent quality of the electrical installation work was good. Certain outstanding electrical items had to be purchased locally and some were quite difficult to find although it had previously been confirmed that they were available locally.

Some of the detailed wiring circuit diagrams were not available and it was necessary to develop these from the over-all circuit diagram. The electrical contractors worked extremely hard; by putting in long hours they helped to meet the target date for the plant commissioning. Considerable time was spent by the UNIDO personnel in supervising and instructing the electricians on the installation of equipment and the drawing up of daily work schedules etc. One of the main problems was the installation of the transformer, which was unfortunately delayed, but as soon as this was available, the remaining electrical work was completed, thus allowing the testing of all the circuitry. Fortunately, no major problems were encountered in the commissioning of the electrical equipment. The electrical problems that did arise indicated the need for more detailed information on the handling of specialized flame-proof equipment wiring and also the need for sufficiently detailed circuit diagrams. This aspect of the plant installation also indicated that the electrical side should be given a critical path analysis as part of the over-all plant installation plan.

Pre-commissioning problems

The factory management wasted no time in making necessary arrangements to obtain custom clearance for some of the urgent equipment that was still being shipped. Special arrangements were made to achieve rapid transportation of vital imported items from the docks; this was a problem that could have been considerably worsened by docking delays owing to harbour congestion, but fortunately it was overcome by judicious use of alternative equipment to allow production to commence.

In some cases simple minor items were fabricated locally and considerable advantage was gained from the good contacts of the factory management with local engineering workshops.

The programme for the pipe welders was carefully considered owing to the shortage of these skilled workmen in the Middle East. Maximum use was therefore made of their time on site in achieving the completion of the programme.

There were some problems with the alignment of variable speed pulley drives and it was necessary to realign these completely. This was successfully achieved and checked. A number of small bore pipes had not yet been completed, but these were joined with rubber hoses to allow start-up.

Pre-commissioning trials and test runs

As it was considered imperative that the local personnel should be absolutely familiar with the installation and operation of each item of equipment, the pre-commissioning tests listed below were all performed by a member of the UNIDO team together with one or more of the local plant personnel. Time was spent in explaining the operating functions of the equipment and the type of problem to look for when pre-commissioning checks were being made. This procedure of performing tasks together with local personnel was followed throughout pre-commissioning and subsequently, not only to ensure that local factory management and operators were fully familiar with the plant but also to impart the necessary confidence to continue with manufacture after the UNIDO team had departed.

Services

When the transformer was commissioned, the electric supply was immediately checked to the main switch-room and the main distribution boards. Earth leakage measurements were also made. The individual circuits were checked later when the relevant plant items such as pumps and agitators were commissioned.

The water storage tanks were cleaned and washed out; they were then filled from the supply and the contents gauges were checked. The cooling-water circulating pumps and the process water pump were started in turn and checks made of bearing temperatures and power consumption. The water-circulating pipelines were filled and a number of leaks were found which were tightened. The whole cooling-water system was then pressure tested and the water pumps given a running check over 12 hours.

The steam boiler control circuits were tested and the boiler was then filled to the correct level and the burner started. The boiler was taken through the established commissioning procedure and all the burner and steam pressure controls were checked including the safety devices, particularly the main safety valve. The low- and high-level controls had to be reset and the pressure control was given particular attention.

The air compressor was started and leaks in the compressed-air system were tightened. A running check was made to confirm operating temperatures and pressures. The water softener was commissioned and excessive flow through this unit was corrected by adjusting the flow controls. The quality of the water obtained was tested in the laboratory and leaks on the soft-water line were tightened.

Production plant

All the cooling and process water as well as the steam circuits in the plant were tested for leaking joints, which were tightened and subsequently pressure tested. All the operating valves were checked to ensure that these closed tightly and opened fully, and that there were no blockages in the lines. The process vessels were filled with water after being cleaned and the process lines as well as the vessels were checked for leaks. Most vessels were fitted with agitators and great care was taken in checking these to ensure that subsequent operation should be trouble free. Partioular attention was given

to the agitator shaft alignment, to belt tightness on pulley drives and to the bottom steady-bearing assemblies. Items originally checked by the manufacturers were rechecked locally such as the tightness of impeller-locking bolts, alignment of couplings and of variable speed drives. Running tests were then made ensuring that the direction of rotation was correct and the power requirements of the units were checked against the estimated figures at different speeds. Twelve-hour running tests were then made with water in the vessels to confirm that excessive temperatures were not obtained either in the drive assembly or at the bearing/gland or seal arrangement. Where gear-boxes were fitted, these were checked to ensure that they had been filled with the correct grade of oil to the right level before the agitator was switched on. Packed glands and mechanical seals were pressure tested and checked under running conditions.

The main reactor (and ancillary equipment) was tested by boiling out with water; this also permitted a check to be made on the heat transfer between the jacket and the vessel contents, the temperature recording instruments, the operation of the jacket steam trap and the main condenser. Attention was given to leaks, temperatures obtained, rates of flow etc. Where flow indicators were fitted these were checked by metering in pre-measured quantities of water.

Chemical raw-material storage tanks were filled and the transfer pumps and lines checked. Problems were experienced with inadequate suction owing to an air leak in the main transfer pump. This was overcome by re-making one of the joints which proved troublesome. The process chemical flowmeters were then calibrated and calibration charts were drawn up for future use. The temperature recorder and temperature indicators were also checked, calibrated and adjusted where necessary during the boiling out of the main reactor. Additional descriptive labels were provided where these had not yet been fixed to all the valves, instruments and other operating equipment, to facilitate identification during manufacture and for reference to the operating instructions.

Further details on pre-commissioning trials are given in the preliminary report in annex II. The annex also covers the actual plant start-up operation and should be read in conjunction with the following information.

Plant commissioning

Prior to commissioning, detailed discussions were held with the local factory management, chemist and operators. The outcome of these discussions was a plan of operation and the preparation of process batch cards, the procedures for preparing the raw materials for each batch and the operating instructions for the reactor, followed by the final laboratory testing of the finished product. Great care was taken to ensure that each man should know his part of the total work-load and should be fully aware of the different tasks and responsibilities that would be expected of him in the future and how all these would be dovetailed.

The raw materials for the first batch were identified, and the quantities required were weighed out by the local chemist, supervised by the UNIDO team member. These were then loaded into the processing vessels and the first batch of emulsion was started on 19 July 1975. The total manufacture proceeded according to plan. It was controlled over-all by the team members but the local trainees were used to operate the plant items such as valves and to read and interpret the instruments; at the same time they were instructed on the over-all techniques of the equipment operation.

As the process developed, each step was explained and the basic chemistry of the polymerization process was discussed with the factory management and the operator. When the batch had been completed, the properties were checked in the laboratory by the chemist, under the supervision of the team member, and the pertinent records were filled in. This procedure for the first batch allowed the team to organize with local management a proper system for sampling of the chemicals and finished products and for recording the results obtained in the laboratory, as well as for demonstrating the techniques to be used for measuring the various physical and chemical properties of the finished product and of some of the raw materials. The vital aspect of laboratory testing during production and of the finished product was fully covered. The local chemist in charge was guided and instructed in the detailed techniques to be used in the laboratory, as well as about the plant. This "teach-in" covered not only the procedures for correct operation but also the steps to be taken when off-specification product had been made or the manufacturing process was not proceeding according to plan. In this way, it was intended to forestall

faulty production by a system of fault-finding and oorrecting procedures, whioh will, in many instances, successfully obviate the manufacture of off-specification material. Great oare was taken to ensure that a proper recording system, covering the manufaoture, the testing and the analysis of eaoh batch, should be drawn up in accordance with previously developed systems for similar plants.

The analysis of the first batch showed it to be entirely satisfaotory. This allowed the commissioning of the final pieces of equipment involving the sieving and drum-filling operations. Again detailed instructions were given to the local personnel on the operation of the plant.

Subsequently, further batches were made to check reproducibility of the initial grade. The other grades were then made to demonstrate the different operating procedures and the varying production techniques required.

Substantial time was also spent in technical discussions with the local factory management covering all aspects of the factory operation. The main items included were:

(a) Raw materials, including prioes, availability, suppliers, storage procedures, chemical checks and safety requirements;

(b) Dispensing from bulk and safety requirements;

(c) Processing techniques and problem areas;

(d) Product range, production planning and sequential production problems;

(e) Factory manning levels, maximizing labour and job motivation;

(f) General factory operation and safety aspects;

(g) Local climatic conditions and emergency procedures to be adopted in case of local service failures such as electricity or water;

(h) Finished product containers, local handling and transportation.

A site visit was also made to a large local paint manufacturer who could be one of the main oustomers for the factory. The visit gave the opportunity for a successful technical trial of the product which had just been manufaotured and for a discussion with the local personnel at the paint factory covering a wide range of technical aspects.

While the team members were present in Jordan, a total of some 24 tons of emulsion were manufactured, covering the five different grades, and all were made successfully. The hard work and enthusiasm of the local factory personnel contributed greatly to this success and the team was particularly pleased with the way that instructions and training were readily accepted and learned.

The disciplines and time availability of the team members did not allow some long-term aspects to be covered in depth. These include advice and guidance on the detailed marketing of the products and technical service back-up required to ensure that the products shall be correctly used. Also, further operator training may be required when additional products are introduced in the factory.

In the laboratory, more experience in practice will help the chemist become familiar with the more routine testing procedures and further guidance could extend his expertise in performing some of the more fundamental tests which may have to be undertaken in particular circumstances. On the engineering side, long-term discussions should cover the planned maintenance procedures, the spares requirements and the standard maintenance operations. It will also prove useful to dismantle and reassemble some of the plant items to familiarize the local engineers with the equipment when maintenance is required. It is often advantageous to delay these longer-term discussions with the local personnel until sufficient operating experience has been attained to allow the manufacturing pattern to emerge. This can then be used as a basis for further instructions on the lines indicated above.

Annex I

UNIDO TEAM MEMBERS

R. Strauss, Ph.D., C.Eng., D.I.C., A.C.G.I., M.I.Chem.E.

M.D. Bowe, B.Sc.

R.R.P. de Silva, M.Sc., Dip. Chem. Eng.

Annex II

PRELIMINARY REPORT

(letter from R. Straus to UNIDO dated 24 July 1975)

I have just returned from the seven day trip to Amman, Jordan as part of the above assignment. Unfortunately, I have only three days in England before my departure on vacation but I would like to give you herewith a short report of the progress we have made at Jordan Polymers & Intermediate Chemicals Co. (Jopolymer).

We started at 7.30 a.m. on the 16th July and were faced with a multitude of problems and immediately cleared the priority in which these should be tackled. They were mainly minor mechanical and electrical problems such as rotating drives, which had seized due to lack of operation or lubrication, initial tensioning of belts, many minor leaking joints and the operation of pumps and similar equipment. We found that a number of items had not yet been installed and where these were essential for the start-up we arranged to have them fitted or made alternative temporary arrangements. I would like, at this point, to express my gratitude and admiration for the help we obtained from all the personnel at Jopolymer who worked with us all the long hours we found necessary to bring the plant to a state of safe operation for the initial test runs and subsequent resin emulsion production. The initial problems we found are quite normal on new plants and were not as extensive as we have experienced with many other licensees. This was due to the ability and conscientiousness of the local engineers and managers. Such "teething troubles" are also indirectly useful as they allow training of the local engineers on problem solving.

On Thursday 17th we arrived at an even earlier time in order to fit in a full programme and check the plant by pump circulation of cold water, check the heating arrangements and allow the agitators to run over a sufficient period to ascertain that we were not obtaining excessive temperature rises. We then calibrated the instruments including the temperature recorder, the flowmeters and the quantity meters.

We now felt confident that the plant could be made ready for the first batch on Friday 18 and it was agreed that we would work with this aim in mind (although Friday is the day of rest). We therefore started transferring the necessary raw materials and again one or two problems showed up which were overcome, some in only a temporary manner but sufficient to enable us to proceed. The equipment was washed out, drained and the raw materials were ready for loading into the feed tanks. On Friday 18th we completed the loading and started the operation of the plant for the production of emulsion. We ensured that the full batch was being witnessed by the two Jordanian operators so that we could, at the same time as proving the plant, start our training session for the local personnel. Mr. Bews was fully responsible here for the procedures to be followed and he explained each move in the operation to our

Jordanian friends so that the local personnel fully understood the reasoning for the procedures. I am pleased to say that the first batch was very successful and within specification and we had reached a point by 2330 hours when we could leave the finishing off until the next day.

On the 19th and 20th we carried on with the laboratory tests. Again this work was done whilst training the Jordanian chemist who would be in charge of this side of the operation. We made adjustments to the batch and we checked the engineering of the equipment as is standard practice after the first production. At the same time we carried on replacing temporary equipment with the correct permanent installations.

Unfortunately, due to previous commitments I was forced to return to England on the 21st but with the substantial help of our Jordanian friends we managed to achieve a successful start-up of the plant in record time and they felt as happy as I did that the initial part of my mission has been completed. I think this feeling was shared by your local representative, Mr. Nagway, with whom we kept in close touch.

Mr. Bews is staying until the 30 th July during which time he will carry on with further production on the plant and particularly with the training of the Jordanian personnel both on the plant and in the laboratory. Mr. de Silva needs to stay on longer and you will already have had an application for an extension of his mission to allow him to complete the detailed engineering requirements and the longer term testing of the equipment. An extension of four weeks has been requested to achieve this and I am hoping that this length of time will allow him to be absolutely thorough in checking all the equipment and iscussing with Jopolymer the problems that might arise and how these should be overcome. He will also continue the training of the local employees in the engineering procedures, fault rectification, dismantling and re-assembly procedures etc.

As far as my mission is concerned there are still a number of important items outstanding and it has been agreed that a second visit is definitely advisable. The same applies to Mr. Bews who will only be able to make a few grades in the time now available and who needs to return in order to show Jopolymer how to manufacture other products.

During my second visit in September/October I would also discuss the organization of the company, the procedures for plant maintenance and for running the engineering stores and the availability of sufficient spares. A split mission such as this is actually a better procedure as one can separate the immediate from the long term problems. We have found from previous similar experience that, on plant start-up, the immediate requirements and problems completely mask the long term needs of a new factory. In September/October Messrs. Jopolymer should be sufficiently established with their production to be in a much better position to discuss with us the longer term aspects and the way to achieve efficient operation of the plant and minimise breakdowns. The same reasoning also applies to the production side as the experience which they will have gained by this time will allow them to understand better the improvements in the process cycle which we will discuss with them and this is best done by Mr. Bews and myself together so that the overall organization, the engineering and production aspects are all covered.

I hope that this short report will indicate to you our way of working and the procedures which we like to adopt with new licensees so that they become self-sufficient not only in the production of emulsion but also in their ability to organise themselves sufficiently and I hope that with this in mind you will be able to grant extensions to the missions as requested.

Figure I. Site plan

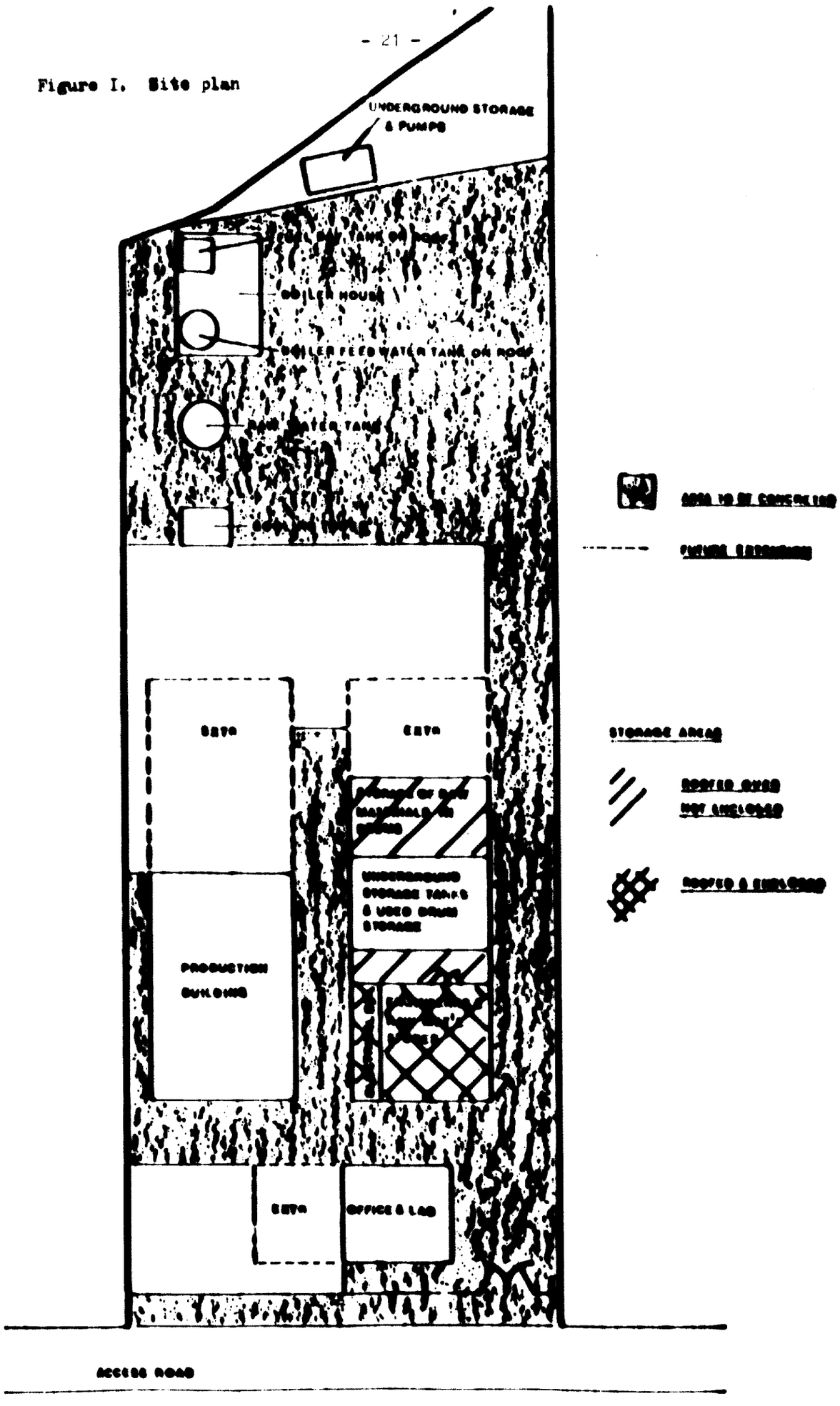
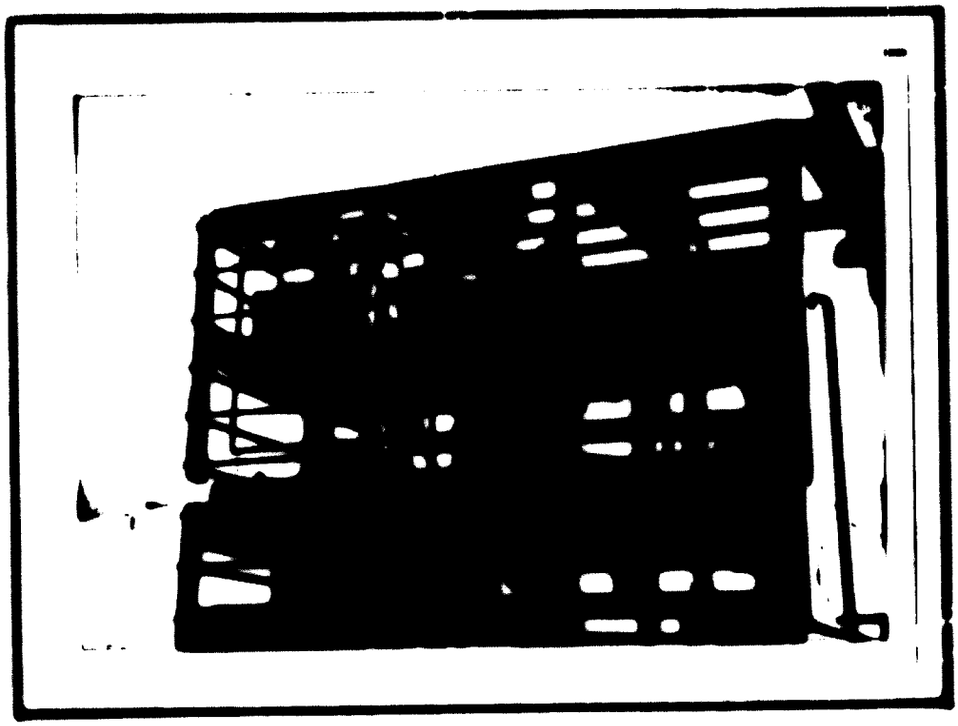


Figure II.

Production building before shooting



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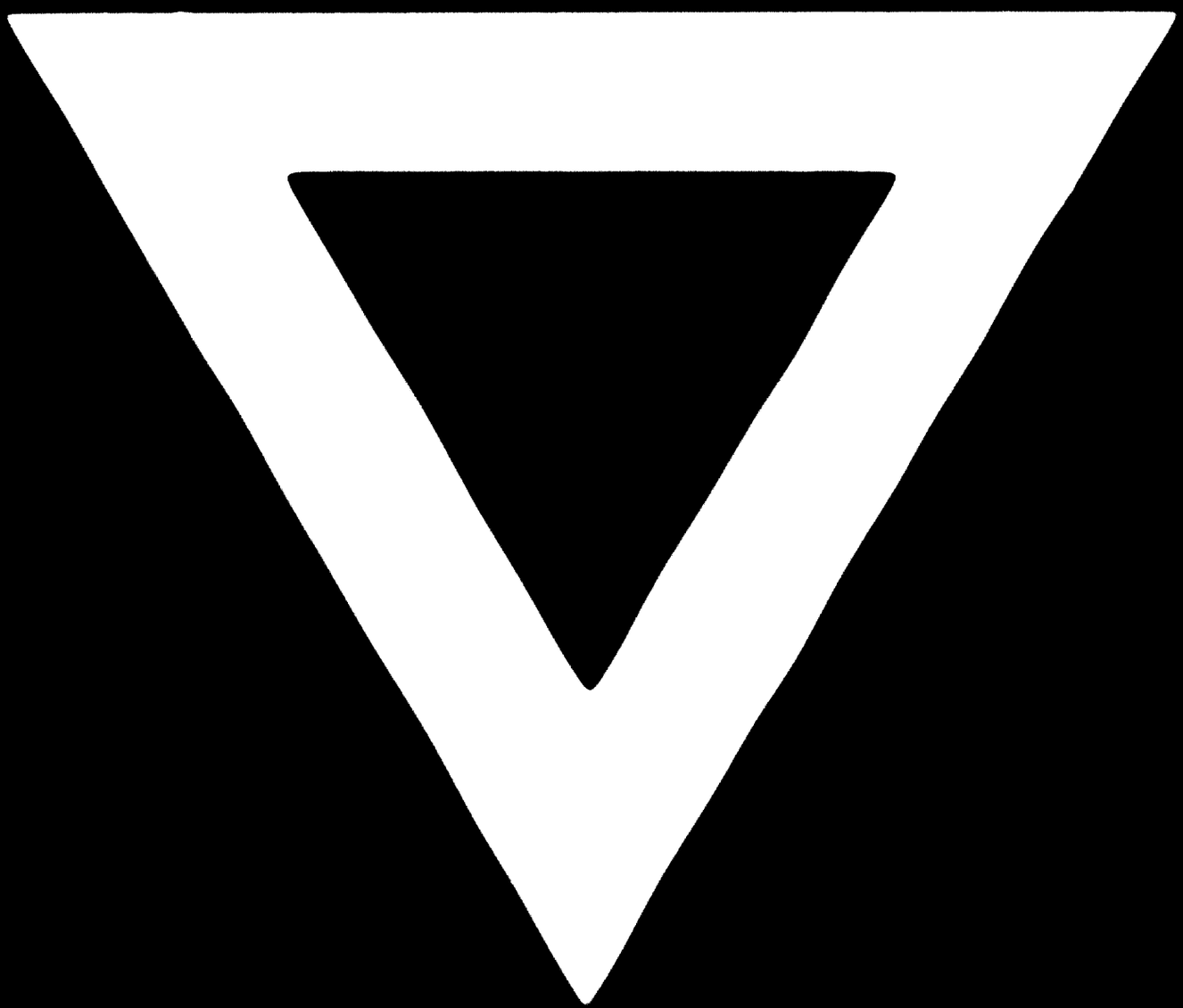

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