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PRODUCT QUALITY IMPROVEMENT ON UREA PRILLS

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INTRODUCTION

Abu Qir Fertilizers and Chemical Industries Company, owns a 1000 tpd ammonia plant and 1550 tpd prilled fertilizer grade urea plant as a single-stream line and offsite facilities, commissioned in 1979.
There is also another 1000 tpd plant with an associated 1800 tpd nitric acid unit and 2400 tpd granulated ammonium nitrate plants commissioned in 1991. The plants were engineered by Uhde Gmbh, West Germany. Feed stock for the plants is the natural gas obtained from the offshore Abu Qir well, 15 km from the plant side.

This paper relates the urea prill mechanical strength which has been subjected to high temperature exit prilling tower which may reach 80°C in the summer. This eventually affects urea prills in storage and handling due to the increases in fine content.

Several trials have been done to improve the mechanical strength of the prills e.g. seeding, coating by uresoft, and conditioning by formaldehyde. However the high outlet prills temperature causes the softening of bags material (polyethylene bags) and inefficient sealing due to the urea fines. The cooling of this product exit prilling tower by means of fluidized bed or bulk flow heat exchanger was necessary to solve the problems raised by the high temperature.

Urea fertilizers in the form of granules or prills are generally subjected to three main problems : caking, dust and moisture absorption.

Solutions to caking tendency

The fertilizer industry has adopted various measures to alleviate caking, including the following :

1. The use of various drying processes to obtain a product with a low moisture content.

2. The use of various cooling processes to obtain a product with a low temperature.

3. The use of various granulation, prilling and pelletizing processes to produce larger particles, thereby decreasing the surface area and the number of contact points between particles.

4. The use of screening equipment to obtain a more uniform particle size thereby decreasing the surface area and number of contact points between particles.

5. The control of storage conditions such as RH, temperature, height of pile, and storage time.

6. Packaging fertilizer products in essentially moisture-proof bags.

7. The addition of anticaking agents (conditioners).

As indicated, much can be done to decrease the caking tendency by improving both process and storage conditions. However, there is always a practical and economical limit to the improvements that are possible. Thus, in many cases of the use of an anticaking agent in combination with process and storage control is the obvious answer to caking problems. However, it should be emphasized here that an anticaking agent can not be used to compensate for a poorly produced or handled fertilizer.

TYPES OF ANTICAKING AGENTS

An anticaking agent is a material added to a fertilizer to promote the maintenance of good physical condition (flowability) during storage and handling. Anticaking agents can be classified several ways including mode of action, conditioner chemistry, method of application, and fertilizer type. For our discussion, we will classify anticaking agents into two categories according to the method of application, namely :

a. Coating agents   b. Internal or chemical conditioners

a. Coating agents

Coating agents are conditioning materials that are applied uniformly onto the surface of the fertilizer particles. Most coating agents are either very finely divided inerts powders (dusts) that adhere to the particle surfaces or are liquids that are sprayed onto the surface.

b. Internal or chemical conditioners

This type of conditioner (anticaking agents) is added to the fertilizer during processing. These conditioners act internally, usually as hardeners or crystal modifiers to improve storage properties. For urea conditioning, a current popular practice in some countries is the inclusion of 0.3 - 0.5 % of formaldehyde in the final product. The formaldehyde is added to the molten urea in the form of 37 % formaldehyde solution. Formaldehyde addition also reduces the formation of dust in the finishing process because the prills are harder and more resistant to abrasion and breakage than is untreated material. Coating may use less treatment agent than conditioning to give the same resistance to caking. In addition to the anticaking effect, coating will reduce the tendency of urea to absorb water vapour from atmosphere.
Conditioning of the urea fertilizer will make the prill harder and so reduces the chance of prill degradation to fines.

SEEDING

The impact strength of the prills determines the percentage of prills breaking under the influence of dynamic forces, that is, during handling. Broken prills give dust problems and increased caking tendency. It is therefore desirable to produce prills of high impact strength.

The impact strength is reported as the percentage by weight of prills unbroken after impingement on a steel plate at a specified velocity. During the fall through the prill tower, urea drops may be super cooled. When a super cooled drop solidifies, many small crystals are formed, all having the same orientation, a prill with this structure has a moderate impact strength. Super cooling can be prevented by seeding. To this end, an amount of urea dust is blown into the tower. These crystals collide with the urea drops and act as nuclei. Because of the coherence between these irregular crystals, the prills have a high impact strength.

In order to prevent deposition in the transport lines for seed dust, a small amount of calcium stearate is added to the urea feed in the seeding installation. DSM/UKF research, in which regular tests were made on the urea prills produced, showed that two modifications of urea prills were found (See Figures 1 to 4).

- Smooth, very round prills.
- Prills with a rough surface showing clear crystalline structures.

There is hardly any difference in crushing strength between the two modifications. The difference in impact strength, however, is considerable. After the impact test, the smooth modification contains only 10% unbroken prills, that with the crystalline appearance as much as 75%.

Further, in the microscopic examination the fracture face of the prills appears to be quite different. The smooth modification shows a very smooth fracture face. With the prills of crystalline appearance, the fracture face is very rough and shows crystals without orientation.
It will be clear that as a result of the way of interlacement in the crystal packing of this latter prill this modification is much less prone to fission and, hence, mechanically stronger than the former.
The following is the explanation for the different modifications of urea prills. During prilling, the impact of the prills on the prill tower floor and the action of the scraper give rise to the formation of very fine urea dust. This dust is carried along with the rising air stream in the tower. On collision with the descending urea droplets the dust particles act as crystallization seeds.

At excessive water vapour pressures of the air, the dust particles may absorb so much water that they pass into solution. They do no longer act as seeds then and the descending urea droplets may get super cooled. Owing to crystallization from the super cooled phase, the weak prill modification is then formed. Super cooling is a phenomenon where a substance is in the liquid phase although the temperature is below the crystallization temperature of the substance. The absence of sufficient seed crystals need not necessarily be imputable to atmospheric conditions. More causes are imaginable leading to insufficient dust formation or to the dust not being carried along in the ascending air, for instance through too low velocity of the rising air stream immediately above the prill bed on the tower floor.

To avoid formation of weak modification prills, we must take no chances in the matter of seeding. Therefore urea dust in the required amount and of the required particle diameter is introduced into the prilling tower.
The improvement in prill quality achieved by introducing urea dust into the prilling tower is evident from the following diagrams tables.

Table I This table shows the frequency distribution of the percentage of round prills after the impact test measured over a long period before the seeding installation was operational.

Table II This table represents the same test, but now with the seeding installation in continuous operation.
The difference is self-evident.

Figure 5 refers to the flow chart of the seeding unit.

UREA PRILL COOLING

The purpose of the installation of a cooler for urea prills is to improve the handling and storage properties.
Two different systems have been considered for this requirement which are the fluidized bed cooler and the bulk flow heat exchanger.

Fluidized bed cooler

The fluidized bed cooler represents a well proven technology, however for this specific case some essential draw backs can be listed :

a. Space needed for its installation is relatively high.
b. Electrical power consumption is high.
c. Dust scrubbing of cooling air excooler is required and scrubbing solution needs to be recycled.
d. During summer, air must be cooled.

Bulk flow heat exchanger

The bulk flow heat exchanger was developed in 1983 by Cominco/Canada, a big fertilizer producer facing the same problems in storage and handling of urea prills with a too high temperature.
They put this heat exchanger (4 units) into commercial operation in 1988.
Compared to the fluidized bed cooler, the following advantages can be listed :

a. The space requirement is little.
b. No off-gases to be scrubbed.
c. Consumption of electrical energy for the cooler itself is zero.

All those factors are related to the installation of a bulk flow heat exchanger.

PROCESS DESCRIPTION (Refer to Figure 6)

As a by-pass to the original product flow a line for optional cooling of the urea prills ex prilling tower is installed in the following way :

The prills are conveyed from the bottom of the prilling tower to the bulk flow heat exchanger, by means of belt conveyors, and bucket elevator.

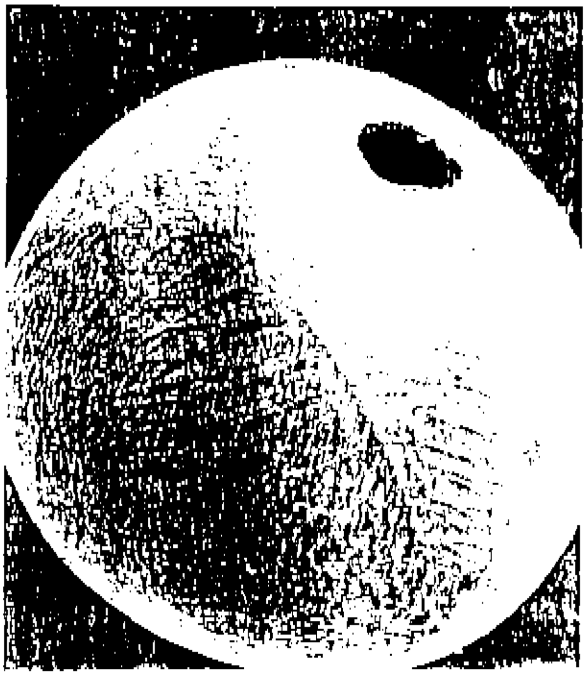
There it is cooled down under true mass flow conditions between the water cooled stainless steel plates.

Flow rate is regulated by a gate in the discharge hopper. The inlet and outlet product temperatures can be seen by the local temperature indicators. Pressure, temperature and flow rate of the cooling water supply are locally indicated as well as the outlet temperatures of heat exchanger, so as to control the efficiency of heat exchanger.

The cooled down product falls back to the old existing belt conveyor where it is weighed by the relocated belt scale.

In case of blockages in the cooler the product is automatically diverted by means of the swivel chute which is controlled by the level indicator controller installed in the heat exchanger top hopper.
The heat exchanger consists of 2 units. The capacity of each unit is 44 M3/hr to be cooled down from 80°C to 60°C (1550 Mt/day prilled urea product) using 200 M3/hr cooling water to be heated from 32°C to about 35°C.

Figure 1



Smooth, very round prills

Figure 2

Prills with a rough surface showing clear crystalline structures

Figure 3

The smooth modification showed a very smooth fracture face (Miscroscopic Examination)

Figure 4

The crystalline appearance, the fracture face is very rough and shows crystals without orientation (Microscopic Examination)

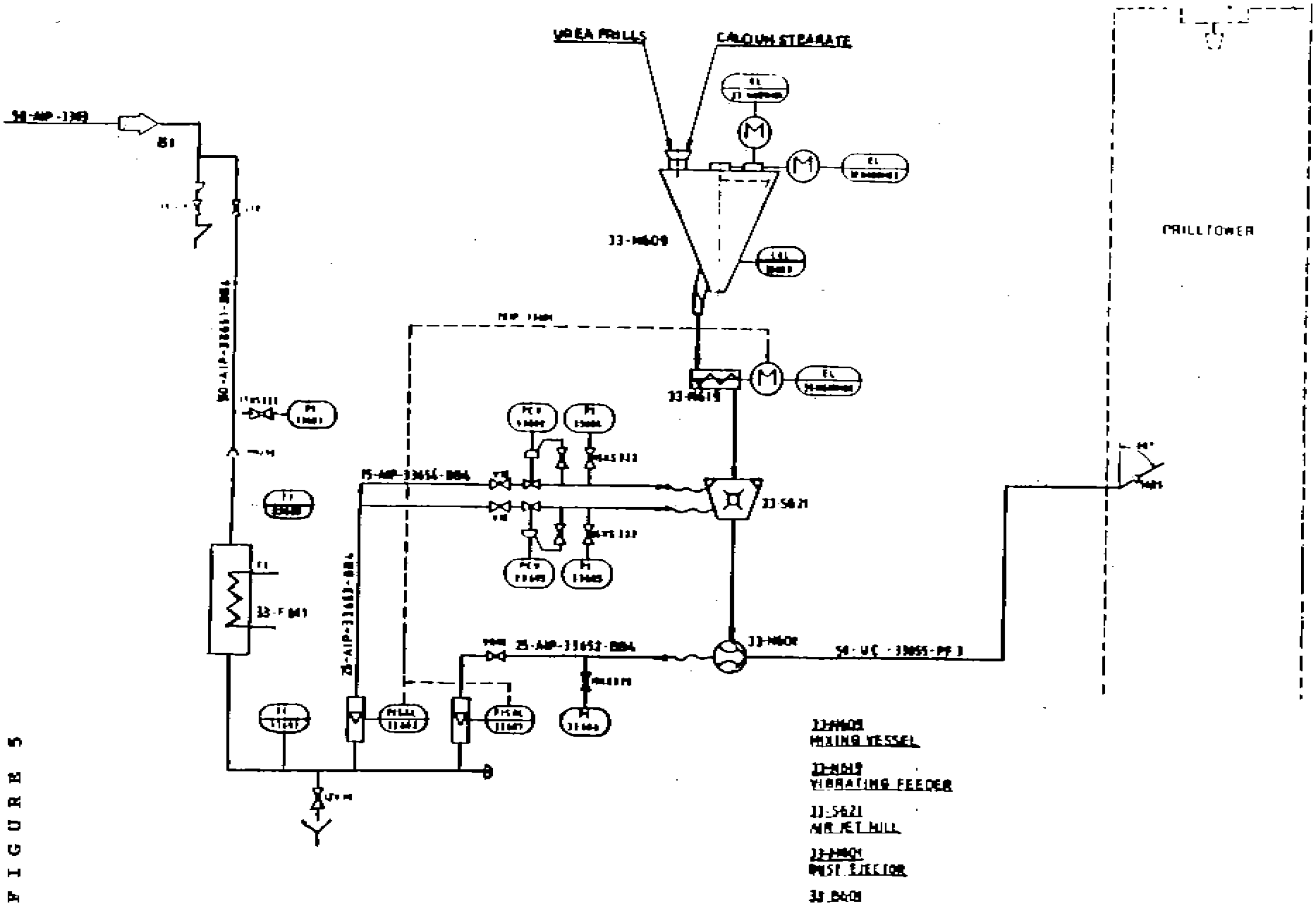
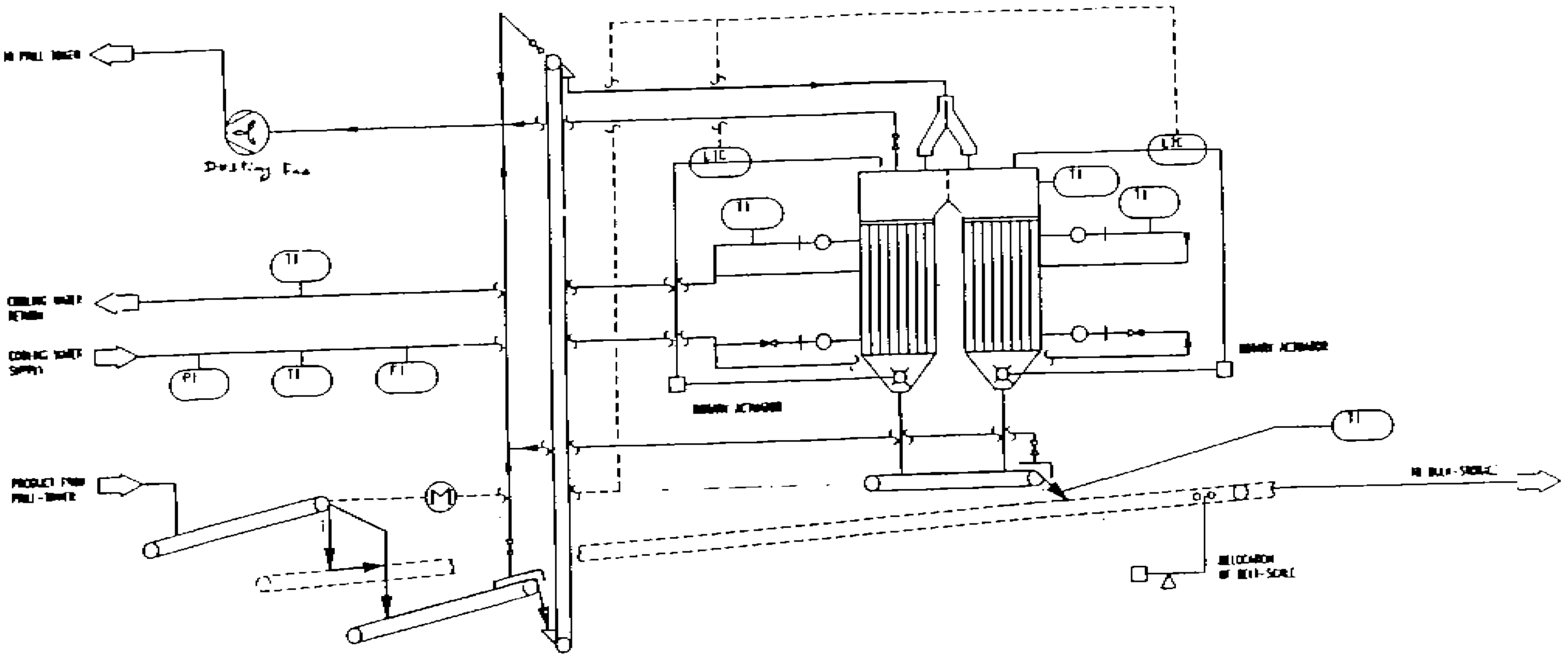


FIGURE 5

Seeding Unit Diagram



Bulk Flow H. X.

(2 Units)

FIGURE 6

TABLE 1

Frequency distribution of dynamic strengths of urea prills without seeding

n = 63 $\mu = 45\%$ $\delta = 18.4$ (V = 45%)

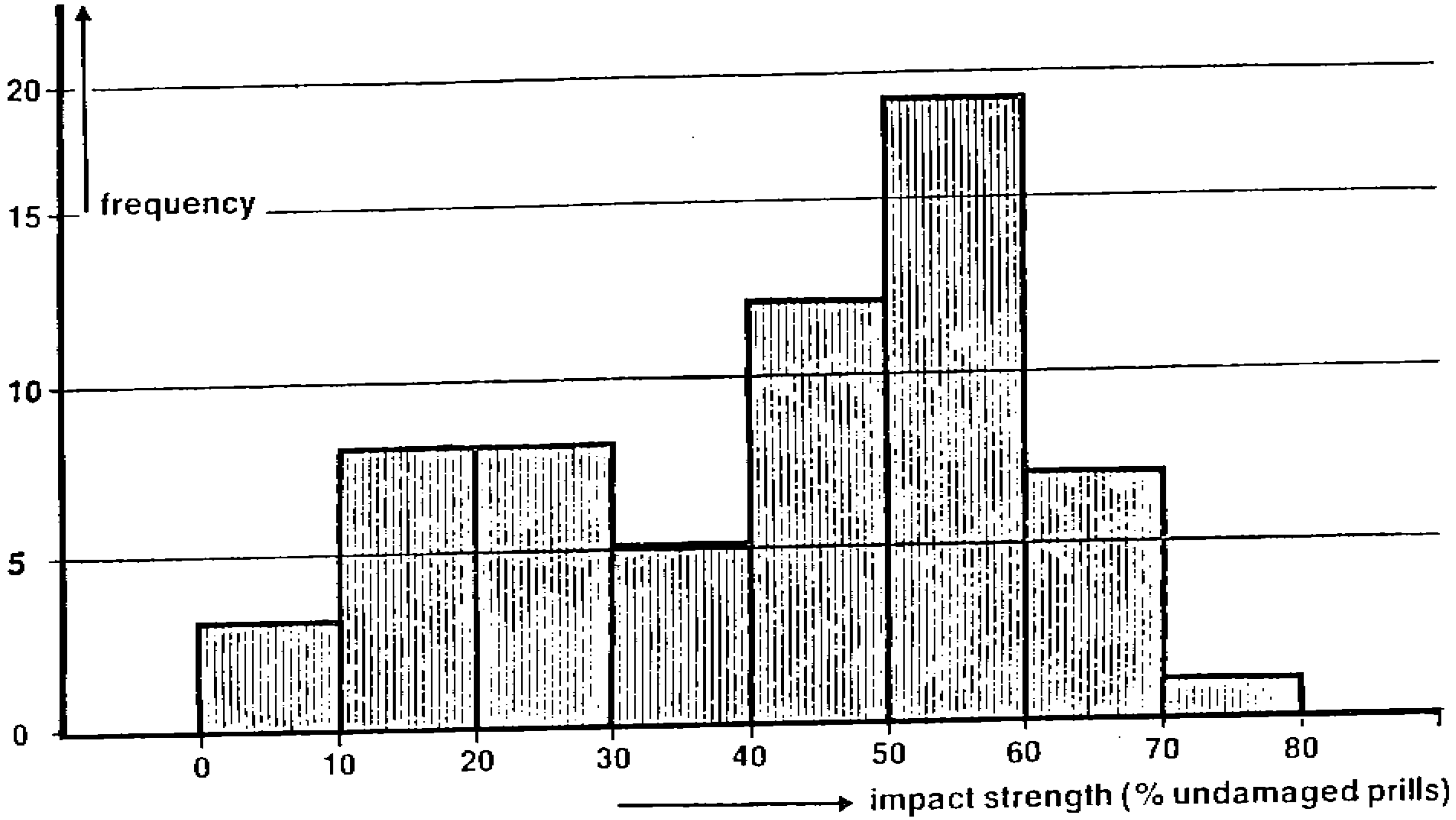


TABLE 2

Frequency distribution of dynamic strengths of urea prills after seeding.