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Scientific and Technical Intelligence Report

Soviet Grain Post-Harvest Processing and Storage (OUO)

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Project Officer

STAT

PRÉCIS

The Soviets perennially experience high losses and deterioration in the quality of grain because of inadequacies in their post-harvest processing and storage capacity and technologies. Such losses are particularly significant in years of abundant harvests because they tend to reduce the carryover available to supplement years of poor harvests. Storing large quantities of unconditioned newly harvested grain in uncovered piles in the open is a major cause of storage losses.

In the next 5 years reduction of grain losses caused by inadequate post-harvest processing will result primarily from increased quantities of improved equipment and balanced distribution. The Soviets will continue to produce improved grain cleaners and dryers to replace obsolete and small capacity equipment and to increase total numbers. Radically new approaches to equipment design or acquisition of foreign technology are not likely to have a significant impact within the next 5 years.

To expand closed storage facilities for grain purchased by the state, the Soviets plan to construct during 1976-80 an additional 30 million tons of storage capacity. If planned construction is carried out, Soviet procured grain storage capacity by 1980 could reach an estimated 166 million tons, with 62 million tons in elevators. Even approximate achievement of the goal could contribute to a significant reduction of losses in grain quality and quantity.

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SOVIET GRAIN POST-HARVEST PROCESSING AND STORAGE

Project Officer

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CENTRAL INTELLIGENCE AGENCY
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PREFACE

Post-harvest processing and storage technology have a major bearing on losses in Soviet grain quantity and quality. These two elements occupy key points in the chain of events between grain production in the field and the consumption of grain as food and feed. Since grain production is seasonal and consumption is relatively continuous, grain must be made suitable for safe storage, and facilities for safe storage must be provided if major grain losses are to be prevented.

Grain storage losses are influenced greatly by harvest factors, e.g., moisture, temperature, mechanical injury, presence of weeds, and the condition of procured grain. One of the primary causes of losses and deterioration in quality in the USSR is the high-moisture content of harvested grain.

The destructive activity of microorganisms, highly dependent on moisture and temperature, is the most serious problem in regard to quality and losses of newly harvested and stored grain. Also microorganisms in the grain mass generate large quantities of heat during storage, a major source of spoilage and quality losses.

This report reviews the status of Soviet grain post-harvest processing and storage capacity and technology, evaluates their effectiveness in relation to biological factors, harvest conditions and procurement practices, and assesses the impact on Soviet grain quality and losses. (A glossary of terms is included at the end of this report.) [redacted] STAT
[redacted] The study was prepared by the Office of STAT
Scientific Intelligence and coordinated within CIA. The report contains information through September 1976.

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SOVIET GRAIN POST-HARVEST PROCESSING AND STORAGE

PROBLEM

To evaluate Soviet grain post-harvest processing and storage capacity and technology and to assess their impact on grain quality and losses.

SUMMARY AND CONCLUSIONS

Soviet post-harvest processing and storage are inadequate in capacity and technological quality to handle properly all of the harvested grain, especially in high grain production years. Inadequate post-harvest processing also reduces the capacity of storage facilities. Grain subjected to spoilage and self-heating has only limited use (primarily for feed or industrial purposes) and reduces Soviet options in utilizing procured grain. Reduction of grain losses because of inadequate post-harvest processing will result primarily from increased quantities of improved equipment and balanced distribution.

Major losses have resulted from the need to store large quantities of newly harvested grain in outdoor piles because of shortages of enclosed storage facilities. Losses in grain stored in the open areas can be twice as large as those in elevators under normal conditions and even greater in unfavorably wet years. Heavy losses occurred in 1973 in both the grain procured by the state and that which remained on the farms, when an estimated 35 million tons or more of grain had to be stored in the open.

Post-harvest processing of grain involves one or more of the following steps: cleaning, drying, and cooling to achieve safe storage conditions. As of 1974, more than 20,000 grain-cleaning machines had been installed within the procurement system. In many cases the technical effectiveness of the cleaners was low and the cost of cleaning was high, resulting in individual batches frequently being stored without cleaning for long periods of time.

Artificial drying of some of the grain is necessary in all Soviet grain-growing regions, even to some extent in the south. Harvest moisture problems are greatest in the New Lands, the Far East, and middle and northern portions of the European USSR. Nearly 40% and in some years up to 60% of the newly harvested grain is damp or wet and requires drying. In unfavorably wet years, 80 to 90% of the grain in Siberia, the Urals, and North Kazakhstan, must be dried. In eastern regions more than 50% of the produced grain must be dried twice to reduce it to proper moisture content. More then 63 million tons, or over 70% of the procured grain, was dried at Soviet reception centers in 1973. About 38 million tons of this was dried within the RSFSR where harvest moisture problems are greatest. Despite large increases in the capacity and number of grain dryers, the Soviets are unable to secure complete drying at reception centers of all grain that is purchased. Dryers of the column-type, which comprise more than 80% of the total in the USSR, suffer from low efficiency, low rate of moisture removal, unequal drying, overheating of the grain, and the inability to dry wet grain directly from the combine.

It is expected that the Soviets will continue to produce improved models of grain cleaners and dryers to replace obsolete and small capacity equipment and to increase total numbers. Modernization and rebuilding of larger drying and cleaning facilities will continue. Little evidence exists to indicate Soviet intent to acquire foreign drying and cleaning technology. New approaches to grain dryer design that may be instituted by the Soviets will not have significant impact on their grain drying problems within the next 5 to 8 years.

The Soviets are relying increasingly on the use of active ventilation (aeration) systems to reduce losses in storage, particularly that in flat storage. The major function of active ventilation is to establish and maintain moderately low and uniform grain temperatures by blowing air through the stored grain. Long-term storage of grain in flat storage, especially if it is wet, is impractical without aeration. In 1973 the USSR Ministry of Procurement had 6,000 grain-receiving and processing enterprises, with a total capacity of 48 million tons, equipped with installations for active ventilation. More than 60% of the flat storage facilities within the procurement systems were so equipped by 1975.

Soviet enclosed storage facilities presently are insufficient for storing grain from normal and above normal harvest years, and they must be supplemented by storage under inadequate open conditions. Although silo elevators are considered the most desirable storage facilities by the Soviets, permanent grain storage capacity is primarily flat storage in long low buildings, comprising nearly 80% of the capacity within the procurement system. Enclosed storage of damp and wet grain is limited to flat storage, with or without aeration. The storage capacity in flat storage is reduced nearly one half when holding wet grain. Even though Soviet grain technologists admit that temporary storage (primarily on open floors) is undesirable, the USSR is forced to rely on this procedure because of inadequacies in processing and storage capacities.

The Soviet Union has recognized the need for greatly expanding the capacity of enclosed permanent storage facilities to reduce storage losses. As of 1 January 1975, the total permanent storage capacity within the procurement system was 136 million tons, of which about 32 million tons were in grain elevators. Soviet farm grain storage capacity was 98.5 million tons in 1973, but only 54.7 million tons were in standard storehouses. Farm grain storage facilities range from open-air platforms and roofed storage areas to standard storehouses.

Plans call for the construction of 30 million tons of new elevator storage facilities within the procurement system during the next 5-year plan (1976-80). The newly constructed elevators will include drying and cleaning facilities and, therefore, also will increase Soviet grain processing capacity. Under the plan grain storage capacity within the procurement system by the end of 1980 could total 166 million tons, with 62 million tons in elevators. This effort represents a greatly accelerated and expensive program and reflects the extremely serious need to reduce storage losses. It is believed that the Soviets will exploit or purchase foreign grain elevator technology but specific evidence of the extent of such efforts is lacking. Past Soviet performance and the unprecedented rate of planned elevator construction make it likely that at best a large portion of the total planned elevator capacity will be achieved by 1980. Even an approximate achievement of the goal could contribute to a significant reduction of losses in grain quality and quantity.

DISCUSSION

INTRODUCTION

Maintenance of quality and prevention of losses during storage of cereal grains are dependent on the fact that dry, dormant grain with an unbroken surface offers resistance to decomposition by microorganisms and granary pests. Dormancy and hardness of the outer surface of grain are controlled largely by the moisture content. Weather during harvest can determine the stage of maturity, extent of physical damage incurred during harvest, and the moisture content of the grain crop.

Grain in storage also interacts with its environment, exchanging heat and moisture. The presence of high-moisture content may lead to increased physiological activity of potentially damaging organisms, chiefly microorganisms, associated with the stored grain. For grain to be safe during collection, transport and storage, biological activity should be kept at a minimum. Since biological activity will occur only in the presence of adequate moisture and at suitable temperatures, the moisture content and temperature of the grain are essential keys to its safekeeping, primarily during storage.[1-3]

FACTORS AFFECTING GRAIN QUALITY AND STORABILITY

Biological Factors

Damage to grain during storage is not simply the result of a departure from known optimum conditions. When moisture and temperature exceed biological thresholds, the resultant biological responses may not only be self-maintaining but also self-generating. An increase in the physiological activity of microorganisms will lead, through breakdown of organic matter, to increased moisture content and heat and hence to a further increase in growth and metabolism. Even small foci of damage can result in rapid deterioration of the grain bulk as a whole. Partial control is not sufficient. Every part of the grain bulk must be kept below the critical levels of temperature and moisture content.

The degree of microbial deterioration of grain depends upon the rate of growth of storage microorganisms. This rate is affected primarily by the interaction of temperature and moisture. The growth is also affected by seed coat damage, arthropod infestation, time, and previous fungal infection.

Grain is hygroscopic and exchanges water vapor with its environment. There is essentially a one to one relationship between grain moisture content and the relative humidity of the ambient air. For many important food grains, moisture content of 13 to 15% corresponds to a surrounding equilibrium relative humidity of about 70%. A moisture content of 13 to 15% is considered to be critical in that fungi can multiply above this level of moisture. However, some storage fungi are known to multiply at relative humidities as low as 62% (grain moisture content of 11 to 13%).[1 3 4]

The rate of reproduction of storage microorganisms increases, within limits, with temperature. To prevent fungal growth entirely by temperature control may not always be practicable, since a number of storage fungi can still grow at temperatures below 0°C. The rate of multiplication may be slowed so that damage becomes negligible. Storage even at 5°C. may result in visible fungal growth after about 2 months at moisture content above 22%. The time necessary for mustiness and visible fungal growth to develop depends mainly on temperature and moisture. Since some fungal growth may occur at below 0°C., low temperature storage alone without some drying cannot prevent fungal growth. Maximum fungal growth is achieved at about 30° to 50°C. (85 to 90°F).[3 4]

The Soviets indicate that self-heating is the primary cause of spoilage of grain during storage. Self-heating is the increase in temperature of a grain mass as the result of physiological processes occurring in it, caused chiefly by microorganisms. Storage microorganisms in the grain mass evolve large quantities of heat through their metabolic activities. The thermal characteristics of bulk grain are such that any heat generated within the bulk is dissipated very slowly. Spontaneous heating of bulk grain is unlikely if the grain moisture content is less than 14%. It occurs in grain with moisture content in excess of 14 to 15% and in most cases with grain having a moisture content in excess of 17 to 18%. This arises chiefly from the respiration of the storage fungi present. The cumulative effects and the spread of these self-induced temperature and concomitant moisture changes are such that grain temperatures approaching 60°C. (140°F.) may be reached.[1 3 6]

Self-heating has negative effects on the state and quality of stored grain. The quantitative and qualitative changes depend on the duration and intensity of the process. If self-heating is allowed to continue, significant losses in the weight of the grain and deterioration in its quality to the point of complete spoilage will occur. Self-heating sharply reduces the germination rate and worsens its bread baking qualities. In wheat the gluten content is lowered and is greatly reduced in quality—it turns dark, its tensile strength is changed and it loses its elasticity. The acidity of the flour prepared from heated grain is increased and its water-holding capacity is decreased. If temperature of the grain exceeds 40° to 45°C. (104-115°F.), the gluten cannot be separated from the wheat. A grain mass that has been subjected to self-heating, even if it is stopped before significant qualitative changes occur, is unstable for lengthy storage because the quantity of fungal growth is high and the protective seed coat has been damaged.[1–3 6]

Mustiness is another result of the activity of storage fungi. When fungi have extensively invaded and partly consumed the grain, they have already produced masses of spores. The grain will have a musty odor and moldy appearance and may cake together in the later stages of spoilage.[4]

Germ damage is the term applied to dark brown or black embryos (germs) in small grains and corn caused by storage fungi. This type of damage is important in grain that is to be processed into flour, meal or other food. The damaged portion may result as dark particles in the final product. Such grain usually contains large quantities of fatty acids and is often extensively moldy, imparting undesirable flavors to food.[1–4 8 10]

Harvest and Procurement Factors

Moisture Conditions During Harvest—One of the main causes of grain losses and of significant deterioration in quality in the USSR is moisture during harvest. Meteorological conditions during ripening and harvest—precipitation, dews, fogs, and relative humidity—have major bearing on the harvest and post-harvest losses. The harvest moisture problem is dependent to a large extent on geographic location. In the Northern Caucasus, the Crimea, and the Southern Volga, newly harvested grain usually has a moisture content at 15% or below, but in regions to the north and west the moisture content rises to 16 to 20% and above (figure).

Two Soviet researchers recently have described moisture conditions during harvest and the average moisture content of newly harvested grain by establishing zones within the grain-growing area. Four zones were established. Characteristics of the four zones coincide with the information on average moisture content of harvested grain shown in the figure. The description of the zones also supplied information on the agrometeorological conditions which contribute to the grain moisture problem. Since the zones encompass fairly large areas, the Soviets state that deviations from the described conditions could occur during any harvest year.[9]

In 1975 a Soviet researcher drew up a table, based on a survey of actual data, showing the probability of the occurrence of proper grain moisture content by economic region.[14] These data, shown in table 1, essentially coincide with data given on the six zones.

The moisture problem in the vast spring wheat areas of the Virgin Lands of the RSFSR and Kazakhstan deserves special discussion. The harvest moisture problems in the Virgin Lands to the north and east of Volgograd Oblast are generally greater than for major Soviet wheat areas in the North Caucasus and southern Ukraine. In Kazakhstan during the period of grain harvest, a large amount of rain falls and freshly harvested grain frequently has a moisture content of 18 to 20% and, in very wet years, up to 30 to 35%.

Table 1

Probability of Harvesting Grain With Less Than 16% Moisture

Economic Region	Probability
Baltic	0.01
Northwest	0.10
Volga-Vyatka	0.11
Eastern Siberian	0.11
Far Eastern	0.13
Central	0.21
Kazakhstan (Northern Portion)	0.30
Belorussia	0.30
Urals, Western Siberian	0.35
Southwest, Central Black Earth	0.66
Volga:	
Northern Portion	0.65
Southeastern Portion	0.98
North Caucasus, South, Donetsk-Dnepr, Moldavia	0.66–0.97
Central Asia	0.99

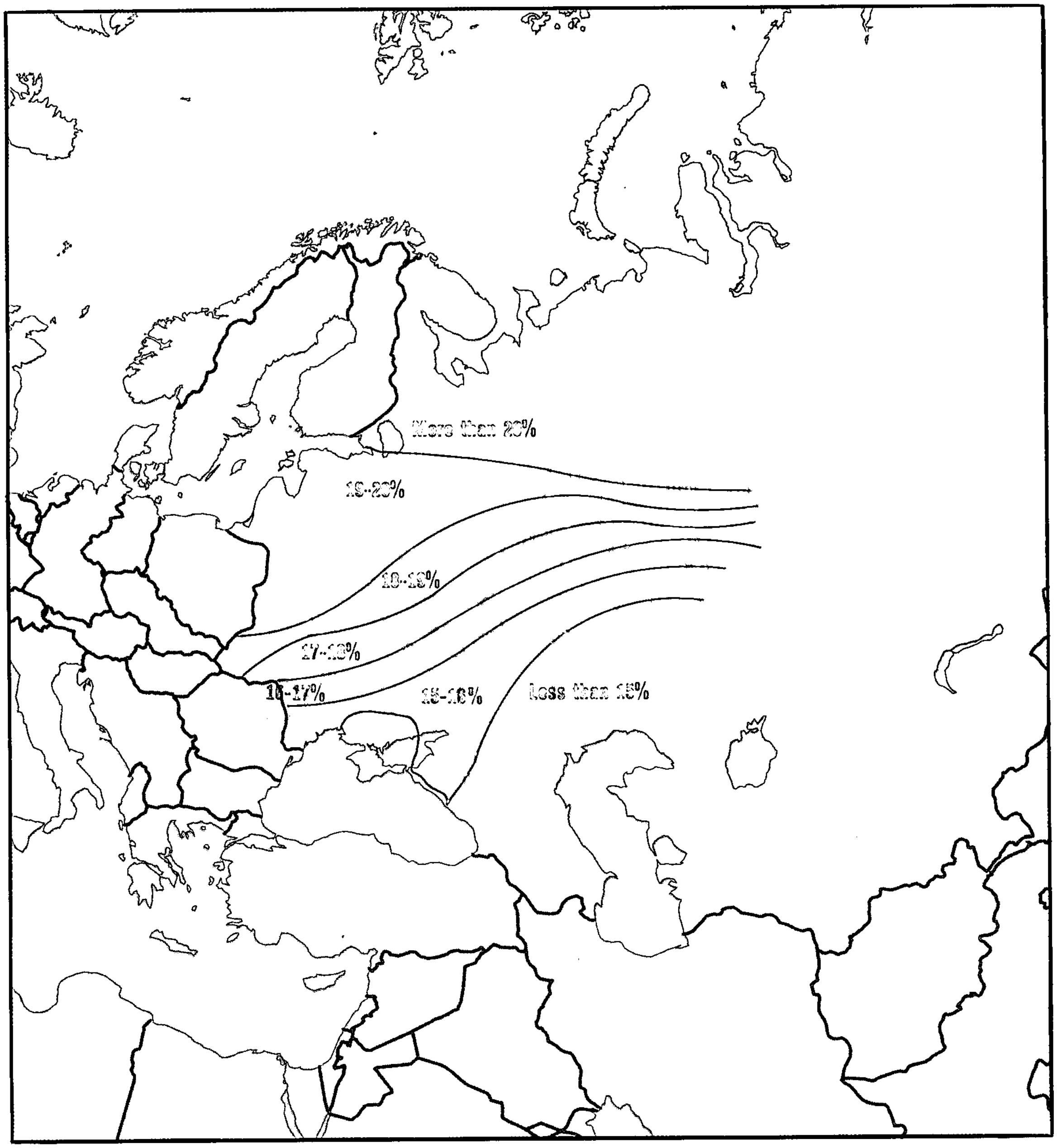
Excess precipitation frequently delays or complicates harvesting operations and interferes with grain processing at the threshing floors.

Significant harvested grain moisture problems have occurred in the Virgin Lands in 5 of the last 7 years. In 1969, 1971 and 1972, harvest moisture problems were associated with a late ripening crop because of delays in spring seeding. In 1973 and 1974 moisture problems were more directly related to harvest weather.[16]

Damp and Wet Grain in Procurement—In the vast Soviet spring wheat area east of the Volga River (the Virgin Lands), grain is frequently procured by the state at moisture levels in excess of 20%, and occasionally significant amounts are delivered to procurement centers with levels in excess of 30%. It is generally accepted that the Soviet grain lands east of the Volga are climatically analogous to the prairie provinces of Canada. The unique Soviet problem is a distinctly wetter moisture regime in the autumn during harvest in the USSR compared with that of Canada and the United States. This places a large burden on the Soviet grain handling system.[16] The magnitude of the grain moisture problem in the Virgin Lands can be seen from various data on the amount of damp and wet grain delivered to procurement centers. (The Soviet classifiction of grain by moisture content is shown in table 2.)

The average moisture content of grain delivered to procurement centers in the Urals, Siberia, and Kazakhstan in the late 1950s, as calculated by a US

Average Moisture Content of Harvested Grain



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researcher, was of the order of 20 to 25%. Data also have been compiled for the 1950-56 period for combined damp and wet grain deliveries as a percent of the total grain deliveries to procurement centers for four of the economic regions in the Virgin Lands. The amount of damp and wet grain in procurements varied from 30% in the Ural region in 1953 to a maximum of 95% in Northern Kazakhstan in 1950. The median percentage of damp and wet grain for 1950-56 was 79.2%, which is consistent with the Soviet Minister of Procurement's statement in 1972 that every year 70 to 80% of the total procurements in the Virgin Lands are recieved wet.[1 16]

The Minister of Procurement of the Kazakh SSR supplied data on the moisture content of procured grain for that republic in 1972 and indicated that almost half of all the grain arrived at grain reception points in a wet state—17 to over 19% moisture. The oblasts included in the Virgin Lands category

Table 2

Soviet Classification of Grain by Moisture Content

Moisture condition	Moisture content, %
Dry	Up to 14 inclusive
Moderately dry	Over 14 to 15.5 inclusive
Moist (damp)	Over 15.5 to 17 inclusive
Wet	Over 17

(Northern Kazakhstan, Kokchetav and Tselinograd) had especially serious problems. Northern Kazakhstan Oblast delivered 87.8% of all grain in a wet condition, Kokchetav Oblast 87.5%, and Tselinograd Oblast 82.8% [18] (table 3).

In the Central non-chernozem economic region during the period 1963-68, a survey indicated that 76.3% of the procured grain was classified as wet; 15% had moisture of 15.6 to 17.0%; and only 8.7% was dry or of average dryness of 15.5% moisture or below. In Ryazan Oblast during this same period, 47.4% was classified as wet (14.3% had up to 19% moisture and 33.4% had over 19%) and the remaining was damp with a moisture content of 15.5 to 17.0%.[20] By contrast, in Krasnodar Kray in the North Caucasus during the period 1963-68, an average of almost 90% of the freshly harvested grain was of dry or average dryness (up to 15.5% moisture); 6.7% was in the 15.5 to 17.0% range, and 4.2% had moisture content above 19%.[20]

In 1973 the harvesting and state procurement of grain was complicated by severe temperature drops and continuous rains in regions of the Central, Central Chernozem oblasts, the North Caucasus, and the in the Volga region. Exceptionally large quantities of grain with high moisture content were received at grain reception points in these areas. In Lipetsk Oblast batches of grain had up to 30% moisture content. In Ryazan Oblast much grain was received with a moisture content over 25% and in separate batches up to 40%. The Soviets reported that analogous examples could be shown in other oblasts. Ryazan, Tambov, Voronezh, Ulyanovsk, Lipetsk, Kursk, Orlov and several other oblasts had continuous rains during harvest, resulting in practically all arriving grain having a 17 to 30% moisture content. On 1 October 1973 in 10 oblasts of the Central Chernozem and Central zones alone, about 10 million tons of damp and wet grain arrived for procurement.[21–23]

During the 1974 harvest in Ryazan, Belgorod, Kursk, Penzensk, Tambov, Uralsk, Aktubinsk, Poltava, Vinnitsa and Kharkov oblasts, nearly all grain that arrived at grain reception enterprises was characterized by high moisture content requiring immediate drying.[20] In 1974 a significant quantity of grain was received in very wet condition. In the Ukrainian SSR alone, more than 10 million tons of grain with high moisture content was accepted at procurement points. Some of it was exposed to overheating and had a high content of germinated grain. Much of this very wet grain originated in the middle to northern and northeastern Ukraine.[15]

MECHANICAL DAMAGE—Mechanical injury or damage to grain has a negative influence on the storage of grain as well as its sowing and production qualities. Not only is mechanical damage injurious in itself, it also intensifies the respiration process and the development of microorganisms and grain pests. According to Soviet researchers, a reduction in mechanical damage of grain during threshing, which indirectly results in losses in quality, is equal in importance to elimination of direct quantitative losses in the process of harvesting.[9]

Table 3

Moisture Content of Procured Grain in the Kazakh SSR 1972

Oblast	14–15.5%	15.5–17.0%	Up to 19%	Over 19%
Karagandinsk	30.0	17.8	15.9	36.6
Kokchetav	4.3	8.2	31.2	56.3
Kustanay	58.9	13.0	13.5	14.6
Pavlodar	14.5	18.2	21.2	46.1
N. Kazakhstan	42	8.1	11.2	76.5
Turgay	48.8	25.2	12.9	13.1
Tselinograd	6.6	10.6	20.2	62.6
Total for Republic	37.2	13.4	15.6	33.8

Mechanical injury to grain is divided by the Soviets into two major categories: macroinjuries and microinjuries. Grain with macroinjuries differs from whole grain and for this reason can be removed on any modern grain cleaning and grading machine. Grain with microinjuries is more difficult to detect and it cannot be separated from undamaged grain even with the most complex machine.[9 13]

A Soviet analysis of 18 varieties of winter rye, 25 varieties of spring wheat, and 9 varieties of winter wheat taken from the combine hopper in the 1970 harvesting season in 38 oblasts, krays, and autonomous republics of the RSFSR indicated that as an average, microinjuries to winter rye were 59%; for winter wheat, 34.8%; and 34.3% for spring wheat.[9]

WEEDS—The occurrence of weeds, trash, and immature and sprouted grain has a significant impact on the moisture content and keeping qualities of grain. These are major problems in the USSR. Grain harvested from weedy fields has a higher total moisture content because of the presence of weed seeds and parts. Such weed seeds and parts are generally immature and contain a high percentage of moisture. The presence of weeds will add at least 3 to 5% to the moisture content of harvested grain.[14] Table 4 illustrates this for Moscow Oblast.

Trisvyatskiy indicates that impurities in grain significantly increase the occurrence of self-heating. The increased moisture content of unripened seeds of weed plants in freshly harvested grain result in high rates of respiration and the evolution of large quantities of heat which facilitate development of microorganisms. An especially strong effect on the grain mass is caused by parts of green plants which contain up to 70 to 80% and more water, are saturated with microflora, and are favorable media for their development. The physiological activity of the grain bulk grows immensely as the result of admixtures of weed seeds. According to Trisvyatskiy the energy of respiration of weed seeds in freshly harvested grain can increase the energy of respiration of grain bulk by 40 times.[1 3] Weed growth in fields and the subsequent presence of weed seeds and parts in harvested grain have long been major problems in the USSR, especially in the New Lands.

Table 4

Moisture Content of Weeds and Grain

Sampling date In August	Moisture Content in Percent		
	Grain	Weeds	Grain and Weeds
11	14.0	56.0	19.8
12	16.9	27.3	19.0
13	18.2	31.0	21.6

In 1972 Kazakhstan had very serious weed problems; more than one-third was "highly contaminated" with weeds. In the Virgin Land oblasts, the situation was even worse. In North Kazakhstan Oblast, 50.9% of the procured grain was weedy; for Kochetav Oblast, 74.9% was weedy; and for Tselinograd Oblast, 62.9% was weedy.[18]

In 1969 the collective farms in North Kazakhstan delivered 20.5% of all grain heavily infested with weeds. Other data indicated that during the 1966-70 period, state farms in North Kazakhstan supplied procurement with 38.7 million tons of grain which contained 1.5 million tons of weeds and moisture. During 1971-72, the figures were 19.6 million tons of grain which contained 0.7 million tons of weeds and moisture. According to calculations of the All-Union Scientific Research Institute for Grain, on an average for every 100,000 tons of grain arriving at grain reception points in the eastern regions of the nation, wastes (water and weeds) amounted to 5,000 to 7,000 tons. Transport expenditures for the useless transportation amounted to an estimated 3.3 million rubles for state farms in the northern oblasts of Kazakhstan during 1966-72.[18]

GERMINATED GRAIN—Extended rains in various zones of the USSR cause a delay not only in harvesting but also often lead to the partial sprouting of the grain in the field and sometimes to complete loss of the crop. Germination in the spike results from rainy weather and an overripe stand of grain. In 1973 in the RSFSR, complaints were noted about the lag between mowing and threshing. In several oblasts, grain was seen germinating in the windrows and in the standing crop. In the Ukraine in 1974, more than 10 million tons of wet grain was accepted at procurement centers. Some if it was overheating and had a high content of germinated grain.[15]

A representative of the Ministry of Procurement stated that overall, a significant quantity of grain was received in 1974 with a high content of germinated grain. Because part of it was delivered immature and with a high germinated grain content, such grain was still unstable for storage with respect to biological characteristics requiring daily inspection of its condition in spite of drying.[15]

POST-HARVEST PROCESSING

Post-harvest processing of grain in the Soviet Union is carried out both on the farms and at State enterprises of the system of procurements. Processing includes receipt of the grain, primary cleaning of it, drying to bring the moisture content within basic standards, and secondary cleaning and sorting to bring it up to basic standards.[24]

Post-harvest processing is one of the most time-consuming procedures in Soviet grain production. Processing at the threshing-floor level, i.e., cleaning and drying, takes up more than 20% of the labor resources involved in grain production. Expenditure of labor for post-harvest processing at the collective and state farms of the non-chernozem zone comprises an average of 40 to 50% and, on some farms, 60% of the total labor expended on grain.[7] [18]

The amount of post-harvest processing accomplished at the farm level varies from geographical regions. In 1974, the Ministry of Procurement representative stated:

> "The experience of past years has shown the high effectiveness of transporting grain to receiving enterprises from the threshing floors of kolkhozes and sovkhozes or directly from the combines on hourly schedules. This makes it possible to free more than 20% of the automotive transportation engaged in delivery of grain, to increase the handling capacity of receiving equipment and technological lines of grain receiving enterprises, and to improve the organization of labor on kolkhozes and sovkhozes and in transportation and procurement organizations."[25]

Economic calculations and Soviet and foreign experience support the economic effectiveness and desirability of post-harvest processing at the place of grain production. This processing in many regions of the USSR, however, is accomplished primarily at grain reception points. Grain is sent directly to reception centers from combines or sometimes after preliminary processing on individual winnowing grain-cleaning machines at the farms. According to Timofeyeev, because the quality of such grain was below desired conditions, collective and state farms of the Central non-chernozem, for example, failed to receive from each ton of grain more than 12 rubles in the form of deductions from purchase value. Transport of admixtures and water in the grain mass comprised up to 30% of the volume of the transported grain. Wastes that could have been utilized for cattle feed were not returned to the farms.[26]

Grain Cleaning

According to the Soviets, at the present time grain is cleaned in the USSR both by enterprises of the USSR Ministry of Procurement and by collective and state farms. There is a two-stage system of post-harvest processing of grain—at mechanized grain points of the farms and at grain-receiving, elevator, and grain processing enterprises.[27]

This two-stage system, however, describes one which exists only in part. The best that can be said is that much of the grain has to be cleaned at the reception centers and that some of it in certain areas of the country is cleaned before it leaves the farms. Apparently some grain is cleaned several times, first at the farms and then at the grain reception centers and at other elevators. One reason for this is that grain at the farm level frequently is only partially cleaned and sorted on small capacity machines. A second reason is that the majority of farm threshing points do not have a capability for drying grain. This means that in those geographical regions where harvests occur in rainy seasons or where freshly harvested grain has a high-moisture content, it is expedient to dispatch grain directly from the combines to reception centers to avoid excessive losses at the farm level. This is especially true in Kazakhstan.[12]

The Soviets publicize the more extensive introduction of the continuous method of post-harvest processing at the farm level. These aggregated systems are called mechanized grain-cleaning points and complexes. These points reportedly are equipped with grain cleaning, drying, loading and unloading, conveyor, and other equipment for fulfilling all operations connected with cleaning, sorting, drying, and storage. In addition some farms have grain cleaning-drying complexes or grain cleaning aggregates with productivity of 5, 10, 20 and 40 tons per hour. Such complex mechanization reportedly increases labor productivity by 7 to 10 times and reduces costs of drying and cleaning 1.5 to 2 times.[28] Table 5 lists the Soviet grain-cleaning machines and grain-cleaning aggregates and their productivity. Grain cleaning-drying complexes simply add various types of driers to these aggregates (these are discussed in the section on grain drying).

Soviet reporting on the use and effectiveness of their systems of grain cleaning, often called flow-level technology, is contradictory and frequently ambiguous. They claim extensive introduction of the systems at the farm level and high rates of supply of grain-

Table 5

Principal Grain Cleaners in the Soviet Union

Designation	Type	Capacity Tons/hour	Primary Use
ZSP-5	Separator	5	Farm
ZSP-10	Separator	10	Farm
ZSM-2.5	Separator	2.5	Farm
ZSM-5	Separator	5	Farm
ZSM-10	Separator	10	Farm
ZSM-20	Separator	20	Farm
OVP-20A	Winnower (mobile)	20	Farm
BAS	Pneumo-Separator	3	Elevator
VO-50	Winnower	50	Elevator
ZV-50	Winnower	50	Elevator
ZSM-50	Separator	50	Elevator
ZSM-100	Separator	100	Elevator
ZS-50	Separator	50	Elevator
KDP-80	Separator	80	Elevator
KDP-100	Separator	100	Elevator
AI-BZG	Screening	10	Elevator
AI-ZSSh-20	Screening	20	Elevator
Aggregates for Cleaning Commercial Grain on Farms			
ZAV-10		10	Farm
ZAV-20		20	Farm
ZAV-40		40	Farm
AZS-30		30	Farm

cleaning machines to the farm. They state also that the situation has changed radically since 1963. As of 1974 it is claimed that collective and state farms operate more than 25,000 mechanized grain points, grain-cleaning aggregates, and grain cleaning/drying complexes. More than 30% of the total grain harvest is processed by farms. As a result, weediness of grain arriving at reception centers reportedly has decreased in several regions. In the Ukrainian SSR, the northern oblasts of Kazakh SSR, the Volga regions, and Altay Kray in 1965-70, for example, weedy grain at reception centers decreased 2 times as compared with 1957-64. Delivery of weedy grain reportedly decreased in many regions in 1971-73.[27]

On the other hand, the same report states that grain cleaning at elevators and grain reception enterprises is necessary for a number of reasons: 1) the need to receive grain directly from the combine, 2) the large masses of grain requiring cleaning at the farm threshing floors during short procurement periods, and 3) the poor supply of modern grain cleaning machines for the farms.[27]

The Soviets claimed that the number of grain-cleaning points on farms in 1973 corresponded to the needs of the oblasts. The qualitative standards, however, were low since the facilities were not provided with the latest equipment. The grain cleaning capacity was based on cleaning and separating equipment that removed only large admixtures from grain. This is reflected in the quality that remains on the farm and creates difficulties for cleaning at grain reception points.[18]

In Kazakhstan, post-harvest cleaning of grain has been reported to be a bottleneck in achieving high-quality grain. It also has been suggested that on the farms, the workers are not interested in bringing grain up to basic condition, since the excess moisture and high content of admixtures are counted in production volume.[12]

Even in lesser areas of grain production, grain cleaning is a problem. In Uzbekistan, it was noted in 1974 that farms often supply the state with grain straight from the combines. As a result the farms were charged for unclean grain. The collective and state farms of Uzbekistan reportedly had the necessary machinery for preliminary and secondary cleaning. But these machines were utilized poorly, primarily because they were not well adapted to flow line processing, had low productivity, and required a great deal of manual labor.[29]

It would appear that effective grain cleaning is primarily conducted at reception centers and elevators. The system of cleaning can be divided into 1) grain cleaning prior to drying and distribution for storage and 2) cleaning in preparation for long term storage, industrial processing, and export.

As of 1974, more than 20,000 grain-cleaning machines reportedly had been installed in the Soviet procurement system (grain reception points and other storage facilities). Of these, 45.8% had a certified productivity of 80 to 100 tons/hour; 50%, 50 tons/hour; and 4.2% up to 10 tons/hour. The average productivity was 25 tons/hour. At many enterprises, however, technical effectiveness was low and the cost of cleaning high. Frequently individual batches of grain were stored without cleaning for long periods.

The ZV-50 and VO-50 pile cleaners certified at 50 tons/hour are used for preliminary cleaning of grain at reception enterprises. These cleaners are designed to almost completely remove large, coarse impurities and separate out a considerable portion of weedy impurities. But these machines are cumbersome and complicated to operate, have a low level of reliability, and are difficult to repair.[27]

The ZSM-50 and ZSM-100 grain-cleaning separators with a 50 and 100 tons/hour productivity, respectively, are used widely at grain reception centers and elevators for secondary cleaning of grain. In addition to large and weedy impurities, they can also separate out grain admixtures. Their maximum technical effectiveness, however, is only 50%, due to in lack of reliability of operation of the sieves and in the irregular operation of inertia cleaners.[27]

Grain arriving at reception enterprises during procurement differs in terms of the type of grain crop, size characteristics, types of weediness, and physicomechanical qualities, depending on its geographic origin. A major Soviet complaint is that with many cleaners, it is impossible to change sieves and air separation regimes rapidly enough to match differences in the grain or to adjust the cleaner to handle the moisture content and degree of weediness.

Higher demands on grain-cleaning machines for preliminary cleaning are the result of improvements in transporting and handling grain which have increased the rate of grain arriving for cleaning. Therefore, the Soviets consider it necessary to develop cleaning machines of greater productivity than those of ZV-50 and VO-50 machines and to simplify their designs.[27]

Grain Drying

The USSR is the world's largest producer of grain crops but differs from many other countries in that a significant portion of the harvested grain must be dried. According to Soviet statistical data over a number of years, nearly 40% and in specific years, up to 60% of the freshly harvested grain requires drying. This is especially true of grain grown in the eastern USSR where in certain years more than 50% of the grain purchased by the state must be dried two times. In certain regions of the USSR (the Far East, Siberia, the Urals, Belorussia, and others), the harvest period frequently coincides with the onset of rainy fall weather, and the freshly harvested grain may contain up to 25 to 30 and sometimes even 35% moisture. In unfavorably wet years, 80 to 90% of the harvested grain in Siberia, the Urals, and North Kazakhstan must be dried artificially.[7, 30]

Artificial drying is applied in all grain growing regions of the USSR, even to some extent in the southern portions. According to the Soviets, the moisture content of grain designated for long-term storage should not exceed 14%. Timely drying, especially if the harvest coincides with periods of precipitation, is essential for preventing spoilage.[7, 30]

In 1973, grain reception enterprises of the USSR reportedly dried more than 63 million tons of grain, or 70% of that procured. Additionally, a considerable amount was dried at the farm level. During the period 1 July 1973 through 1 January 1974, grain receiving enterprises of the RSFSR dried around 38 million tons. In the Ukrainian SSR in 1974, more than 13 million tons of grain and oil seeds were dried. This was more than 2.5 times that of the first years of the 9th Five Year Plan (1970-72). In 1972 in Tselinograd Oblast, of a total of 2,667,800 tons received at reception points, some 2,300,000 tons, or 86% required artificial drying. The figures in Kustanay Oblast were about the same.[15, 18]

Various types of dryers are utilized in the USSR, but the most widely used are column dryers. These comprise more than 80% of the active installations having a productivity in the range of 2 to 50

Table 6

Principal Grain Dryers in the Soviet Union

Designation	Type	Tons/Hour	Primary User
Petkus (GDR)	Column	1.5	Farm
SZSh-8	Column	8	Farm
SZSh-16	Column	16	Farm
SZPSh-8	Column	8	Farm
SZPB-2.0	Drum	2	Farm (mobile)
SZPB-4	Drum	4	Farm
SZSB-4	Drum	4	Farm
SZSB-8	Drum	8	Farm
ZSPZh-8	Column	8	Farm and grain reception center
VTI-8	Column	8	Elevator and mill
VTI-15	Column	15	Elevator and mill
ZSZ-8	Column	8	Elevator
ZhZS-22	Column	22	Elevator
DSP-12	Column	12	Elevator
DSP-16	Column	16	Elevator
DSP-24	Column	24	Elevator
DSP-24Cn	Column	24	Elevator
DSP-32	Column	32	Elevator
DSP-32-OT-2	Column	32	Elevator
DSP-50	Column	50	Elevator
PS-50	Pneumo-gas recirculating	50	Elevator
RD-2 x 25-75	Gas recirculating	50	Elevator
Tselinnaya-50	Gas recirculating	50	Elevator

tons/hour.[7 30] Dryers available in the USSR are listed in table 6. The column dryers have a number of deficiencies which have been pointed out by Soviet grain technologists. Perhaps the most serious deficiency of all is that drying grain is possible only if it has been cleaned or is relatively free of admixtures and wastes. Even a small quantity of weedy admixtures frequently leads to congestion of grain between the heat chambers and consequent burning of it.[7 30] These deficiencies in column dryers have led the Soviets to search for other types of dryers. As a result pneumogas and gas recirculating dryers, the jalousie grain dryer ZhS-22 and drum dryers S2Pb-2, and SZPB-8 were developed. All of these, however, also have certain deficiencies.[30]

For post-harvest processing, a number of Soviet scientific research and project-design organizations have developed a family of unified grain cleaning, drying complexes of varying productivity. These sets of unified equipment are designed to provide flow methods of processing. The complexes differ in the quantity of dryers and type of procedures utilized. For zones where the moisture content is excessive (22% or more), the procedure calls for sequential processing through two sets of dryers with an intermediate rest period. In regions where moisture content is 18 to 22%, a single processing through one dryer or one set of dryers is specified. Grain dryers are not specified for regions where moisture content is below 18%. Instead, it is recommended that the grain be brought down to standard moisture, if necessary, by active ventilation with heated air. Basic grain cleaning/drying complexes produced in the USSR are cited in table 7.

Table 7

Soviet Grain Cleaning/Drying Complexes for Commercial Grain on Farms

Designation*	Type of Dryer**	Capacity Drying	Capacity Cleaning
KZS-5Sh	Column	4	5
KZS-10Sh	Column	8	10
KZS-20Sh	Column	16	20
KZS-40	Column	32	40
KZS-5B	Drum	4	5
KZS-10B	Drum	8	10
KZS-20B	Drum	16	20

*All complexes include cleaning machines for preliminary cleaning, secondary cleaning and grading-sorting.

**Total capacity of the complex is limited by dryer capacity.

The Soviets point to a number of problems that can occur during drying of grain:

1) Unequal heating and drying, especially in column dryers, resulting from insufficient cleaning of grain before drying, self-sorting in the shaft, varying speeds of grain movement in the column, and unequal distribution of heat in the chamber.

2) Faulty condition of dryers and also incorrect servicing or operation (odor of smoke, sulfur).

3) Roasted or burned grain when temperature is too high.

4) At high temperatures, wet, freshly harvested grain may become swollen and wrinkled; to correct this, the temperature should be reduced.

5) Lessening of the quality and content of gluten in wheat. Reducing the temperature prevents this but reduces dryer productivity.[30]

Despite large increases in the capacity and number of grain dryers, the Soviets admit grain-drying problems at reception enterprises, especially at the state and collective farms in Siberia, North Kazakhstan and the Far East.[23] The Soviets acknowledged that the shortage of drying capacity in Kazakhstan in 1973 ranged an average of 30 to 40% for each of the leading grain oblasts.[18] In Kustanay Oblast (RSFSR), many grain reception enterprises still had obsolete SZS-2 and SZS-8 dryers. The low-capacity dryers represented about 30% of the existing drying capacity in the oblast.[32 33]

Errors in the use of dryers contribute to lowered productivity and also to lower quality because of incorrect operation. In 1974 the RSFSR Ministry of Procurement indicated that many errors were occurring. These errors included low quality repairs and the consequent equipment down time and tardy start-ups when moist and wet grain arrived. Violation of temperature regulation caused heat deterioration in the grain. Because of improper regulation of grain movement in the column and unsatisfactory performance of blowers, the productivity was reduced. Also proper grain cooling after drying was not being maintained.[22]

Grain dryers at farms and especially at grain procurement centers are utilized unsatisfactorily or inefficiently. For example, in 1974 in Penzensk, Kuybyshev, Lipetsk, Kursk, Tambov, and Ryazan oblasts (RSFSR), utilization of existing grain drying capacity was unsatisfactory. When large quantities of wet grain were arriving at the grain reception centers, the productivity of dryers in these oblasts was 30 to 50% of capacity (34% in Penzensk, 40% in Tambov, 43% in Kursk and 30 to 50% in the other oblasts). In 1973 many of the grain reception centers permitted accumulation of dried grain near the dryers which prevented the dryers from being used. Meanwhile raw, wet grain was accumulating and some underwent self-heating that resulted in quality deterioration.[20 34]

In 1973 in the RSFSR (Central Chernozem, Volga, and Ural areas), complaints were reported concerning overloading of grain-drying capacity at the reception centers. The principal collective and state farms were not making full use of their drying and cleaning equipment and consequently sent to reception centers wet and dirty grain without regard to the actual capacity at the reception center. The rates of shipments at many centers exceeded the means of drying. Dryers were being used around the clock but could not meet demand. As of 5 September 1973, around six million tons had been dried but much wet grain remained. To provide drying assistance, 130 ZSPZh-8 mobile dryers were sent into the areas from eastern regions. Some of the procured grain was so wet that even after repeated passage through the dryers, it still remained damp. Part of the seven million tons of grain being shipped to other regions included wet grain for drying at other locations. Such out-shipment of grain for drying also occurred in 1974 in the RSFSR, Ukrainian SSR, and Kazakh SSR.[20 21 35–37]

Active Ventilation (Aeration)

Although artificial drying of grain is most widely applied, in recent years the method which the Soviets call "active ventilation" also is applied for preserving and, to a lesser extent, drying of freshly harvested grain. Active ventilation consists of blowing air (or heated air if drying is the goal) through the grain mass, usually by means of blowers attached to perforated ducts.

Active ventilation with unheated air can be employed either for temporary preservation prior to drying in a grain dryer or for long-term storage by preventing self-heating. The purpose is to cool the grain to a point low enough to reduce or inhibit the activity of fungi and insects and to establish a uniform temperature throughout the mass, thus preventing moisture translocation.[7]

Safe storage of food and feed grain is required to prevent mold and self-heating. Even a small reduction of the temperature will increase the period of safe storage. The Soviets indicate that "reduction of grain temperature by two times increases the time of its safe storage by 10 times." Research by the All-Union Scientific Research Institute of Grain (VNIIZ) showed that cooling grain to 10°C or below sharply reduces the activity of biochemical and microbiological processes, inhibits the development of insects, ticks, and other pests in stored grain, eliminates the danger of occurrence of self-heating and spoilage, and preserves the natural properties of grain.[7]

In the Soviet Union, active ventilation reportedly is conducted in storehouses (flat storage), bunkers or silos, and also on platforms. In production practice, flat storage storehouses, sheds, platforms, bunkers, and silos equipped with installations for active ventilation are utilized for temporary storage and for aerating with cold air of wet and moist grain that cannot immediately be sent to dryers because of the amount of grain requiring drying. This capacity also is used for storing dried grain that has been cooled insufficiently in the dryer chamber.[30]

Initially active ventilation was considered by the Soviets only as a means of quickly and effectively cooling grain. Further study showed, however, that the method can be utilized for drying. By applying sufficiently dry air, it is possible to reduce moisture by 1 to 3%. During aeration for the purpose of drying, it is necessary to introduce into the mass large quantities of air.[3 7 20]

Because of the poor temperature conductivity of grain, if placed in flat storage at harvest, grain may retain high temperature in its depth. According to Kleyeva, grain 80 cm from the surface after 45 days can retain its summer temperature even while the temperature of the outside air is reduced to −2.5°C. Thus a temperature gradient can be set up between the outside and inside of the pile. As a result moisture is transferred from warm to cooler areas and, in time, zones of moist grain occur which become foci for self-heating.[7] To prevent this the Soviets recommend periodic ventilation of grain which equalizes the temperature. Moisture accumulation as a result of condensation also is eliminated during ventilation. This so-called prophylactic aeration is conducted only at times of day when the air is dry and cold.[3 7] If self-heating has already begun, the Soviets recommend that the grain be aerated at a maximum rate independently of the weather and relative humidity until completely cooled.[3 7]

Soviet installations for active ventilation of grain are of several types: the permanent (built-in) types, transportable air duct systems, and portable tube systems. The permanent and transportable duct systems are used for aerating large quantities of grain and the portable tube systems are used for eliminating pockets of self-heating grain in bulk.[3 7 30]

Permanent installations are used at grain reception points and typically at grain storage buildings of 3,200-ton capacity. The installation consists of a blower and a system of air distribution channels built into the floor of the storehouse and air distributing gratings or screens covering the channels. The air passes upward into the grain above it. Permanent aeration systems reportedly are not utilized in collective and state farms but only in grain storehouses of the procurement system.[3 7 34]

Transportable air duct systems can be utilized for aerating in storehouses, under sheds, and in open areas. The air ducts in this system are placed on the floor of storehouses or on the ground of open areas.[3 34] Portable systems include vertical and horizontal tube systems. The tubes are inserted in the grain after the storage areas are filled, and the tubes are applied frequently to eliminate foci of self-heating detected in the grain bulk. Such tube systems require high expenditures of manual labor.[3 7 30 34]

In 1973, the USSR Ministry of Procurement indicated that there were 6,000 receiving and processing enterprises which had 48 million tons of storehouse capacity equipped with installations for active ventilation of grain. More than 60% of the storehouses within the procurement system reportedly were equipped with active ventilation systems by 1975.[30] Soviet grain technologists state that drying grain with unheated air is not profitable and under specific conditions it may worsen the quality or induce spoilage of the upper layers of grain.[7 30] By heating air 1°C, its relative humidity can be reduced by 5%. Therefore to dry grain by ventilation during unfavorably rainy or misty weather (relative humidities near to 100%), the Soviets recommend heating the air by not more than 7°C.[7 30]

By increasing the temperature of air 5°C, the rate of drying is increased by 10 to 12%, but unevenness of drying grows by 1.5 times. This leads to overdrying in the lower layers of the grain (down to 8 to 6% moisture) which is undesirable. According to the Soviets, overdried grain for feed reduces its assimilation by animals.[7 30] For accelerating the drying of grain in Soviet practice, the air for active ventilation is heated to temperatures up to 40 to 50°C. In this case the process is referred to by the Soviets as drying grain with heated air. It is believed that drying by heating air during active ventilation is applied primarily by the Soviets to drying seed grain and that it is used infrequently or only in exceptional cases for procured grain.[7 30]

GRAIN STORAGE

Storage Facilities

Enclosed grain storage facilities within the Soviet grain industry are in general similar to those in the United States. These facilities are of two principal types: 1) the tall cylindrical, or square silo, usually grouped together in elevators; and 2) flat storage buildings, which are long low rectangular buildings, usually single storied. Both facilities often are located together at state grain procurement centers. Silo elevators are equipped with bucket and belt conveyors for transporting grain into silos and for handling the grain within and between silos. Flat storage buildings may be mechanized for loading and handling grain or they may be unmechanized. Flat storage buildings have been utilized extensively in the USSR because they can be constructed more quickly and cheaply than silos. The permanent grain storage capacity in the USSR is primarily in long, low, flat storage buildings. In 1970 it was reported that such storage comprised more than 85% of the total storage capacity within the procurement system.[6 30 39 40]

Grain silo elevators are considered to be the most desirable facilities for storage by the Soviets. However, in silo elevators, grain for storage must be dry or moderately dry (14 to 15% moisture content). Storage of damp or wet grain in silos is prohibited with the exception of grain designated for immediate drying, not to exceed the 3-day productivity of the dryers at the elevator. Wet grain storage in elevator silos is prohibited because it is readily subject to deterioration and self-heating which can rapidly lead to obstruction of the silo by caked grain, resulting in complete spoilage. Since 1930 grain dryers have been an obligatory part of any newly constructed Soviet grain silo elevators. Recently, in addition to grain dryers, at some elevators there may be silos equipped for active ventilation.[6 30]

Grain stored in long, low storage buildings not equipped with active ventilation can have a moisture content up to 17%, but the height of the pile must be reduced. The height of the grain bulk in such storage buildings depends on the technical condition of the building, the crop, moisture content, weed and litter content, and time of year (hot or cold) the grain is stored. Ordinarily with dry or moderately dry grain, the height is 2 to 2.5 m near the outside wall and 4.5 to 5 m in the middle of the building. With grain containing up to 17% moisture, the height overall should not be higher than 2 m. During the temporary storage of grain at up to 19% moisture content, the height must not exceed 1.5 m and, with grain over 19% moisture, must not be higher than 1 m. In long, low storage buildings equipped for active ventilation, the overall height of grain bulk can be 3.5 m for 16% moisture content, 2.5 m for 18% moisture, and 2 m for any above 18% moisture. But any with moisture content above 19% must be constantly aerated until it can be sent for drying. Therefore the wetness of the grain stored in long, low buildings can affect the amount of grain stored. The storage capacity for grain of 17 to 18% moisture or above in storehouses with or without active ventilation is reduced roughly to at least half that of dry grain.[1 6 30]

In addition to permanent enclosed grain storage facilities, so-called temporary storage facilities are utilized in the Soviet Union. These facilities include: 1) prepared open-storage areas, sometimes paved with asphalt. These are narrow and long open platforms upon which the grain is piled, 2) walled open storage, called clamps similar to the asphalt areas but having low walls (1.8 m high) on the long sides of the asphalt area to increase the storage capacity by permitting higher piling. The Soviets indicate that grain on these walled clamps should be covered with tarpaulins over a supporting framework, but this is frequently not done, and 3) roofed storage areas or sheds without walls but with asphalt or concrete floors. Such roofed areas represent only a small percentage of temporary storage.[1 30 40]

Storage Capacities

It generally has been accepted that as of 1 January 1974, the Soviet Ministry of Procurement had storage capacity for only 126 million tons of grain and oilseeds; only 28 million tons of it was in elevators. Total off-farm storage capacity, as of 1 January 1975, probably reached a little over 136 million tons, including grain elevator capacity of approximately 32 million tons. An unknown amount of this total capacity is used for holding reserve stocks and seed supplies, which reduces the total annual storage capacity. Also some of this capacity is utilized for oilseed storage (5 to 7 million tons produced annually). Further, Soviet storage facilities probably operate somewhat below capacity and some may be closed for repairs.[41–43]

Soviet grain storage facilities on collective and state farms recently have been estimated to be about 100 million tons capacity. The Soviets themselves reported that farm grain storage capacity was 98.5 million tons in 1973. However, only 54.7 million tons of this farm storage was in standard storehouses.[43–46]

A recent (1974) Soviet text on the elevator industry stated that in 1968, within the procurement system, 10 million tons and in 1973, 14 million tons of grain were stored in clamps (short-walled, open area storage) within the procurement system. Whether these figures include all outside storage within the procurement system for those years cannot be determined.[30]

Storage Losses

According to Soviet data, grain stored under optimal conditions (moisture and temperature primarily) will lose from 0.07 to 3% of its dry matter during a year's storage. As the result of self-heating, grain may lose 3 to 8% of its dry substance in addition to losses in quality and technical properties. Grain that is stored in elevators, if state standards are met, is likely to be subject to the least losses. Grain stored in long low flat storage buildings does not have to meet such stringent requirements and as a result is susceptible to higher losses. Grain in so-called temporary storage facilities is the most susceptible to high losses because of lack of protection from the environment and lack of post-harvest processing. One Soviet researcher has generalized that natural losses in grain stored on asphalt areas and clamps, under normal conditions, can be twice as large as those in grain properly stored in elevators. It is believed that these losses in outdoor storage may be even greater in unfavorably wet years.[4, 46]

The Soviets have stated that their enclosed grain storage facilities are of insufficient capacity during years favorable to grain production. Shortages of storage capacity vary depending on geographic location. For example, the Kazakh Ministry of Procurement indicated that in 1972, there was a shortage of about 4.55 million tons storage capacity to meet the actual amount of newly harvested grain being received. The Soviets have indicated also that the capacities of processing equipment and storage facilities are calculated on the basis of meeting the requirements of average conditions. The peak loads at grain reception centers during the height of harvest exceed capacities by two to four times. Therefore a portion of the grain must be stored temporarily without processing.[37, 47]

Two Soviet grain technologists have conducted extensive research on length of time for stable storage in some representative zones of the USSR. They studied the dates of harvest and the actual temperature and moisture content of freshly harvested grain arriving at procurement centers. As criteria for safe storage, they considered no loss in germination rate, no noticeable fungal growth (absence of moldy odor and less than 4% presence of fungal colonies), and absence of grain fermentation. The approximate periods of safe storage of grain, without post-harvest processing, determined for typical regions are cited in table 8. The research showed that in Moscow Oblast, an average of 55.6% of all newly harvested grain accepted at grain reception centers requires immediate processing—cleaning, drying or active ventilation—if it is to be stored safely; 35.7% can be held without deterioration for 7 to 10 days, and the remaining 8.7% must be treated within less than 2 months. By contrast in Krasnoyarsk Kray, despite the high amount, 67.3%, of grain received with above 19% moisture content, the length of safe storage without processing is less limited. This results from the fact that the average temperature of the grain received is about 12°C, making it possible to hold the grain without quality changes for at least 10 days.[48]

A major cause of storage losses in the USSR is the fact that during recent years, large quantities of newly harvested grain have had to be stored for extended periods of time in huge outdoor piles, either in clamps or on asphalted areas because of shortages of covered storage facilities. Heavy losses under outdoor storage conditions occurred in 1973 as a result of undesirable moisture and temperature relationships, improper processing and handling procedures, and inefficient grain transport.

Criticizing the high losses involved, Brezhnev in December 1973 stated "because of the large harvest, large quantities of grain had to be stored in piles under the open sky." He further indicated that Soviet planning organizations had not even "estimated the sum total of losses involved." This criticism probably related to state procured grain. The Deputy Minister of Procurement confirmed that storage capacities in 1973 could not handle the increase in procurements and the accumulation of state grain supplies;

Table 8

Approximate Periods of Safe Storage of Grain Prior to Processing

	14-15.5% Moisture		15.5-17% Moisture		17-19% Moisture		Above 19% Moisture	
Zone and Macroregion	Percent of grain	Safe storage (days)	Percent of grain	Safe storage (days)	Percent of grain	Safe storage (days)	Percent of grain	Safe storage (days)
Central-Non Black Soil								
Moscow Oblast	8.7	50	15.0	10	20.7	5	55.6	1 or less
Ryazan Oblast	38.2	17	14.1	7	14.3	3	33.4	1 or less
North Caucasus								
Krasnodar Kray	89.1	17	6.7	7	—	—	4.2	1 or less
Southern Ukraine								
Nikolayev Oblast	70.5	10	13.2	2	5.9	0	10.4	0
Crimean Onlast	96.6	15	3.2	5	0.2	1	—	—
Urals								
Chelyabinsk Oblast	19.2	100	16.0	40	18.3	15	46.5	10
Eastern Siberia								
Krasnoyarsk Kray	4.6	160	8.6	80	19.5	20	67.5	10

therefore, a large amount of grain from state resources was stored in piles for extended periods of time.[49 50]

The actual quantity of grain stored in outdoor piles and the total resulting losses have not been reported and cannot be determined. The Soviets did report that in 1973, grain stored in clamps within the procurement system amounted to 14 million tons. It is not known whether this represents all outside storage of grain. Generally the Soviet Union strives to move grain stored in the open to covered storage by the beginning of December. Even when this is possible, deterioration is unavoidable. To the extent that some of the grain in temporary storage was moved to covered storage by December 1973, the total amount of grain in outside storage prior to that date probably exceeded 14 million tons.[30]

The 1974 grain harvest was the second largest grain crop produced in the USSR and, because of inadequacies in storage capacity, a portion of the grain had to be stored in the open. The ministries of procurement of the RSFSR, Ukrainian SSR, and Kazakh SSR proposed measures to ship raw grain from open storage to the nearest grain collection enterprise equipped with dryers and from clamps to areas of more immediate consumption or to places where unused storage was available. A significant quantity continued to remain in open storage in Saratov, Volgograd, Orenburg, and Rostov Oblasts and the northern oblasts of the Ukraine.[20]

Elevator and other grain storage facilities in 1974 in the Ukraine reportedly had an increased capacity of one-half million tons over that of 1973. Many storage facilities in 1974 still contained grain from 1973, creating problems in coping with the 1974 harvest. The state had allocated an additional 31.7 million rubles for constructing new facilities and "large asphalt covered" areas. By October 1974 over half of these were already in use.[52]

The Soviets admitted that the year before (1973), much of the grain stored outside had undergone self-heating. Anticipating similar problems in 1974, they expressed the need for daily concern for grain at reception centers. They stated that the grain stored outside must be monitored carefully in order to take measures in time to prevent serious deterioration.[20]

The storage of grain outside in clamps and on the ground is considered undesirable by Soviet grain technologists and to be avoided if at all possible. When used as a stop-gap measure, Soviet technologists unanimously recommend covering the grain with canvas or other means of protection. Foci of self-heating are especially dangerous in grain stored in clamps.[3 6 30 40 46]

Temporary storage of grain destined for procurement on Soviet farm threshing floors is considered highly risky. When storage capacities at reception centers are overloaded, delivery from farms frequently is slowed. In 1973 a great deal of grain designated for procurement accumulated at farm threshing floors. This condition was considered highly undesirable because of the threat of spoilage.[53]

Grain storage on Soviet farms is inadequate. As of 1973, the on-farm capacity was reported to be 98.5 million tons, of which only 54.7 million tons was in standard storehouses. In 1973 more than 120 million tons reportedly had to be stored on farms. It was not stated where the 21 million tons of grain in excess of capacity was kept, but presumably, some of it was stored outside in piles. Farm storage ranges from open-air platforms and roofed open storage to standard storehouses. Generally the conditions of storage are considered to be more primitive than that within the procurement system. In addition grain stored at the farm level frequently has undergone limited or almost no post-harvest processing. The Kazakh Ministry of Procurement noted in 1973 that grain remaining on the farms—40 to 50% of the gross harvest—was not subjected to any industrial post-harvest processing at all.[18]

In discussing losses in Soviet grain quality, a general assumption is often made that procured grain which loses its quality or is spoiled in storage can be used for animal feeding. This should not be taken to mean that losses of low quality or spoiled grain have been reduced through feeding. There is a loss, first of all, in the sense that the grain has only limited use which, in effect, reduces Soviet options in utilizing it. Second, storage losses may reduce the feed value. For example, Soviet animal nutritionists have discussed the losses in nutritive substances in barley stored for 30 days.

If the barley is stored at proper moisture content and temperature conditions in covered grain storehouses, the following reductions in nutrients occur: 0.04% in dry substance, 0.041% in protein content, and 0.39% of the carbohydrates. By contrast if barley is stored on open areas or in clamps at 30% moisture, the following losses occur within 30 days: dry substance 50%, protein 65%, and carbohydrates 80%. The percent of nutrient losses in grain above the critical moisture level (14.5%) but below the 30% level were not cited but would be considerably greater than in properly stored barley. It is indicated that grain with increased moisture within 2-3 days begins to self-heat and spoil resulting in loss of its food, feed, and industrial qualities.

Future Trends

The Soviets are acutely aware of many of their problems in post-harvest processing and storage of grain, particularly in regard to the need for more enclosed storage facilities. Problems in post-harvest processing include quantity and distribution of cleaning and drying equipment and improvement of their efficiency. The Soviets have a continuing program to modernize drying and cleaning facilities at grain receiving centers through rebuilding and addition of improved components. It is expected that they also will continue to produce improved models of grain cleaners and dryers to both replace obsolete, inefficient and small capacity equipment and to increase the total numbers. One of their primary goals will be to achieve a better balance in distribution of the equipment within existing problem areas.[30 44 63]

Little evidence exists to indicate that the Soviets will attempt to resolve some of their grain post-harvest processing deficiencies through acquisition of foreign technology. Soviet efforts are directed toward improvement of existing models of equipment and increasing their effectiveness through aggregation of individual units into flow lines to increase capacity and efficiency. The All-Union Council of Scientific and Technical Societies, however, has called for new designs of drying equipment which would replace traditional grain drying operations. They would like to see a conversion to newly designed highly productive units employing preliminary heating of damp grain prior to drying. Scientific research and experimental work directed toward the creation of new highly efficient drying equipment possibly under a single planning and design center specializing in grain drying equipment was called for. It is doubtful that this new approach to grain drying design will be implemented rapidly, if at all. In any event the impact on Soviet grain drying problems probably would not be significant within the next 5 to 8 years.[64 65]

Recognizing the need for further expansion in permanently enclosed storage facilities, the Soviet 5-year-plan (1976-80) calls for the construction of 30 million tons of new elevator (within the procurement system) storage facilities. The Soviets indicate that this additional storage capacity will meet the country's requirements fully for closed storage facilities for procured grain by 1980. If achieved and if existing facilities are maintained, off-farm capacity at the end of 1980 could total an estimated 166 million tons, with 62 million tons in elevators. This effort represents a greatly accelerated and expensive program and reflects the extremely serious need to reduce storage losses.[54 58]

It is believed that some exploitation of foreign grain elevator technology either in design or through purchase of specific equipment will occur in support of the massive elevator construction program, but specific evidence is lacking. Considering the unprecedented annual rate of construction (almost twice the annual rate in 1971-75) and the difficulties historically encountered in Soviet grain elevator construction, it is considered unlikely that the planned total elevator capacity will be completely achieved by 1980. On the other hand planned increased rates of investment and modernization of elevator construction organization and implementation could permit the completion of a major portion of the planned construction. Even the approximate achievement of the target goal could contribute to a significant reduction of losses in grain quality and quantity.[41 42 50 56 61 62]

GLOSSARY

Active ventilation (aeration)—Blowing air through grain bulk in storage to establish and maintain a moderately low and uniform temperature

Clamp ("bunt")—Large rectangular asphalted areas with low wooden walls along the length of the area; used to store grain in the open; sometimes covered with a canvas

Combine—Grain harvester which cuts and threshes the grain in the field in one operation; may also be used to pick up and thresh cut grain in windrows if two-phase harvesting is employed

Elevator—A group of grain silos (cylindrical towers) associated with an elevator building for conveying grain into the silos

Flat storage—Storage in long, rectangular grain storage buildings

Grain reception center—Centers which accept grain purchased from collective and state farms and subject the grain to post-harvest processing and storage; usually located in close proximity to grain growing regions

Platform storage—Storage of grain in the open on rectangular areas on the ground; usually the area has an asphalt floor

Post-harvest processing—The treatment of grain after harvest to make it suitable for storage by cleaning and drying; also the treatment of newly harvested grain in storage to maintain its safe storage (cleaning, drying and cooling by active ventilation)

Procurement—The purchase of grain from collective and state farms by the Ministry of Procurement of the USSR or certain Soviet republic ministries of procurement

Procured grain—Grain purchased from collective and state farms by the Soviet Government procurement system

Procurement system—The system under the USSR Ministry of Procurement which purchases grain from the collective and state farms, processes the purchased grain to make it suitable for storage, stores the grain, and makes it available to various grain consumers

Self-heating of grain—The "spontaneous" heating of grain as the result of the heat evolved by the metabolic activity of microorganisms in damp and wet grain

Silo—Tall cylindrical hollow tower for storage of grain; almost always combined with other silos and an elevator building for loading, unloading and moving grain

Storage fungi—Fungal microorganisms which are distinct from field fungi and are found in bulk or stored grain; they primarily are comprised of about a dozen species of Aspergillus, several species of Penicillium, and a few species of yeasts

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