_ nκι-UP
AND ADJUSTMENT OF NEW PRODUCTION
22 OCTOBEER 1980 BY G. A. KASHLINSKAYA 1 OF 2

JPRS L/9359

22 October 1980

Translation

ECONOMICS OF START-UP AND ADJUSTMENT OF NEW PRODUCTION

By

G.A. Kashlinskaya

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300040039-2

JPRS L/9359

22 October 1980

ECONOMICS OF START-UP AND ADJUSTMENT OF NEW PRODUCTION

Moscow EKONOMIKA PUSKA I NALADKI NOVYKH PROIZVODSTV (Economics of Start-up and Adjustment of New Production) in Russian 1976 pp 3-137

[Book by G.A. Kashlinskaya, Stroizdat, 1976, 139 pages, UDC 69.003:658.152.011.46]

CONTENTS

[II - USSR - FOUO]
[III - USSR - 3 FOUO]

Annotation

[Text] Published in accordance with a 30 October 1974 decision by the Construction Economics Literature Section of the Stroyizdat editorial council. The book examines problems of the economics of the start-up period for new production facilities, using the chemical industry as an example. Methods are given for calculating normatives for start-up and adjustment work duration and expenditures during this period. Considerable space is given to determining the effectiveness of reducing start-up time for new projects and to methods of improving start-up and adjustment planning and organization. The book is intended for scientists and engineers in research, planning, construction, and start-up and adjustment organizations.

Chapter 1. Work Organization in the Start-Up Period

Section 1. Essence of Start-Up and Adjustment Work

1. Composition and Place of Start-Up and Adjustment Work in the Overall Process of Creating New Production Facilities

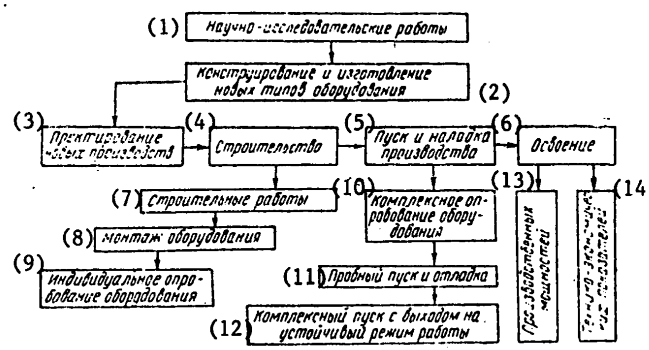
The creation of new production encompasses a whole series of jobs, including scientific research on developing new formulas and technological processes, designing and manufacturing new types of equipment, planning and building enterprises, finishing and starting-up new production facilities.

All this work can be divided into work preceding construction, construction and installation proper, and work following completion of construction and installation work at the construction site. The period of creating and mastering new production thus includes:

scientific research;
designing and manufacturing new equipment;
project planning;
construction and installation;
putting new facilities into operation;
enterprises reaching the production volume and technical-economic indicators prescribed in the plan.

This period can be represented in the form of a chart which takes into account the fact that a number of jobs are being done at the same time (Figure 1, following page). In the chemical industry, the preceding or preparatory stages average 5-8 years, sometimes longer. In this regard, 1-2 years is spent planning the enterprise and the remaining time is taken up by research (including working out the technology and experiments) and in designing and manufacturing nonstandard equipment. By the start of construction, the site must have available to it the planning documentation and equipment anticipated in the plan. From three to five years must be spent building and installing equipment for new production using existing norms in the chemical industry.

Figure 1. Creating and Mastering a New Production Facility



Key:

1. Scientific research
2. Designing and manufacturing new types of equipment
3. Planning new production
4. Construction
5. Start-up and adjustment
6. Utilization
7. Construction jobs
8. Equipment installation
9. Testing individual pieces of equipment
10. Comprehensive equipment testing
11. Trial start-up and check-out
12. Full start-up, to steady operating conditions
13. Production capacities
14. Technical-economic indicators

After construction and installation are complete, start-up and adjustment work begins to put the facility into industrial operation. The start-up and adjustment work which results in putting production capacities into operation is the final link in creating new production. Then comes utilization of the capacities and economic indicators of production already in operation.

The normative start-up and adjustment period is 3-6 months, and the mastering period -- up to two years.[1] The creation and mastering of new production thus requires many years, and reducing the above-indicated periods is of enormous importance to increasing industrial efficiency.

The effectiveness of new production is shaped at all stages of this work:

---

1. The SNiP [construction norms and regulations] currently set normatives only for mastering production capacities. There are no normative periods for mastering technical-economic indicators.

at the planning stage, the technical foundations of the future enterprise with consideration of modern scientific and engineering requirements;

at the construction stage, previously developed planning decisions are implemented; construction quality and duration influence effectiveness;

at the stage in which production capacities are started up, the quality of the construction and installation work and of the equipment installed is checked; the quality of the equipment and technological process check-out and the time involved in the start-up and adjustment work take on special importance;

at the stage in which production capacities and technical-economic indicators are mastered (in accordance with the indicators prescribed in the plan), the time involved in reaching these indicators is very important.

The quality of the work done in preceding stages determines the level and schedules for work in subsequent stages. Individual stages in the development of new production are characterized by specific features.

As is evident from Table 1 [following page], construction accounts for 60-75 percent of the whole development period for a number of new production facilities in the chemical industry, time expenditures on start-up and adjustment account for 5-10 percent, and time spent on mastering capacities accounts for 20-30 percent.

During the construction period, capital investments are "frozen," withdrawn from circulation, and it is only after the facility is put into operation and its production and economic indicators are being fully utilized that the national economy begins to obtain the effect anticipated by the plan. Thus, society advances capital investments for a considerable time period in anticipation of a long period of circulation in the future by obtaining a useful effect expressed in growth in the social product.

Failure to meet construction schedules postpones the time when capital investments will be recompensed and in so doing increases the time lag before the effect begins. The final moment is understood to be utilization of the planned capacities and economic indicators. In other words, the full economic impact can be obtained only when the output volume, production profitability, labor productivity and net cost anticipated in the plan have been achieved. On the other hand, any reduction in the lag between capital investment and obtaining the effect leads to increased capital investment effectiveness.

Increasing construction duration generally makes it more expensive, since some construction expenses are linked directly to construction time. Fifty percent of all general overheads depends on construction duration. Calculations show that every 10-percent increase in construction time increases the net cost of construction-installation work by 1-2 percent.

Accelerating the rate of construction and start-up of new facilities is exceptionally important from the viewpoint of using the achievements of

Table 1. Time Involved in Creating New Production in Individual Branches of the Chemical Industry (Normatives), numerator = months, denominator = percent

(a) № п.п	(b) Производство	(c) Всего	(d) Продолжительность			
			(e) строительства	(f) в том числе строительно-монтажных работ	(g) пуска производства	(h) освоения производства
1	Серной кислоты	35/100	23/66	12/34	3/8,5	9/25,5
2	Аммиака	54/100	33/61	18/38,4	3/5,5	18/33,5
3	Слабой азотной кислоты	41/100	17/66	16/49	5/18,2	9/22
4	Аммиачной селитры	24/100	18/75	9/37,5	2/8,5	4/17
5	Метанола	22/100	20/57	10/24	3/7	15/36
6	Хлора	43/100	30/69	15/35	3/7	10/24
7	Капронового корда	60/100	34/55,8	18/29,6	2/3,2	24/40
8	Капронового шелка	51/100	30/59	15/29,5	3/6	18/35
9	Ацетилцеллюлозы	51/100	29/57	13/25,5	7/14	15/29
10	Смол	30/100	22/73	10/33	2/7	6/20
11	Винилацетата	32/100	20/62,5	7/22	4/12,5	8/25
12	Капролактама	62/100	33/52	15/24	5/8	24/40
13	Красок, эмалей, лаков	30/100	32/73	10/34	2/7	6/20

Key:
- a. In order
- b. Production
- c. Total
- d. Duration
- e. Construction
- f. Including construction-installation
- g. Start-up
- h. Mastering

[Key continued on following page]

[Key to Table 1, continued]

1. Sulphuric acid
2. Ammonia
3. Weak nitric acid
4. Ammonium nitrate
5. Methanol
6. Chlorine
7. Capron [nylon-6] cord
8. Capron silk
9. Cellulose acetate
10. Resin
11. Vinyl acetate
12. Caprolactam
13. Dyes, enamels, varnishes

scientific and technical progress in production. During the course of planning enterprises, construction and technological decisions are generally made at the level of modern scientific and engineering achievements. However, during the creation of the facility newer and more progressive, more economical resolutions might arise. Facility construction and utilization delays therefore cause equipment to become obsolescent and reduce the period of its efficient operation.

The finish of capital construction and erecting the facility still does not make it possible to begin operating the production facility. Before the fixed assets created during the construction period can be put into operation, we are faced with checking the readiness of the equipment for operation and adjusting the technological conditions and operation of all interacting systems. And that is what start-up and adjustment work is. It occurs only when putting new production capacities into industrial operation, so work done during the start-up period is of a one-time nature.

Start-up and adjustment work has a dual purpose. On the one hand, it is connected with the completion of capital construction and is a check of the installation quality and of the conformity of construction to the plan. On the other hand, it is the initial stage in the operation of the facility, the stage in which the workability and reliability of the planning resolutions are checked.

In preparing and performing the technological process, start-up and adjustment ensure and organize the initial stage of the operation period. In this regard, they are closely associated with the period of utilizing a new facility; they precede it, and the mastering period depends to a considerable extent on the quality of this work.

Only projects at which construction-installation work is finished and at which production assets have been prepared to begin operating and can in fact be operated can be considered finished.

After construction is complete, production must be set up, the required operating speeds must be ensured, the prescribed product output and quality and the necessary operating smoothness must be ensured, and additional material and labor resources are directed into this work during the start-up period.

Start-up and adjustment begin when we switch over from testing individual pieces of installed equipment, which completes the builders' work, to comprehensive equipment testing done for the entire technological system of the production facility by enterprise operating personnel, with the participation of specialized start-up and adjustment subcontractor organizations.

Individual pieces of equipment are ordinarily tested either at idle or under load in inert media (water, compressed air). Construction must be complete prior to testing individual pieces of equipment under load. Testing individual pieces of equipment under load is the finish of equipment installation. When individual types of equipment cannot be tested under load apart from a complex of related equipment, the finish of installation work is considered to be the testing of individual types of equipment. Equipment installation is thus a complex of jobs related both to assembling and installing equipment and to checking that it conforms to planning and technical resolutions.

The comprehensive equipment testing which begins the start-up period is done in inert media, with subsequent changeover to operating media. It is the purpose of this work to bring production up to planned operating conditions, with the release of test output as outlined by the plan. Comprehensive testing in inert media is done to check the quality of equipment installation, reveal the ability of individual subassemblies and technological systems to function, and adjust remote-control regulation and control systems.

The duration and type of comprehensive equipment testing depend on the nature of the production. When the SNiP does not include comprehensive testing recommendations for individual types of equipment, the duration is set at a working level of 24-72 hours of normal uninterrupted operation of the individual types of equipment under operating conditions prior to the start-up and adjustment of the technological complex as a whole.

After eliminating bugs and making final adjustments on the equipment, the entire production facility is started up, ending in the release of the first test lots of quality output and putting the facility on a steady technological operating routine. In a number of cases, workers from organizations setting up the production and starting up the facility remain at the enterprise for 15 days after the initial lots are obtained to render technical assistance, continue observing the production process, and making recommendations to ensure uninterrupted operation and improved equipment operating conditions.

It follows from the above that work in the start-up period includes:

1) comprehensive testing of individual types of equipment using inert media to check the operability of all subassemblies of the technological system;

2) trial start-up of individual technological stages, units and production equipment using working media;

3) final adjustments and start-up of the whole facility, bringing it up to a steady technological routine, and the trial release of quality output as anticipated by the plan.

In order to ensure the prompt, proper start-up of new capacities, production start-up is preceded by work in the prestart-up period, when the engineering inspection and preparation to release the facility to the customer take place.

In the prestart-up period, which begins while construction is still underway, planning, construction and installation quality are monitored, as is equipment quality, personnel are trained, and the thoroughness with which the facilities are being completed is checked.

The quality with which capacities are prepared for start-up is one of the basic conditions for the successful putting of new production facilities into operation. Planning documentation is reviewed during this period and the enterprise leadership is sent observations and recommendations regarding the plan.

Changes are made in the technical documentation already sent to a contractor for execution only with the permission of the ministry, with the submission of materials to the all-union associations which will run that particular enterprise.

Therefore, when planning organizations do not agree with such observations, the enterprise leadership appeals to the corresponding ministry all-union association.

There is an engineering inspection of installation progress and the conformity of the work being done to the plan, of the technically complicated installation of individual units, internal elements of apparatus and installations, at the construction-installation stage. The work schedule notes each unit of equipment installed, each technological subassembly.

Installation quality is checked in accordance with the technical norms and conditions on installation. Flaws revealed are called attention to and must be promptly eliminated.

Incoming equipment is also checked and inspected in the prestart-up period; any structural shortcomings in technological, power and other types of equipment are revealed.

In order to ensure high-quality preparation of production for start-up, there is engineering monitoring of equipment pressure-testing by fitters and of the testing of utilities and individual pieces of equipment in accordance with specifications and the SNiP.

Technological raw material, fuel, basic and auxiliary materials must be provided in accordance with plan requirements when preparing a project for start-up: electric power, steam, water, compressed air, waste water cleaning and purification facilities, stack gas cleaning devices, communications and warning devices, living quarters equipment, personal protective devices and work clothing. This ensures normal start-up and adjustment work.

All start-up period work is done according to a schedule drawn up in the form of a grid line graph or a calendar plan reflecting all work involved in preparing the production for start-up and the start-up itself, and it must indicate the schedules for performing individual work stages.

The work procedure for the start-up period is indicated in a special instruction drawn up with consideration of all changes made in the plan in the pre-start-up period. Organizational and technical documents are attached to the start-up instruction: plans for (air) blast-cleaning apparatus and pipelines, plans for starting up individual lines and units, and a list of all the materials needed in the start-up period.

Under the "Rules for Accepting Finished Enterprises, Facilities, Shops and Production for Operation in USSR Chemical Industry," operational technical supervision of the entire complex of start-up and adjustment work is entrusted to specialized start-up and adjustment organizations.

After a project has been put into operation, representatives of these organizations, together with the enterprise, draw up a program for utilizing the capacity and work to put the facility in steady production of output corresponding to the plan in terms of quality and quantity.

The entire complex of this work is called start-up and adjustment. In terms of content and time of implementation, it is subdivided into engineering supervision of the quality of the construction and equipment adjustment being done, starting up the production, as well as assistance in utilizing the capacities. Table 2 diagrams this.

Table 2. Start-Up and Adjustment Work

(1) Предпусковой период	(2) Период пуска производства	(3) Период освоения мощностей
(4) Инженерный надзор за качеством: (5) проектной документации (6) строительно-монтажных работ оборудования	(7) Комплексное опробование оборудования. (8) Пробный пуск оборудования, отдельных технологических линий. (9) Отладка и комплексный пуск производства	(10) Техническая помощь в освоении мощностей. (11) Разработка рекомендаций по обеспечению бесперебойной работы оборудования

Key:

1. Prestart-up period
2. Production start-up period
3. Capacities utilization period
4. Engineering quality supervision:
5. Planning documentation
6. Equipment construction and installation
7. Comprehensive equipment testing
8. Trial start-up of equipment and individual technological lines

[continued on following page]

[continuation of key to Table 2]

9. Final adjustment and comprehensive start-up of production
10. Technical assistance in utilizing capacities
11. Development of recommendations to ensure uninterrupted equipment operation

Start-up and adjustment work (PNR) can be done by individual production technical lines, by departments or sectors with a final technological cycle. Start-up and adjustment are done both in building new production and when renovating existing production. Start-up and adjustment work ends with release of the facility for industrial operation based on a document from a State Acceptance Commission.

The task of reaching planned power can be partially resolved for individual types of equipment or at individual technological stages, and certain economic indicators such as expenditure norms for raw material and energy and for labor intensiveness can also be reached while production is still being started up and adjusted.

Production facilities are accepted for operation only on the condition that they are ready for release to the customer, that is, steady release of the output anticipated in the plan has been set up on the equipment installed. In this regard, a facility for which the entire complex of anticipated work has been carried out and release of the basic output has begun is considered ready to begin operation. Installation defects and equipment bugs revealed as a result of the comprehensive testing must be eliminated.

If several types of output are to be produced on the same equipment using combined flow charts, comprehensive testing can be done just for the release of any one product. For production consisting of several parallel, identical flow charts, testing production using one flow chart in working media is permitted. All other systems are tested in inert media.

As was noted above, start-up and adjustment work is the final link in the process of creating a new facility.

From the moment the facility is released for industrial operation, it is the period of production utilization, which is now the start of enterprise operations.

In this period, a plan is approved for the enterprise, which must begin producing output steadily in a volume and of a quality conforming to the plan and must achieve the level of technical and economic indicators anticipated by the plan. The utilization period includes technical, production and economic utilization stages. The overall utilization period ends when the enterprise reaches the planned economic level.

A summary indicator describing the economic level of a new enterprise can be set as a percentage of a standard, which could be the plan or indicators from the best existing enterprise:

$$E_1 = \frac{K_1 E_m + K_2 E_w + K_3 E_e}{K_1 + K_2 + K_3}, \qquad (1)^1$$

where E_1 is the economic level of the new enterprise;

K_1 is the proportion of expenditures on raw and other materials and energy in overall expenditures to produce a particular product;

E_m is the economic level of use of raw and other materials and energy;

K_2 is the proportion of wages in overall production expenditures;

E_w is the economic level of worker use;

K_3 is the proportion of depreciation in overall production expenditures;

E_e is the economic level of equipment use.

Consequently, the time from the day the document accepting the facility for operation is signed until the facility reaches steady release of output in the volume and with the economic indicators conforming to the plan should be considered the normal duration of enterprise economic utilization. In this regard, the duration of steady output is determined by the SNiP and the production cycle; it is one month in branches with a short production cycle.

Sometimes the utilization period is delineated by two dates:[2] the period is said to start when the facility is started up for temporary operation, and the end of the period is said to be the start-up of the facility for continuous operation. At the same time, this interpretation refers not to the utilization process, but to the start-up period, as the utilization process begins only when the facility is released for industrial operation, when the enterprise is set a plan assignment for output release.

In spite of the fact that the normative period for utilizing new enterprises is less than two years, in practice, the period needed to reach technical and economic parameters stretches out to 5-7 years. The utilization of designed capacity in terms of production volume and the attainment of other technical and economic indicators often do not coincide. Thus, according

---

1. V. S. Sominskiy, "Ekonomika khimicheskoy promyshlennosti" [Economics of the Chemical Industry], Moscow, Izd-vo Vysshaya Shkola, 1969, pp 333-334.

2. R. M. Merkin and G. V. Nikolayeva, "Methods of Setting Norms for and Planning the Economic Utilization of New Enterprises," in "Sb. nauchnoy informatsii 20. Metody i praktika opredeleniya effektivnosti kapital'nykh vlozheniy i novoy tekhniki" [Scientific Information Handbook No 20. Methods and Practice of Determining the Effectiveness of Capital Investments and New Equipment], Moscow, Izd-vo Nauka, 1972, p 47.

to USSR Central Statistical Administration data, output net cost corresponds to the planned level at only nine of every 50 new chemical enterprises.

In some instances, this is to be explained by errors in calculations of indicators at the planning stage. It sometimes happens because of planning confusion at the new enterprises: setting unsubstantiated plan assignments or a lack of coordination among the various planning indicators. At the same time, it is hard to count on the planned technical and economic indicators to serve as a realistic basis for planning 10-12 years after they were calculated. That is approximately how much time passes from plan approval to the start-up of a new facility for industrial operation.

The reasons for slow utilization generally emerge long before the start of enterprise operations, that is, at the planning and construction stage. Future enterprise production activity depends on the extent to which defects in plans, equipment and installation are revealed and eliminated, on how well technological conditions are set up.

In terms of time involved and expenditures, start-up and adjustment for chemical production facilities in a number of foreign countries are capital construction. This testifies to the fact that the companies are guaranteeing that all the indicators anticipated in the plan will be reached immediately after the facility is released for operation.

Installation and adjustment are a single, continuous process without whose final completion industrial operation of new capacities is impossible.

According to the SNiP, "completed production facility construction projects are accepted for operation by the State Acceptance Commission only if the release of output anticipated by the plan has begun on the equipment installed and the facility is ready for operation."

The construction norms[1] anticipate a time for starting up production, but in practice, no time remains for equipment testing after the builders finish the installation work, so it is handed over to the customer. What happens is, construction is complete, but the facility is not ready to be put into operation. In this connection, V. P. Krasovskiy notes quite correctly that, "given the availability of highly skilled operating personnel, the utilization period could be eliminated entirely if the builders and installers would release to them output ready for operation at full planned capacity."[2]

2. Responsibility of Those Participating in Creating New Capacities

The creation of new capacities signifies technical actualization of scientific and engineering schemes which are a result of the joint activity of

----

1. "SNiP III-A.33-66," paragraphs 2 and 5.

2. KOMMUNIST, No 12, 1975, p 47.

the collectives of planning, construction-installation, start-up and adjustment organizations and the personnel of the new production facility itself.

Various organizations bearing a certain responsibility for the work they are doing are involved in all stages of creating new production.

According to the 28 May 1969 CPSU Central Committee and USSR Council of Ministers Decree "On Improving Estimate Planning," planning organizations are obligated to organize planning on the basis of maximum consideration of the latest achievements of science and engineering in order that enterprises being built or renovated will be technically advanced at the time they are put into operation and have high indicators in terms of labor productivity, production net cost and output quality.

Planning organizations consequently are responsible for the correctness of planning resolutions, planned installed capacity, and technical-economic indicators. The general planner exercises authorship supervision of observance of plan assignments and blueprints. For the most important planning projects, authorship supervision is also exercised after the enterprise begins operating, until the facility reaches planned capacity. Planning organization representatives participate in accepting a facility for operation and offer consultation on problems requiring refinement, on changes and corrections during start-up and utilization.

Subcontractor construction and installation organizations are responsible for performing construction and installation work in the least amount of time and in accordance with the plan and for ensuring suitable quality.

The general contractor and his subcontracting organizations install and test equipment following the requirements of part III of the SNiP and the technical requirements and conditions agreed to by the planning organizations and the plants manufacturing the equipment.

The manufacturers of special or unique equipment are responsible for adjusting technological processes. Equipment suppliers oversee the installation (installation supervision) or entrust it to specialized organizations, based on agreements drawn up.

After installed equipment is released to the enterprise, construction-installation organizations are obligated to conduct individual testing to eliminate installation bugs and defects which have been discovered. Then a document is drawn up transferring the equipment from the general contractor to the customer, the enterprise.

The enterprise is responsible for prompt preparation of the facility to produce output at the capacities being put into operation, for staffing, for supplying raw and other materials, tools and energy resources, for start-up and adjustment work.

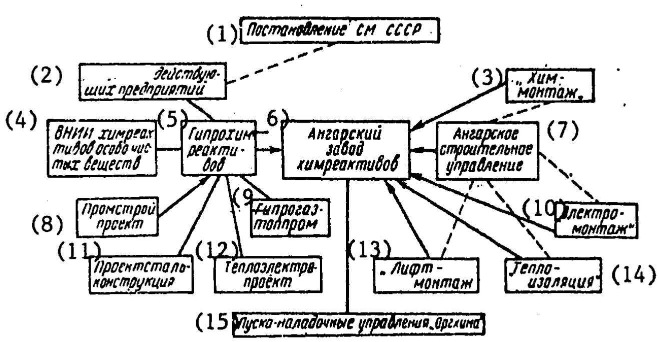
Jointly with planning, contractor, construction-installation, start-up and adjustment organizations and, when necessary, plants manufacturing special or unique equipment, the enterprise is responsible for putting facilities into operation and utilizing planned capacities within the time periods anticipated in the norms currently in effect.

These are the requirements and obligations stipulated in the instructions for organizations participating in the creation of new production. Unfortunately, planning and construction organizations and machine builders supplying equipment do not guarantee the release of output or the reaching of planned technical and economic indicators at new facilities. This appreciably reduces their responsibility for the indicators outlined.

Under the established rules, after the general contractor hands over to the customer installed and individually tested equipment, the customer must do the start-up and adjustment work on the technological equipment, including comprehensive testing of the entire production flow chart, to ready the facility for release to begin operating. In order to do this work, he calls in specialized start-up and adjustment organizations, and representatives of planning and contractor construction-installation organizations also participate.

In accordance with the normatives, the schedules and procedures for the start-up and adjustment work and a list of persons responsible for carrying it out are established by order of the enterprise director for each production facility. Based on that order, operational technical supervision of start-up and adjustment work is entrusted to a specialized start-up and adjustment organization, but the overall administrative supervision of the work remains the task of the chief engineer of the new or renovated enterprise. One example of the participation of different organizations in starting up a production facility is represented in the diagram in Figure 2.

Figure 2. Participation of Organizations in Creating New Production



[Key on following page]

Key (to Figure 2, preceding page):
1. USSR Council of Ministers decree
2. [illegible] of existing enterprises
3. "Khimmontazh"
4. All-Union Scientific Research Institute of Very Pure Chemical Reagents
5. Giprokhimreaktivov
6. Angara Chemical Reagents Plant
7. Angara Construction Administration
8. Promstroyproyekt
9. Giprogaztopprom
10. "Elektromontazh"
11. Proyektstal'konstruktsiya
12. Teploelektroproyekt
13. "Liftmontazh"
14. "Teploizolyatsiya"
15. "Orgkhim" Start-Up and Adjustment Administration

The interaction between enterprise production-operations personnel participating in the start-up of production and specialists of the start-up and adjustment organization involved are stipulated in the "Staff Workplace Substitution Record," which outlines for the start-up period a precise distribution of specialists by specific workplace and distributes the functions and duties anticipated in the production instructions, regardless of what organization a given worker is a part of.

According to the "Staff Workplace Substitution Record" drawn up by the leader of the start-up and adjustment subunit and approved by the enterprise director, all work in the start-up period is done following the following scheme:

Overall technical and administrative supervision of work at a new project being put into operation during the start-up period -- Chief Engineer of the enterprise;

Immediate supervision of start-up work -- a technical start-up leader designated by the enterprise;

Operational supervision of all production-process operations -- Senior Shift Chief;

The work itself -- Senior Instrument Control Man, Senior Machine Operator, Senior Laboratory Worker, instrument control man, machine operator, laboratory worker;

Operational supervision of all shop, department and sector operations -- shop, department or sector shift chief.

The above scheme anticipates that instructions will emanate from above and that permission for operations will be received from below under a strict procedure. The start-up technical supervisor, in order to ensure unity and precision of leadership, does not have the right to give operational instructions to a shop shift chief, who in turn is obligated to coordinate all his own actions with the senior production shift chief. Only the shift chief issues instructions to specific individuals at the workplace.

Production leaders are obligated to ensure normal operation in the sectors subordinate to them during the start-up period -- supplying raw material and power, sending on finished output, stopping and starting up equipment. When the start-up of several shops is done on a one-time basis, shift chiefs must coordinate the start-up sequence in each shop. In this instance, overall supervision of the start-up is done by the senior shift chief through the appropriate shift chiefs. A working commission is created to prepare the facility for release to the customer for operations. It is designated well in advance of acceptance of the facility for operation, at a time which depends on the nature and complexity of the production.

After the individual testing done by the installation organization is complete, the equipment is accepted by the working commission for comprehensive testing. The working commission is created by the customer no later than five days after it has been informed that the equipment is ready for comprehensive testing. Subcommissions can be created for each individual shop or installation comprising an industrial complex. The working commission includes:

a representative of the directorate of the enterprise being built or renovated; that representative is the commission chairman;

specialists from among enterprise industrial-production personnel: the chief engineer, the chief mechanic, the chief power engineer, the shop chief and the equipment safety engineer;

representatives of the planning organization, the general contractor and subcontractor organizations;

representatives of organizations involved in the start-up and adjustment work;

representatives of the trade union council's technical inspectorate and the enterprise trade union organization.

The working commission is obligated to check:

conformity of the construction-installation work done to the approved plan;

individual components, subassemblies and equipment;

installation quality;

the provision of the start-up complex with material resources and personnel.

After comprehensive equipment testing and the entire complex of start-up and adjustment work are complete, the working commission checks work quality, decides the readiness of the equipment for acceptance for operation, and submits the facility to a State Acceptance Commission.

The State Acceptance Commission accepts capacities for operation after final installation of all equipment and completion of start-up and adjustment work. Individual auxiliary installations of the system which comprise the start-up complex but which do not participate directly in producing the output anticipated by the plan (such as power plants and pump stations, compressors, warehouses, maintenance shops, access roads, and so on) are accepted for operation on the basis of their readiness by working commissions prior to acceptance of the facility as a whole by the State Acceptance Commission. The date the document releasing facilities for operation is signed by the working commission is considered the date the individual auxiliary installations begin operation.

The State Acceptance Commission is designated by a superior organization no later than three months prior to the established start-up of the facility for operation to accept production facilities or start-up complexes:

by a ministry when the estimated cost of the facilities is 2.5 million rubles or more;

by a ministry all-union association when the estimated cost of facilities subordinate to them is 500,000 to 2.5 million rubles;

by the enterprise director when the estimated cost of the facility is under 500,000 rubles.

Participating in the State Acceptance Commission are a representative of the ministry (chairman), representatives of the directorate of the new enterprise, the general contractor, the general planner, the bank financing the project, and the State Construction Architectural Control agency.

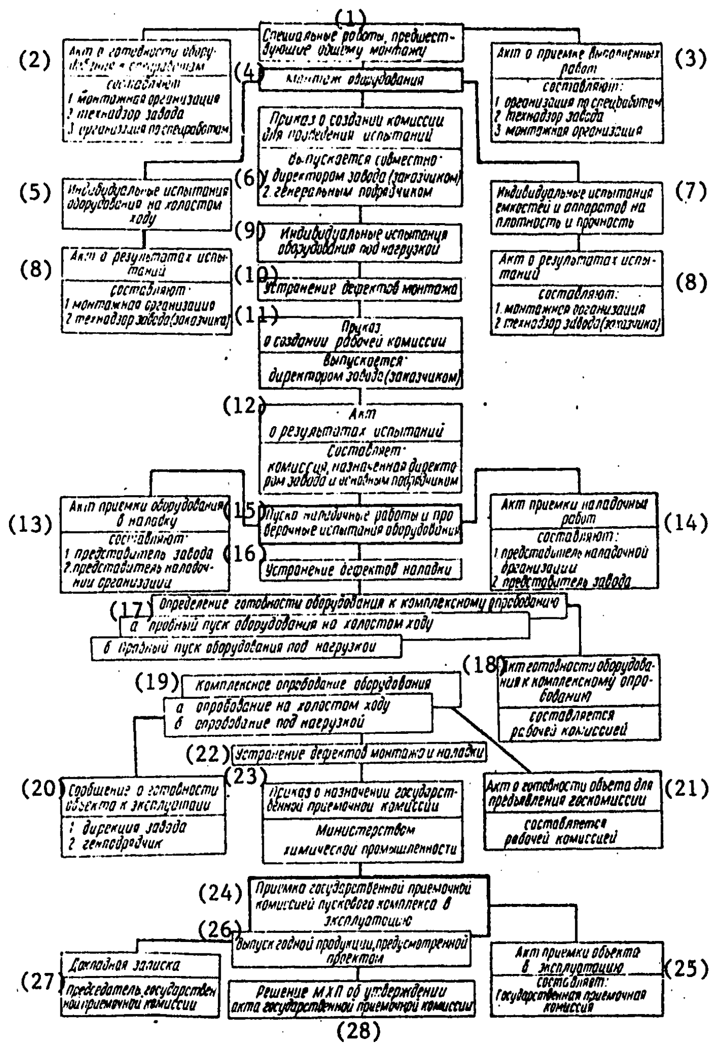
The production facility is submitted for acceptance for continuous operation by the working commission to the state commission in accordance with the "Rules for Accepting Completely Built Enterprises, Facilities, Shops and Production of the USSR Chemical Industry for Operation" and SNiP (10)-(III-66) only after it has been brought up to steady operating conditions.

The State Acceptance Commission checks the conformity of start-up complex capacities to planned and actual construction cost and the approved estimate; it evaluates the new facility in terms of progressiveness of technological production processes and makes suggestions on improving the operating qualities of the equipment installed and on increasing production profitability. Changes in production capacities which were anticipated by the plan and in other technical and economic indicators are generally not permitted in accepting a production facility for operation. They can be introduced into the plan in exceptional cases, as for example, accepting a facility for operation using a temporary or abbreviated flow chart, with the permission of a superior organization and with the concurrence of the USSR Gosplan and Gosstroy. The date the document is signed by the State Acceptance Commission is considered the date the start-up period ends and the facility begins continuous industrial operation. A diagram of acceptance of a facility for operation is given in Figure 3 [following page].

Thus, the start-up period begins after construction-installation work is complete and ends with release of the facility for continuous industrial operation, when a plan is set the enterprise in accordance with the accepted capacity.

The "fixation points" of the start of the start-up period are the date the working commission signs the document releasing the facility to the customer and the end of the start-up period is the date the State Acceptance Commission signs the document putting the capacities into operation.

Figure 3. Diagram of Acceptance of a Start-Up Complex for Operation



[key on page following]

Key (to Figure 3, preceding page):

1. Special work preceding general installation
2. Document of equipment readiness for special work, drawn up by (1) installation organization, (2) plant technical supervisor's office, (3) special work organization
3. Document accepting work done, drawn up by (1) special work organization, (2) plant technical supervisor's office, (3) installation organization
4. Equipment installation
5. Testing individual equipment at idle
6. Test results document, drawn up by (1) installation organization, (2) plant technical supervisor's office (customer)
7. Individual testing of tanks and apparatus for tightness and soundness
8. Order creating test acceptance commission, issued jointly by (1) the plant director (customer), (2) the general contractor
9. Testing individual equipment at load
10. Eliminating installation defects
11. Order creating the working commission, issued by the plant director (customer)
12. Test results document, drawn up by a commission designated by the plant director and the basic contractor
13. Document accepting equipment for adjustment, drawn up by (1) plant representative, (2) adjustment organization representative
14. Document accepting adjustment work, drawn up by by (1) adjustment organization representative, (2) plant representative
15. Start-up and adjustment work and check tests of equipment
16. Eliminating adjustment defects
17. Determining equipment readiness for comprehensive testing; (a) first start-up of equipment at idle, (b) first start-up of equipment at load
18. Document of equipment readiness for comprehensive testing, drawn up by the working commission
19. Comprehensive equipment testing, (a) testing at idle; (b) testing at load
20. Report that the facility is ready for operation, (1) plant directorate, (2) general contractor
21. Document of facility readiness for submission to a state commission, drawn up by the working commission
22. Eliminating installation and adjustment defects
23. Order designating the State Acceptance Commission, by the Ministry of Chemical Industry
24. State Acceptance Commission acceptance of the start-up complex for operation
25. Document accepting the facility for operation, drawn up by the State Acceptance Commission
26. Release of finished output as anticipated by the plan
27. Report of the State Acceptance Commission chairman
28. Ministry of Chemical Industry decision to approve the document of the State Acceptance Commission

Under the provisions in effect, the enterprise at which the production is being introduced is responsible for starting up newly created production. The enterprise accepts capacities ready for operation from the builders.

In order to increase the responsibility of the builders for the work done by them, we think a facility should be transferred to the customer not after the installation work is complete, but only after the complex of start-up period work has been done. Were this the case, a construction organization would act as a general contractor, involving specialized organizations in performing the start-up and adjustment work and guaranteeing the release of capacities ready for operation.

3. Start-Up Facility

We should make clear what we mean by start-up facility. A number of concepts, such as construction site, start-up complex and construction project, are used in planning practice and construction.[1]

The start-up complex is an aggregate of facilities (or portions thereof) of basic, production and auxiliary designation, of power, transport and warehousing systems, communications, utilities, purification facilities and public amenities which ensure the release of output as anticipated by the plan for a given start-up complex and ensuring normal working conditions for servicing personnel in accordance with current norms.

There can be several complexes at one construction site, each of which is an independent facility.

The aggregate of buildings and installations whose construction, expansion or renovation is, as a rule, carried out in accordance with one set of estimate planning documentation is called a construction site.

A construction project is each separate building or installation, with all the equipment, subsidiary and auxiliary structures and supply lines related to it as anticipated by the plan. One shop or several shops can be construction projects.

An enterprise is often put into operation not as a whole, but gradually, by start-up line, each of which can include individual production facilities, shops or shop sections. The sectional start-up of individual types of equipment is economically advantageous, since it permits working out start-up acceptance and utilization for a small number of units and sharply reduces the time and expense involved in mastering subsequent sections.

----

1. The definitions following are given in "Metodicheskikh ukazaniyakh k razrabotke Gosudarstvennykh planov razvitiya narodnogo khozyaystvo SSSR" [Methods Instructions for Working Out State Plans for Development of the USSR National Economy], Moscow, Izd-vo Ekonomika, 1974, pp 281-282.

Start-up by shop is possible where each shop has a finished production cycle. A majority of the enterprises of chemical industry and branches related to it are put into operation by production facility producing a certain type of finished product.

A production facility is accepted for operation only if release of the output anticipated by the plan has begun on the technological equipment installed.

In any start-up method, the appropriate start-up complex composition, the aggregate of basic and auxiliary production facilities, must be ensured.

Start-up completeness is achieved not only given a certain production composition, but also given a certain sequence of start-up of individual shops or portions of shops in each start-up line. In those instances when a facility consisting of a number of independent flow charts is released for operation, they can be accepted for operation as they become ready, on the condition that production is operating normally and that purification facilities and utilities are ready and all labor-protection and equipment-safety norms are being followed.

When enterprises are installed by start-up line, more funds are usually spent to create auxiliary-system reserves when building the first lines and putting them into operation. Construction of the second and subsequent lines is less expensive (approximately 75-80 percent of the capital investments anticipated).

Usually, the first line is released for operation, the enterprise becomes an operating concern, it does its basic activity, and at the same time capital construction continues. Given such construction practices, it is sufficient to invest 20-25 percent of the average estimated cost for the enterprise to begin producing output. This method speeds up the process of utilizing new capacities. It is therefore a mistake to view production start-up and utilization schedules apart from the conditions under which facilities are being created.

The gap between times of release of individual lines is sometimes very large, which makes it hard to evaluate the enterprise as a new entity. In view of the large gap in times of release of facilities, we should speak not of "new production" but, as Z. P. Korovina recommends, of "a newly operating facility."

Calendar time since the start-up of a facility alone is inadequate to define the concept of "new production." Consideration should be given to the newness of the output and the level of the equipment being introduced.

Production based on the following should be considered new:

manufacturing output not previously produced by that enterprise;

using technological processes which substantially alter output manufacturing technology;

use of equipment which substantially alters enterprise technical and economic indicators;

new production organization.

At present, we are using a new-output gradation which corresponds to the essence of the process of up-dating and developing production. It consists of dividing enterprise output into:

1) own new output having no analogs, output being manufactured for the first time in the USSR;
2) new output having prototypes, but substantially different from them;
3) output improved in part, with retention of basic characteristics.

Renovated enterprises can also be newly operating facilities. According to the "Methods Instructions for Developing State Plans for USSR National Economic Development," renovation and expansion include the construction of new and expansion or reorganization of existing shops and installations at existing enterprises which is done following a single plan or plans and estimated for individual facilities, as well as the continuation of construction of a new enterprise based on a plan which has been changed since capacities ensuring the release of basic finished product were put into operation.

Renovated production ordinarily includes that in which the coefficient of fixed assets renewal as a result of capital expenditures made is 0.4 to 0.6.

Expansion includes the construction of second lines or new shops on the site of an existing enterprise, as well as the start-up of units in order to release additional output in short supply. Production renovation, along with new construction, is one method of increasing capacities. It generally permits ensuring output increment more quickly with proportionately fewer capital investments. However, if a significant portion of the renovation allocations goes not to up-date equipment but to radically restructure production buildings, the subsidiary and warehousing system, a high proportion of construction-installation work in renovation expenditures reduces its economic effectiveness. For the chemical industry as a whole, the intensiveness of renovation and expansion of existing enterprises is higher than the construction of new ones, as is borne out by the coefficient of capacities start-up, which describes the ratio of cost of fixed assets introduced to volume of capital expenditures.

Thus, the coefficient of capacities start-up in chemical industry in 1961-1965 was 0.9 for renovated and expanded enterprises and 0.55 for new enterprises; in 1966-1970, the figures were 0.97 and 0.87, respectively.

In accord with the definitions given, a facility subject to start-up is understood to mean new or renovated production which can be an entire industrial complex, enterprise, individual enterprise lines, or a shop with a finished production cycle.

Section 2. Specialized Start-Up and Adjustment Organizations.

The considerable capital investments being directed into developing industry and increasing the number of facilities being put into operation, on the one hand, and technical progress in industry leading to increased unit capacity and process speeds, to increasing complexity of flow charts and a rising level of production process mechanization and automation, on the other, necessitate involving new, specialized start-up and adjustment organizations in starting up and adjusting new production.

The creation of start-up and adjustment organizations was outlined by the 11 January 1963 CPSU Central Committee and USSR Council of Ministers Decree "On Increasing the Role of the State Committees and Their Responsibility for Developing Branches of Industry."

Positive experience in starting up and adjusting technological installations of petrochemical and oil refining industry, which the "Orgneftezavody" office has been involved in since 1952, has been the basis for creating start-up and adjustment organizations in all branches of industry.

The involvement of specialized organizations using more improved methods of doing start-up and adjustment work. These organizations are staffed by skilled adjusters (engineers, technicians).

A three-link management system is characteristic of a majority of the start-up and adjustment organizations; a lead start-up and adjustment organization (trust, office, association) subordinate directly to a ministry or department is the basic economic link. Included in the lead start-up and adjustment organization are start-up and adjustment administrations, which in turn include sectors, groups and brigades, that is, individual production subunits directly involved in start-up and adjustment work at the facilities.

The start-up and adjustment organizations are primarily enterprises of the given branch and are called on to solve a whole complex of technical problems. They are fully specialized to perform start-up and adjustment work.

In the chemical industry, the State All-Union Engineering-Technological Trust (Orgkhim) of the USSR Ministry of Chemical Industry, created in 1963, is concerned with start-up and adjustment work at newly operating facilities and with rendering technical assistance to existing enterprises.

Along with the Orgkhim, a number of planning organizations also participate in the start-up of new chemical industry production. Thus, since 1965, in the Lenniigiprokhim, State Committee for Chemical Industry, attached to the USSR Gosplan, has been entrusted with start-up and adjustment work for the complex of planning developments done by them. In this connection, a start-up and adjustment administration (UPNR) has been created under the Lenniigiprokhim.

The Union "Orgneftezavody" office is an organization which has accumulated considerable experience both in starting up new petrochemical and oil refining enterprises and supervising and adjusting operating procedures at existing installations with a view towards using them efficiently.

The All-Union "Orgbumdrev" association, which operates under the "Regulations on Procedures for Performing Start-Up and Adjustment Work by the All-Union 'Orgbumdrev' Association at Enterprises of the Ministry of Pulp and Paper Industry," starts up enterprises of the lumber, pulp-paper and wood-processing industries.

Along with the indicated specialized organizations, the USSR Ministry of Installation and Special Construction Work has trusts designed to adjust and start-up new production capacities.

There is also a broadly specialized type of organization which has no particular specialty and which performs several types of work on a facility, such as installation and repair and the associated start-up and adjustment.

Machine building has no specialized start-up and adjustment organizations starting up production facilities as a whole. However, the design bureaus and plants assigned to them participate in starting up equipment designed and manufactured by them in industrial operation on a lead-prototype basis by exercising authorship supervision of their development. Thus, for example, experimental plants of a number of ministries are permitted to include in the cost of the equipment manufactured by them expenditures on its start-up and adjustment, which comprise 20-25 percent of total expenditures on the equipment.

The technological planning institutes and technological-design bureaus render enterprises technical assistance in utilizing planned capacities when introducing new technological procedures, processes and equipment. Thus, for example, a department concerned with starting up and adjusting new developments has been created within the Central Technological Design Bureau of the Latvian SSR Ministry of Building Materials Industry. Introduction work comprises 10-20 percent of the total cost of a development.

The experience of the All-Union Technological Planning Institute of Foundry Industry (VPTIlitprom) is very interesting. The VPTIlitprom plans start-up and adjustment work, supervises observance of the plan, treats start-up and adjustment work in progress, consults, and provides additional instruction to servicing personnel at the workplace.

These plans anticipate:

the participation of planning and design organizations, equipment manufacturing plants and construction-installation organizations in start-up and adjustment work;

the responsibilities and interaction of the organizations and the extent and nature of their participation;

the system of organizing equipment start-up and adjustment and of introducing technological processes at all stages of the technological process;

the procedure for calculating start-up and adjustment expenditures and for drawing up documentation for this work.

At the plan development stage, the VPTIlitprom draws up a loose financial estimate for the start-up and adjustment work, which outlines a plan for organizing the work on putting the enterprise into operation; this comprises in cost terms approximately one percent of total estimate expenditures. The leader of the comprehensive start-up and adjustment brigade created from among institute specialists is the authorized representative for the production start-up period.

The basic task set by the institute in developing plans for organizing start-up and adjustment work at enterprises of the foundry industry is to meet conditions for reducing to a minimum the time involved in putting the facility into operation.

This experience has unfortunately not found the proper support and dissemination, which is connected in considerable measure with shortcomings in financing and determining expenditures on start-up and adjustment work.

The literature has a number of recommendations on improving work organization in the start-up period. Thus, Z. P. Korovina[1] thinks it necessary to draw up an organizational plan (a plan for organizing the preparation, start-up and utilization of planned capacities) in the facility planning stage. It is the author's opinion that this must be done by special planning institute departments comprised of skilled specialists with a great deal of experience in organizing start-up.

The organizational plan must cover the time from the start of development of the technical plan to reaching planned technical and economic indicators and must contain these sections:

1) methods of putting the enterprise into operation;
2) organizing preparation of the enterprise for start-up;
3) content and duration of the start-up period;
4) organizing utilization of start-up lines.

Of interest in foreign publications are works in which it is recommended, for prompt and proper start-up, that a program for implementing the start-up be developed in advance and include staff, organizational measures, the preparation of working instructions, completing construction work, and organizing initial adjustment operations when starting up new facilities.[2]

----

1. "Methods and Practice of Determining the Effectiveness of Capital Investments and New Equipment," in "Sb. nauchnoy informatsii 20" [full title in footnote 2, p 12], Moscow, Izd-vo Nauka, 1972, p 60.

2. E. Troyan, "How to Prepare the Starting of Chemical Industry," in CHEMICAL ENGINEERING, 67, N 18, 1960.

Along with the large specialized start-up and adjustment organizations serving entire branches, several start-up and adjustment organizations belonging to various departments also often do start-up and adjustment work at large construction sites. For example, simultaneously with Orgkhim production administrations, the Belpromdaladka Trust, Khimremstroymontash Trust, Sevzapmontazhavtomatika Trust and others did start-up and adjustment work on the Gronenskiy Chemical Combine.

The fact that there are a large number of small, departmental organizations is unjustified in a majority of cases. These organizations are poorly provided with equipment, have poorly skilled workers, and generally their services are high in cost. It has been estimated that the unification and consolidation of such organizations in the Belorussian SSR alone would enable us to save a million rubles per year and to simplify the administrative apparatus by 300 persons.

The involvement of several similarly specialized organizations in starting up a facility testifies to a lack of precise centralized planning. At the same time, the plans for utilizing capital investments and putting new production capacities into operation must be coordinated with the need for the services of specialized start-up and adjustment organizations. In drawing up such plans, capital construction plans are used as the base, wherein an assignment for putting production capacities into operation is set for each facility.

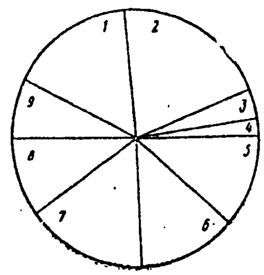
Afraid of high start-up and adjustment expenditures if specialized organizations are involved and of high net cost during the utilization of new production, enterprises sometimes start up production using their own efforts. This obviously lowers work quality, schedules for putting facilities into operation are often not met, and the time involved in utilizing new production increases. The Ministry of Chemical Industry obligates enterprises to use the Orgkhim All-Union Engineering-Technological Trust's technical assistance in starting up new production and to submit applications at the proper time for including them in the start-up and adjustment plan.

Orgkhim specialists are called on to do start-up and adjustment work at new, expanded and renovated production facilities, on individual units and pieces of complex technological equipment, technological installations, air conditioning units, pneumatic transport, ventilation systems, waste water purification facilities, check and test point systems, and automatic machines. Their participation in doing individual types of work is shown in Figure 4 [following page].

Such broad specialization in organizing the start-up of newly operating production and of individual systems in it is reflected in how the structure of production administrations is shaped.

The Orgkhim Trust consists of six branch (OPU) and four specialized (SPU) production administrations. The branch administrations cover such branches of chemical industry as nitrogen, chlorine, basic chemistry, chemical fibers,

Figure 4. Structure of Work Done by the Orgkhim, in percent

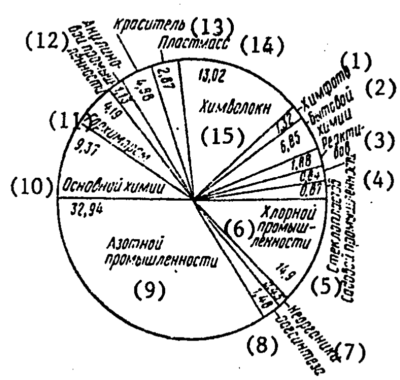


Key:

1. Adjusting the check and test point system and automatic machinery, 14.2 percent
2. Start-up preparation, start-up and utilization of production, 21.5 percent
3. Start-up of water circulation systems, 2.5 percent
4. One-time engineering services, 1.7 percent
5. Start-up of technological stages and individual units, 14.2 percent
6. Technical assistance to existing enterprises, 14.1 percent
7. Adjusting ventilation systems, pneumatic transport and air conditioning, 16.8 percent
8. Starting up boiler rooms, refrigeration and compressor stations, 9.6 percent
9. Starting up complex purification installations, 5.4 percent

lacquers and dyes, plastics and their processing, paints and organic products, production of household chemicals and chemical reagents. The participation of Orgkhim specialists in starting up new production in individual branches of the chemical industry is shown in Figure 5.

Figure 5. Orgkhim Participation in Starting Up Facilities, By Branch of the Chemical Industry, in percent [key on following page]



Key (to Figure 5, preceding page):

1. Photographic chemicals
2. Household chemicals
3. Reagents
4. Horticulture
5. Fiberglass
6. Chlorine industry
7. Inorganic chemicals
8. Organic synthesis
9. Nitrogen industry
10. Basic chemistry
11. Mining chemical industry
12. Aniline industry
13. Paints
14. Plastics
15. Chemical fibers

The specialized Orgkhim administrations are concerned with preparing and starting up check and test point systems and automatic machinery, ventilation and air conditioning systems, gas and industrial waste water purification systems, at enterprises being put into operation. The Orgkhim structure (Table 3) is one way of combining branch and territorial management of start-up and adjustment work.

Table 3. Structure of Orgkhim Production Administrations, by amount of work done and by number of personnel

	(1) Производственные управления Оргхима	(2) Объем работ в % к итогу	(3) Численность персонала в % к итогу	(4) Выработка, руб.-чел.
(5)	Балашихинское	7,5	6,6	5089
(6)	Дзержинское	7,5	6,9	4860
(7)	Долгопрудненское	8	7,2	4992
(8)	Киевское	5,4	10	2429
(9)	Куйбышевское	7,5	6,8	4931
(10)	Ивано-Франковское	4,8	4,8	4494
(11)	Люберецкое	18	17,8	4513
(12)	Мытищинское	10,1	9,3	4790
(13)	Северодонецкое	14,5	14,3	4514
(14)	Черкасское	7,9	7,7	4599
(15)	Ярославское	8,7	8,8	4428

Key:

1. Orgkhim production administration
2. Work volume, in percent of total
3. Personnel, in percent of total
4. Output, in rubles per person
5. Balashikhinskoye
6. Dzerzhinskoye
7. Dolgoprudnenskoye
8. Kiyevskoye
9. Kuybyshevskoye
10. Ivano-Frankovskoye
11. Lyuberetskoye
12. Mytishchinskoye
13. Severodonetskoye
14. Cherkasskoye
15. Yaroslavskoye

Trust administrations are situated in individual industrial centers (regions) and are specialized to start-up the basic or auxiliary systems of new or renovated enterprises. Several production administrations often participate in starting up a facility. Thus, for example, the Cherkasskoye branch production administration started up the viscose staple production at the Sokal'skiy Chemical Fibers Plant and the Lyuberetskoye specialized production administration started up the check and test point systems and automatic machinery.

The Cherepovetskiy Nitrogen Fertilizer Plant is an example of the participation of various Orgkhim production administrations in starting up a new facility: 104 people from the Severodonetskiy OPU were involved in starting up the weak nitric acid production; 69 people from the Lyuberetskiy SPU were involved in starting up the check and test point systems and automatic machinery; 27 people from the Balashikhinskiy SPU were involved in starting up the compressor equipment and air distribution unit; 12 people from the Mytishchinskiy OPU were involved in starting up sulfuric acid production; four people from the Yaroslavskiy OPU were involved in starting up the industrial ventilation, and four people from the Kiyevskiy SPU were involved in starting up the waste water purification system.

Orgkhim branch production administrations are specialized to prepare, start-up and utilize the following types of production:

Dzerzhinskoye OPU -- caprolactam;

Dolgoprodnenskoye OPU -- organic products and paints;

Kuybyshevskoye OPU -- toxic chemicals and their by-products, detergents, acetic acid;

Mytishchinskoye OPU -- basic chemical industry (sulfuric and phosphoric acid, salts, basic sulfur, superphosphate, fertilizer mixtures and others), iodine and bromine, and enriching nonmetallic minerals;

Severodonetskoye OPU -- ammonia, nitric acid, carbamide, methanol, ammonium nitrate and other products of nitrogen industry;

Cherkasskoye OPU -- synthetic and artificial fibers, fiberglass and fiberglass materials;

Yaroslavskoye OPU -- lacquers, dyes, enamels, pigments and fillers; testing and adjusting industrial ventilation, air conditioning and noise-level systems, gas and dust levels in production premises;

Soligorskoye OPU -- mining chemistry.

Specialized production administrations (SPU) do the following preparation, start-up and adjustment:

Balashikhinskoye SPU -- air-distribution, gas-distribution and refrigeration installations of all types, pump and compressor equipment, thermal engineering installations;

Kiyevskoye SPU -- industrial waste water purification facilities and reverse water supply systems;

Lyuberetskoye SPU -- check and test point systems and chemical production automatic machinery, quality control devices (chromatographs, mass spectrometers and others), electrical engineering installations, dispatching and computer centers at chemical enterprises.

Production cooperation among the specialized and branch Orgkhim administrations performing the start-up and adjustment work is anticipated for performing the entire work complex.

The customer is the enterprise, which is obligated prior to the start of the work to submit to Orgkhim representatives all planning and technical documentation relating to that particular facility. The work done is paid for by the financing bank on the basis of an agreement concluded upon submission, by the organization doing the work, of non-acceptance calculation accounts based on documents submitted upon completion of individual work stages.

After the start-up and adjustment work is complete, a technical document affirming that the work is complete is drawn up, indicating the basic technical and economic indicators achieved, as is a technical report generalizing the experience in starting up and utilizing the capacities.

The date the technical report is submitted is the date the agreement ceases to be in force. The amount of work anticipated by the agreement is done by a production subunit headed by its responsible representative.

The "Production Subunit Staffing Chart" (Table 4) outlines the composition of the Orgkhim production subunit and the participation of subunit workers in individual start-up and adjustment work stages.

Table 4. Production Subunit Staffing Chart for Start-Up and Adjustment Work

(1) Состав производственного подразделения	(2) Периоды											
	(3) инженерный надзор						(4) пуск производства				(5) освоение мощностей	
	(6) Количество дней работы в календарные месяцы											
	1	2	3	4	5	6	7	8	9	10	11	12
(7) Руководитель предприятия	—	6	8	11	12	10	13	15	16	19	23	22
(8) Гл. технолог	1	6	8	11	12	10	13	15	16	18	20	20
(9) Гл. механик	6	6	8	11	12	10	13	15	16	17	—	21
(10) Начальник смены	—	—	14	14	14	10	13	13	15	17	—	21

Key:
1. Production subunit composition
2. Periods
3. Engineering supervision
4. Production start-up
5. Utilization of capacities
6. Number of work days in the calendar month
7. Enterprise leader
8. Chief technologist
9. Chief mechanic
10. Shift chief

Contractual obligations are met by planning in stages. The essence of this method is that planning and accounting are done by specific type of work; their nature and composition are determined by the program, and their cost is determined by price list or financial estimate. This method serves to raise the organizational and technical levels at which the start-up and adjustment work is done; it concretizes the duties of each worker and determines the sequence in which the work is to be done. Based on the readiness of the facility for comprehensive testing, the rate of construction-installation work and the availability of trained operating personnel, raw material and energy resources, a work front is planned for the production subdivision.

Plan assignments for start-up and adjustment work to be done by the production subunit are set within 20 days prior to the start of the period being planned. The complexity of the equipment, subassemblies and units is the criterion for evaluating the cost of individual start-up and adjustment work stages and types.

Given planning by stage, expenditures for all types of work in the established period are determined based on the overall cost of the work stage. One example of such planning is given in Table 5.

Table 5. Stage Plan for Work Distribution

(1) Этапы пусконаладочных работ	Стоимость пусконаладочных работ (2)	Выполнено за предыдущие месяцы (3)	Стоимость работ на планируемый квартал (4)
(5) Предпусковой этап:			
(6) Инженерный надзор за строительно-монтажными работами	18	6	6
(7) Из них по позициям:			
(8) насосное отделение	2	2	—
(9) отделение синтеза	5	—	5

Key:
1. Start-up and adjustment stage
2. Cost of start-up and adjustment work
3. Done in preceding months
4. Cost of work in the quarter being planned
5. Prestart-up stage:
6. Engineering supervision of construction-installation work
7. Of these, by position:
8. Pump department
9. Synthesis department

When he begins to carry out his duties in putting the facility into operation, the production subunit leader participates in working out and implementing a complex of organizational-technical measures:

1) training subunit specialists to start-up new production;

2) drawing up a long-range work plan with a breakdown of work stage schedules and a production subunit staffing chart;

3) studying and selecting planning and technical documentation, generalizing the production experience of similar facilities in operation.

For work on the facility, the production subunit leader provides administration departments with copies of agreements with the customer and organizations concerned, with a start-up and adjustment work price list, with methods guides for organizing and planning by stage, with a work plan and a subunit staffing chart, and with instructions for the various positions.

Concerning the direct production activity of the Orgkhim, it should be noted that during the years of its existence, the amount of start-up and adjustment work being done by the trust has grown considerably.

In 1970, the Orgkhim work volume had increased 2.3-fold as compared with 1965 and 6.6-fold as compared with 1963 (the year it began its activity). The work volume being done by the Orgkhim in the Ninth Five-Year Plan has grown 1.25-fold as compared with 1970.

Average annual rates of increment in work volume in the Eighth Five-Year Plan were 26.5 percent; during the Ninth Five-Year Plan, with an increase in work volume -- about 10 percent.

An absolute increment of one percent in work volume being done by the Orgkhim during 1963-1970 rose from 19,000 to 113,000 rubles, and by the end of the Ninth Five-Year Plan, to 140,000 rubles, as is evident from Table 6.

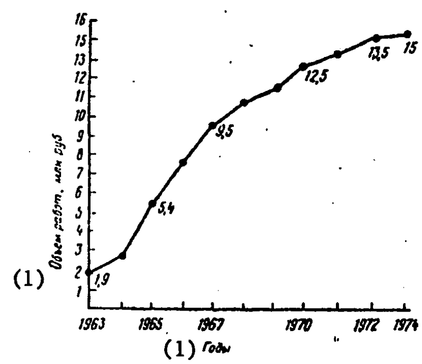
Table 6. Growth Rates

(1) Показатели	(2) Годы					
	1963	1965	1967	1970	1972	1974
(3) Темпы роста объема работ Оргхима в % к предыдущему году	100	186	128	111	112	114
(4) Объем работ, приходящийся на 1% прироста (тыс. руб.)	—	29	74	113	128	136

Key:
1. Indicators
2. Years
3. Rates of Orgkhim work volume growth, in percent of preceding year
4. Work volume per one percent increment, in 1000 rubles

Such significant rates of growth in orders for start-up and adjustment work are associated with growth in capital investments in the construction of new chemical industry production and with the necessity of putting new production into operation. Thus, 8.4 billion rubles was spent in 1966-1970 from centralized capital investments to develop chemical industry. Orgkhim expenditures during that same period on starting up new production were 51.4 million rubles; they grew 1.4-fold in the Ninth Five-Year Plan as compared with the preceding period, given a 70-percent increase in capital investment in the branch. Orgkhim expenditures were up to 0.6 kopecks per ruble of capital investments in putting production capacities into operation. Growth in Orgkhim work volume is shown in Figure 6.

Figure 6. Orgkhim Work Volume Growth Rates



Key:
1. Work volume, in million rubles
2. Year

All the practical activity of Orgkhim specialists is aimed at ensuring the accelerated start-up of new production capacities. The start-up of capacities to produce sulfuric acid, ammonium nitrate, phosphate fertilizer, complex fertilizers, ammonium sulfate, caustic soda, ethylene and caprolactam is carried out entirely through Orgkhim efforts, which also account for the start-up of more than 80 percent of the capacities put into operation to produce ammonium and potassium fertilizers, more than 70 percent of capacities to produce nitric acid, carbamide and carbamide resins, more than 50 percent of capacities to produce chemical fibers and household chemicals, and 30 percent of capacities to produce plastics.

A considerable proportion of Orgkhim engineering efforts is focused on starting up plants to produce nitrogen fertilizers.

As a whole, more than 40 percent of the trust's technical services personnel are engaged in starting up mineral fertilizers enterprises. This is associated with the fact that 60 percent of all mineral fertilizer capacities available in the USSR were put into operation in the Eighth Five-Year Plan and that output has nearly tripled.

Inadequate numbers of Orgkhim specialists are involved in starting up chemical fiber and plastics production.

The proportion of capacities being put into operation by the Orgkhim to capacities put into operation for the Ministry of Chemical Industry are given below, in percent:

sulfuric acid	100
ammonia	80
carbamide	73
nitric acid (weak)	70
ammonium nitrate	100
phosphorite ore	70
phosphate fertilizer	100
potassium fertilizer	84
granulated superphosphate	44
fertilizer mixtures	50
complex fertilizers	100
ammonium sulfate	100
caustic soda	100
isobutylene	100
carbamide resins	70
glycerine	100
acetic anhydride	100
carbanol	100
ethylene	100
caprolactam	100
large fiberglass items	100
chemical fibers	56
plastics	30
household chemicals	52
working polymer materials into packaging	100
manufacturing aerosol containers	100

It should be noted, in describing Orgkhim economic activity, that it is in need of continued improvement.

During the Eighth Five-Year Plan, profit relative to work volume done by trust production administrations was 23 percent. In this regard, each ruble of work volume included 77 kopecks of expenditures and 23 kopecks of savings. A comparison of actual expenditures on start-up and adjustment work with the normative value enables us to establish a systematic reduction in Orgkhim expenditures. It was 13 percent for the five-year period.

Such a significant reduction in expenditures testifies to the availability of reserves in evaluating start-up and adjustment work cost and has been a consequence the basis for a review of them.[1]

A significant savings of funds was also observed when comparing cost and net cost of work done for individual newly operating facilities. Thus, for example, each ruble of start-up and adjustment work volume done at sulfuric acid production facilities of the Gomel'skiy Chemical Plan accounted for 35 kopecks in savings, the Almalykskiy Household Chemicals Plant and the Angara

----

1. In 1973, the proportion of accumulations in the cost of start-up and adjustment work done was reduced for the Orgkhim trust.

Chemical Reagents Plant -- up to 37 kopecks, and superphosphate production at the Gomel'skiy plant -- up to 20 kopecks (Table 7).

Table 7. Ratio of Net Cost and Cost of Start-Up and Adjustment Work, By Orgkhim Project

Предприятия (1)	Объем выполненных работ по стоимости, тыс. руб. (2)	Затраты на выполнение работ по себестоимости, тыс. руб. (3)	Фактические затраты на руб. объема работ (4)
(5) **Гомельский химический завод**			
(6) Серная кислота	72,8	46,3	0,64
(7) Суперфосфат	63,4	50,3	0,8
(8) **Крымский завод двуокиси титана**			
(6) Серная кислота	134,7	87,5	0,65
(9) **Алмалыкский химический завод**			
(10) Аммофос	233,6	213,8	0,92
(11) **Актюбинский комбинат**			
(7) Суперфосфат	55,07	47,5	0,86
(12) Гранулированный суперфосфат	108,45	74,2	0,69
(13) **Солигорский комбинат**			
(14) Калийные удобрения	37	30,1	0,81
(15) **Ангарский завод химреактивов**			
(16) Химреактивы	29,7	21,7	0,73
(17) **Алмалыкский завод бытовой химии**			
(18) Товары бытовой химии	113,2	81,85	0,72
(19) **Невинномысский завод бытовой химии**			
(20) Аэрозоли	55,2	49,1	0,89

[Key on following page]

Key (to Table 7, preceding page):

1. Enterprise
2. Amount of work done in terms of cost, in 1,000 rubles
3. Work expenditures in terms of net cost, in 1,000 rubles
4. Actual expenditures per ruble of work volume
5. Gomel'skiy Chemical Plant
6. Sulfuric acid
7. Superphosphate
8. Krymskiy Titanium Dioxide Plant
9. Almalykskiy Chemical Plant
10. Ammophos
11. Aktyubinskiy combine
12. Granulated superphosphate
13. Soligorskiy combine
14. Potassium fertilizers
15. Angarskiy Chemical Reagents Plant
16. Chemical reagents
17. Almalykskiy Household Chemicals Plant
18. Household chemicals
19. Nevinnomysskiy Household Chemicals Plant
20. Aerosols

Along with saving funds, evaluation shows that Orgkhim production subunits sometimes do not fully exhaust the funds allocated them when carrying out the program. As is evident from Table 8 [following page], the sum anticipated by the agreement for starting up potassium fertilizer production at the Soligorskiy combine was used by only 47 percent; it was used by 80 percent at the Aktyubinskiy combine and the Gomel'skiy and Almalykskiy chemical plants.

The possibility of lowering the cost of Orgkhim services is confirmed by the high level of output per worker, which has risen from 3,535 rubles in 1966 to 5,530 rubles in 1970, that is, 1.56-fold (given an average wage increase of 1.26-fold); output was 4,367 rubles in 1974.

The fact that permanent Orgkhim subunit engineering and technical workers comprise 85 percent of all production personnel facilitates a high level of labor productivity, which provides an opportunity for accumulating experience in starting up production, for improving work quality, and for reducing the time needed to start-up new production.

Data from a questionnaire survey done for the Dolgoprudnenskiy production subunit, which was starting up the Olaynskiy Chemical Reagents Plant, showed that 70 percent of subunit workers had a higher special education and 30 percent had a secondary technical education. Twenty-five percent of those in the subunit had been employed in the chemical industry for up to 20 years, 50 percent for up to 10 years, and 25 percent for up to five years. Subunit specialists repeatedly participated in the start-up of such chemical industry production as chemical reagents at the Angarskiy Petrochemical Combine, Volzhskiy Chemical Plant, Novomoskovskiy Chemical Combine, and so on.

Table 8. Actual Expenditures for a Number of Orgkhim Projects Put Into Industrial Operation (in 1,000 rubles)

Предприятия (1)	(2) Стоимость работ предусмотренная договором	(3) Фактическая стоимость объема выполненных работ	(4) Фактическая стоимость по отношению к стоимости работ по договору, %
(5) Гомельский химический завод			
(6) Серная кислота	82,4	72,8	88,4
(7) Суперфосфат	80;5	63;4	78,8
(8) Крымский завод двуокиси титана			
(6) Серная кислота	163,4	134,7	82,4
(9) Алмалыкский химический завод			
(10) Аммофос	233,6	233,6	100
(11) Актюбинский комбинат			
(7) Суперфосфат	69,8	55,7	79,8
(12) Солигорский комбинат			
(13) Калийные удобрения	79,1	36,97	47
(14) Ангарский завод химреактивов			
(15) Химреактивы	29,7	29,7	100
(16) Усольский завод бытовой химии	7,6	7,5	98,7
(17) Невинномысский завод бытовой химии			
(18) Аэрозоли	55,3	55,2	99
(19) Алмалыкский завод бытовой химии			
Товары бытовой химии	129,4	113,2	87,5

Key:

1. Enterprise
2. Work cost anticipated by the agreement
3. Actual cost of amount of work done
4. Actual cost relative to work cost in the agreement, in percent

[Key continued on following page]

[Key to Table 8, continued from preceding page]
5. Gomel'skiy Chemical Plant
6. Sulfuric acid
7. Superphosphate
8. Krymskiy Titanium Dioxide Plant
9. Almalykskiy Chemical Plant
10. Ammophos
11. Aktyubinskiy combine
12. Soligorskiy combine
13. Potassium fertilizers
14. Angarskiy Chemical Reagents Plant
15. Chemical Reagents
16. Usol'skiy Household Chemicals Plant
17. Nevinomysskiy Household Chemicals Plant
18. Aerosols
19. Almalykskiy Household Chemicals Plant

The Orgkhim production personnel staff includes engineering-technical workers and instrument control workers in the leading occupations, and enterprises provide workplaces for operating personnel in accordance with the staff schedule during the production start-up period.

During the 10 years since the Orgkhim was created, the volume of work it has done to start-up new production has increased eight-fold, given a 2.7-fold increase in the number of production personnel, that is, basically due to a high level of output. The dynamics of Orgkhim activity indicators, given in Table 9, are shown in Figure 7 [both on following page].

We should remark that the system of shaping expenditures on rendering technical assistance to an enterprise on the part of start-up and adjustment organizations is in need of continued improvement.

At present, this work is financed through the circulating capital of the enterprises being put into operation, even before the operational activity of the new production begins.

The cost of start-up and adjustment work is sometimes inflated; accumulations are collected from the enterprise when paying for technical assistance rendered under an agreement in starting up a facility and remain entirely at the disposal of the superior organization (ministry).

However, before examining the ways in which the system of financing work associated with starting up facilities can be improved and setting rates for these expenditures, we must analyze existing practices shaping start-up expenditures and the influence these expenses have on the technical and economic indicators of new production.

Chapter II. Analysis of Start-Up Expenditures of New Production

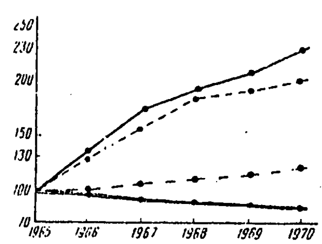
Section 1. Planning and Recompensing Start-Up Expenses

Table 9. Orgkhim Work Indicators, in percent

(1) Показатели	(2) Годы		
	1966	1970	1971
(3) Объем работ к 1965 г.	137,3	232,3	281,5
(4) Темпы прироста объема работ к предыдущему году	37,3	11,1	14,3
(5) Численность производственного персонала к 1965 г.	130	203	267
(6) Темпы прироста численности производственного персонала к предыдущему году	31,2	4,7	10,7
(7) Уровень производительности труда к 1965 г.	101	124	105
(8) Темпы роста производительности труда к предыдущему году	1	5,5	10,8
(9) Затраты на 1 руб. стоимости объема работ:	84,4	77	86,3
(10) Снижение затрат к 1965 г.	4,6	12	1,7

Key:
1. Indicators
2. Years
3. Work volume as of 1965
4. Rates of increment in work volume over preceding year
5. Number of production personnel as of 1965
6. Rates of increment in number of production personnel over preceding year
7. Level of labor productivity as of 1965
8. Rates of labor productivity growth over preceding year
9. Expenditures per ruble of work volume cost:
10. Reduction in expenditures over 1965

Figure 7. Orgkhim Work Indicators



Key:

-·-·-·- volume of Orgkhim work

——— labor productivity

------- change in number of workers

═══ expenditures per ruble

In accordance with paragraphs 3-4 of SNiP III-A.10-66, "all work done to determine the readiness of a facility for start-up is done by the customer using basic activity funds." Expenditures associated with the start-up of newly operating production are reflected in start-up expenses estimates.

However, there are currently no single methods provisions for drawing up estimates of start-up expenses, and neither have normatives been developed for planning them which take branch production features into account. In order to classify expenditures associated with the start-up of individual facilities and to substantiate their amounts, we require a single set of methods for determining their size, a firm list of estimate items, and expenditure normatives.

Preliminary recommendations in this area are based on studying existing methods provisions on drawing up estimates of start-up expenses and instructions on procedures for forming and paying them, as well as on analysis of practical enterprise data.

A procedure has been set up which anticipates drawing up start-up expenditure estimates by planning organizations, with the concurrence of the enterprise and their approval by branch union associations of the Ministry of Chemical Industry.

Based on this provision, several leading planning organizations have developed branch methods indstructions on drawing up start-up expenses estimates. Thus, the State Scientific Research and Planning Institute of Nitrogen Industry and Organic Synthesis Products (GIAP) developed "Methods Instructions on Drawing Up Start-Up Expenses Estimates" in 1966 for newly operating nitrogen industry production.

In order to evaluate and record expenditures on the start-up of new basic chemistry production, the Lenniigiprokhim in 1971 developed "Methods of Determining Start-Up Expenses for a Number of Chemical Industry Production Facilities." The basis for drawing up start-up expenses estimates using the methods recommended above was existing new production start-up schedules approved by the Ministry of Chemical Industry.

Expenditure coefficients and staff schedules used in the plans were used in calculating individual estimate items. But in the opinion of the GIAP, total raw material expenditure must not be higher than that anticipated by the plan, in view of the fact that units are tested and started up individually, while the plan calculates raw material for all equipment operating simultaneously.

The Lenniigiprokhim start-up expenses estimate methods take into account:

raw material for initial charging of equipment to be started up;

energy for individual equipment testing for 12 hours and comprehensive testing for 72 hours;

water to fill tanks three times for individual and comprehensive testing in inert media and for filling pipelines twice.

Using the GIAP instructions, standard-quality finished output (conforming to established GOST's or specifications) obtained as a result of test operation of production is calculated at transfer prices and deducted from overall start-up estimate expenditures. The amount of output suitable for sale under these methods instructions examples is 10 percent relative to the total amount of output produced during the start-up period.

GIAP recommendations are that start-up expenses be covered by writing them off to the net cost of output of the production being put into operation after the facility is operating profitably. However, it was later proven that enterprises are forced to recompense start-up expenses immediately after putting facilities into operation through production outlays of the existing enterprise, regardless of whether they were operating at a profitable level.

The methods given above have shortcomings associated with the calculation of start-up expenses included in estimates, to wit:

1) depreciation deductions, when enterprises begin deducting them after releasing a facility for industrial operation, that is, after start-up and adjustment work is finished;

2) expenditures on energy and water for individual equipment testing, which must be done by the builders prior to the start of the start-up period using capital construction funds;

3) expenditures on building and installation maintenance and routine equipment maintenance, which do not relate to production start-up, but to other expenses in subsequent periods at the enterprise.

All this leads to considerable overstatement of start-up expenses, even in the planning stage. This is borne out by the adjustment we made of start-up expenses estimates for specific production facilities used as examples in the Lenniigiprokhim methods. By excluding from the estimates items not related to start-up period work, expenditures could be reduced 20 percent.

In spite of the fact that planning organizations are obligated to draw up start-up expenses estimates, the calculations are actually made by the enterprises. When drawing up estimates, enterprises often mix start-up expenses in with other expenses of future periods. Expenses not relating to particular jobs are sometimes included in enterprise start-up expenses estimates, such as:

equipment depreciation, when production has not yet been put into industrial operation;

the cost of inexpensive, rapidly wearing tools and stocks;

expenses associated with heating and lighting;

labor protection;

other office expenses.

These expenditures comprise more than 30 percent of all start-up expenses, according to the estimate.

Table 10. Estimate of Start-Up Expenses

(1) Показатели	(2) Усредненные показатели по волокнам, %	(3) Предприятия химических волокон											
		(4) Даугавпилсский завод химволокон		(5) Курский химкомбинат (III очередь)		(6) Щекинский химкомбинат (поток шелка)		(7) Щекинский химкомбинат (поток корда и шелка)		(8) Сокальский завод химволокон (I очередь)		(9) Энгельсский комбинат химволокон	
		(10) тыс. руб.	%	(10) тыс. руб.	%	(10) тыс. руб.	%	(10) тыс. руб.	%	(10) тыс. руб.	%	(10) тыс. руб.	%
(11) Сырье, основные и вспомогательные материалы	18,7	64,7	14,6	165	9,6	413,6	13,2	1225,5	18,6	1069,5	28	1846,9	64,7
(12) Энергия	13,3	38	8,6	204	11,9	234,3	7,5	1315,7	20	297,4	7,8	116,5	4
(13) Основная и дополнительная заработная плата рабочих с начислениями	17,2	40	9	194	11,3	751,6	23,9	1069,3	16,2	649,4	17	166,9	5,8
(14) Амортизация	16,8	53	11,8	258	15	—	—	1266,2	19,2	1059,2	27,7	—	—
(15) Услуги вспомогательных цехов	2,2	—	—	—	—	—	—	—	—	100	2,6	—	—
(16) Техническая помощь предприятию	31,8	248	56	897	52,2	1740,3	55,4	1714,1	26	404,6	10,6	646,6	22,7
(17) Прочие расходы		—		—		—		—		239,7	6,3	79,5	2,8
(18) Итого	100	443,7	100	1718	100	3139,2	100	6590,8	100	3819,8	100	2854,4	100
(19) Возврат от реализации продукции	22,3	—	—	349	20,3	349,5	11,1	2519,3	38,2	280,8	7,4	665	23,3
(18) Всего	77,7	443,7	100	1369	79,7	2790,3	88,9	4071,5	61,8	3539	92,6	2189,4	76.7

Key:
1. Indicator
2. Averaged indicators, by fiber, in percent
3. Chemical fibers enterprises
4. Daugavpilsskiy Chemical Fibers Plant
5. Kurskiy Chemical Combine (3rd line)
6. Shchekinskiy Chemical Combine (silk line)
7. Shchekinskiy combine (cord and silk line)
8. Sokal'skiy Chemical Fibers Plant (1st line)
9. Engel'sskiy Chemical Fibers Combine
10. 1,000 rubles
11. Raw, basic and auxiliary materials
12. Energy
13. Worker basic and supplemental wages, with additions
14. Depreciation
15. Auxiliary shop services
16. Technical assistance to the enterprise
17. Other expenses
18. Total
19. Recovered from output sold

Summary data on enterprise start-up expenses estimates are given in Table 10 in a cross-section of individual expenditure elements and their structure. In accordance with branch instructions on planning, recording and calculating output net cost at enterprises of the chemical industry, start-up expenses estimates must anticipate expenditures on comprehensive testing of installed and individually-tested equipment, on its adjustment and on starting up production on a test-run basis. The start-up expenses estimate indicates the dates the start-up period begins and ends and the time needed to recompense those expenses. Start-up expenses are recompensed through current enterprise activity by writing them off to the net cost of output from the moment the facility is put into operation. The start-up expenses recompensation period must not exceed two years. During that time, start-up expenses are included in output net cost according to recompensation norms, which are set per unit of output based on the total estimated expenses, length of time needed to recompense them, and volume of commodity output in the planning year.

When several types of output are manufactured, start-up expenses for new production are distributed among them in proportion to the total basic wages of production workers.

The normative for writing off start-up expenses to net cost per unit of output can be represented as follows:

$$H_n = \frac{\Pi_p}{B_1 + B_2}, \quad (2)$$

where H_n is the normative for writing off start-up expenses per unit of output;

Π_p are estimated start-up expenses;

B_1 is output released in the year the facility is put into operation;

B_2 is output released in the period following the year of start-up until start-up expenses have been fully recompensed.

Output obtained in the test start-up of production which conforms to the established standards and specifications is sold, and the start-up expenses estimate is lowered by the amount received from the sale.

State-up expenses estimates are substantiated by appropriate calculations using as initial data: equipment composition, start-up and adjustment period, work front scheduled, motor energy expenditure normatives, rates, expenditure norms and prices for raw and other materials and fuel, equipment servicing norms, planned number of operating personnel, wage system. Start-up expenses estimates for new production are approved by the Ministry of Chemical Industry.

When drawing up draft plans by branch, the Ministry of Chemical Industry and its branch associations reflect the influence of start-up expenses on the net cost of output from new production, in which they indicate the amount of the start-up expenses, the period over which they are to be written off, the amount of commodity output, and start-up expenses per unit of capacity.

When calculating the new cost of output from newly operating production, start-up expenses are included in output net cost in the form of a complex item called "Expenses on Preparing and Utilizing Production."[1]

Related to this item are one-time expenditures made at an enterprise prior to the release of output and not being recompensed through capital expenditures. In addition to start-up expenses, the indicated item includes expenditures on pr paring production of new types of output. At those enterprises where the start-up and utilization periods are short and expenses are relatively low, they are included in "shop expenses."

Payment on agreements for specialized organization technical assistance to an enterprise in doing start-up and adjustment work is sometimes included in "general plant expenses."

Start-up expenses subject to write-off to output net cost in the planning year are reflected in enterprise technical-industrial financial plans.

Change in the output net cost level being planned due to start-up expenses can be expressed by the formula:

$$Э_c = \sum_{i=1}^{i=h} \left[\left(\frac{C_o}{B_o} - \frac{C_п}{B_п} \right) B_п \right] i, \tag{3}$$

where $Э_c$ is change in net cost due to start-up expenses;

C_o is total start-up expenses written off to net cost of i output in the reporting year, in rubles;

$C_п$ is total start-up expenses written off to net cost of i output in the planning year;

h is number of products-list positions;

B_o is volume of commodity release of i output in the reporting year in existing prices, in rubles;

$B_п$ is volume of commodity release of i output in the planning year.

That portion of start-up expenses not subject to recompensation in the current year, is applied to expenses in future periods, that is, to enterprise expenditures made in the reporting period, to those written off to output

----

1. "Osnovnyye polozheniya po planirovaniyu, ucheru proizvodstva i kal'kulirovaniyu sebestoimosti produktsii na promyshlennykh predpriyatiyakh" [Basic Provisions for Planning and Recording Production and Calculating Net Cost of Output at Industrial Enterprises], USSR Gosplan, Moscow, 1971.

net cost in time subsequent to the reporting period. Start-up expenses relate to enterprise circulating capital. In determining the normative of expenditures of future periods in a planning year, added to carry-over start-up expenses at the start of the year are anticipated additional expenditures on start-up and adjustment during the year, and that portion of the expenses subject to being written off to output net cost is deducted.

$$Н_{р.б.} = П_н + П_д - П_с, \qquad (4)$$

where $Н_{р.б}$ is the normative of expenses in future periods;

$П_н$ is the carry-over start-up expenses at the start of the year;

$П_д$ is additional expenditures on start-up and adjustment work during the year;

$П_с$ is that portion of start-up expenses subject to write-off to output net cost.

Change in carry-over expenses of future periods is reflected in the estimate of production expenditures, and an increase in them is deducted from the net cost of gross output or a decrease (as compared with the reporting period) is added, as is shown in Table 11.

Table 11. Example of Write-Off of Start-Up Expenses to Commodity Output Net Cost

(1) Показатели	(2) Производства	
	(3) карбамида	(4) серной кислоты
(5) Дата ввода предприятия в промышленную эксплуатацию	1 973	1 974
(6) Пусковые расходы по утвержденной смете, тыс. руб.	2 190	1 540
(7) Установленный срок списания пусковых расходов, месяцы	24	24
(8) Объем товарной продукции, на который предусматривается списание пусковых расходов, т	105 500	519 000
(9) Норма списания пусковых расходов на единицу продукции, руб.	20,75	2,96
(10) Объем товарной продукции, т:		
(11) а) по отчету 1973 г.	500	—
(12) б) ожидаемое выполнение плана 1974 г.	46 000	219 000
(13) в) проект плана 1975 г.	59 000	300 000
(14) Сумма списания пусковых расходов на себестоимость продукции:		
(11) а) по отчету 1973 г.	150	—
(12) б) ожидаемое выполнение 1974 г.	950	650
(13) в) проект плана 1975 г.	1 090	890

[Key on following page]

Key (to Table 11, preceding page):

1. Indicator
2. Production
3. Carbamide
4. Sulfuric acid
5. Date enterprise was put into industrial operation
6. Start-up expenses based on approved estimate, in 1,000 rubles
7. Established period for writing off start-up expenses, in months
8. Amount of commodity output for which start-up expenses write-off is anticipated, in tons
9. Start-up expenses write-off norm per unit of output, in rubles
10. Amount of commodity output, in tons
11. 1973 report
12. Anticipated 1974 plan fulfillment
13. 1975 draft plan
14. Total start-up expenses write-off to output net cost

In accordance with the CPSU Central Committee and USSR Council of Ministers Decree "On Economic Stimulation of Enterprises and Increasing Worker Material Interest in Creating and Introducing New Equipment," since 1965 the enterprise has been permitted to recompense expenditures associated with significant expenses on mastering individual production facilities through the new equipment utilization fund.

When production outlays for a newly operating facility exceed the cost of the output sold (in wholesale prices), start-up expenses are covered by the profitable operation of other sectors of the existing enterprise, which undoubtedly leads to a deterioration of technical-economic indicators as a whole.

Section 2. Shaping Start-Up Expenses

After the content of enterprise start-up estimates and existing methods orders and instructions have been examined, one might conclude that start-up expenses estimates include two groups of expenditures -- enterprise overheads in the start-up period, and payment for the services of specialized organizations called in by the enterprise for technical assistance in doing start-up and adjustment work.

Start-up expenses on new production capacities can be expressed by the formula:

$$C_{\text{пнр}} = \sum^{n} C_{\text{эр}} + \sum_{1}^{m} C_{\text{тп}}, \qquad (5)$$

where $C_{\text{пнр}}$ are enterprise expenditures on start-up and adjustment work

$C_{\text{эр}}$ are enterprise overheads in the start-up period for all expenditure elements (n)

$C_{\text{тп}}$ is the cost of technical assistance to the enterprise by specialized organizations for all start-up and adjustment work stages (m).

The relationship of enterprise overheads in the production start-up period to the cost of services specialized organizations render the enterprise as technical assistance in doing this work differs greatly, even for a number of similar types of production, as is evident from Table 12. It sometimes is determined by enterprise opportunities for financing these services and it often depends on subjective organizational factors which are displayed in how quickly specialized organizations are called in to do start-up and adjustment work. This is a question not of additional expenditures borne by the enterprise in calling in and paying for the services of specialized organizations, but of the quality of and time involved in performing start-up and adjustment work.

Table 12. Relationship of Enterprise Overheads in the Start-Up Period to the Expenditures of Specialized Organizations on Start-Up and Adjustment Work, By Individual Facility, in percent

Предприятия (1)	Эксплуатационные затраты предприятий в период пуска новых производств (2)	Затраты специализированных пусконаладочных организаций (3)
(4) Ровенский завод азотных удобрений	54,4	45,6
(5) Производство аммиака		
(6) Дзержинский химический комбинат		
(5) Производство аммиака	84	16
(7) Невинномысский химический комбинат		
(8) Производство аммиачной селитры	92	8
(9) Даугавпилсский комбинат химических волокон		
(10) Производство синтетических волокон	36,5	63,5
(11) Олайнский завод химических реактивов		
(12) Производство химических реактивов	86,5	13,5

Key:
1. Enterprise
2. Enterprise overheads in start-up period for new production
3. Expenditures of specialized start-up and adjustment organizations
4. Rovenskiy Nitrogen Fertilizers Plant
5. Ammonia production
6. Dzerzhinskiy Chemical Combine
7. Nevinnomysskiy Chemical Combine
8. Ammonium nitrate production
9. Daugavpilsskiy Chemical Fibers Combine
10. Production of synthetic fibers
11. Olaynskiy Chemical Reagents Plant
12. Chemical reagents production

The effectiveness of start-up and adjustment work is displayed in the observance of normative schedules for putting production into industrial operation and in the extent to which the quality of this work ensures stable operation during the mastering of production capacities.

The relationship among individual elements of enterprise operating expenditures during the start-up period depends on production features, expenditure norms for raw and other materials and energy, labor expenditures to produce output during the test start-up period, and the design complexity of the equipment and technology. The composition of start-up expenses based on start-up and adjustment work content is shown in Table 13.

Table 13. Start-Up Expenses Estimate Content

(1) Затраты	(2) Нормы расхода против проектных	(3) Назначение затрат
(4) Сырье и материалы*	1,2—1,3	(5) На заполнение систем На комплексное опробование на рабочих средах при пробном пуске
(6) Вода	1,2	(7) На заполнение емкостного оборудования при комплексном опробовании на нейтральных средах На двукратное заполнение трубопроводов На технологические цели при пробном пуске производства
(8) Энергия	1,8	(9) На обкатку оборудования при 72-часовой непрерывной работе На комплексное опробование оборудования на инертных и рабочих средах
		(10) На пробный пуск производства
(11) Заработная плата эксплуатационного персонала	1**	(12) В период комплексного опробования оборудования В период пробного пуска производства
(13) Пробная партия продукции	(14) До 20% итога	(15) До 10% годовой проектной мощности

[Key on following page]

Key (to Table 13, preceding page):

1. Expenditures
2. Expenditure norms to planned norms
3. Purpose of expenditures
4. Raw and other materials*
5. To fill systems; comprehensive testing in working media for test runs
6. Water
7. To fill tanks for comprehensive testing in neutral media; filling pipelines twice; for technological purposes during test runs
8. Energy
9. To test run equipment for 72 hours continuous operation; comprehensive equipment testing in inert and working media
10. Production test run
11. Operating personnel wages
12. In the comprehensive equipment testing period; in the production test run period
13. Output test lot
14. Up to 20 percent of the total
15. Up to 10 percent of annual planned capacity

(*) Up to 10 percent of total raw and other materials are used to charge systems, 50 percent for comprehensive testing in working media, and 40 percent for test start-up

(**) In connection with the uneven load during the start-up period, worker wages are set at the planned level.

On the basis of the above, we can formulate the content of individual elements of the operations portion of start-up expenses. Thus, start-up period expenditures on raw and other materials can be expressed by the formula:

$$M_{\text{п}} = \sum_{1}^{k} P_{\text{к}} K_{\text{м}} \Pi_{\text{у}} T_{\text{э}} + O_{\text{з}} N + O_{\text{з}}' N' K_{\text{o}}, \tag{6}$$

where $M_{\text{п}}$ is the expenditure of raw and other materials expended during start-up and adjustment work;

$P_{\text{к}}$ are expenditure coefficients for all raw and other material components expended (K) per unit of finished output;

$K_{\text{м}}$ is the coefficient of planned expenditure norm overrun during the start-up and adjustment period;

$\Pi_{\text{у}}$ is installation productivity, in tons per 24-hour period;

$T_{\text{э}}$ is production test operation period, in days;

$O_{\text{з}}$ is amount of raw material used to charge systems, in tons per unit of equipment;

$O_{\text{з}}'$ is amount of raw material used in comprehensive equipment testing, in tons per unit of equipment;

N is amount of tank-type equipment to be filled;

N' is amount of tank-type equipment to be comprehensively tested;

K_{o} is number of raw material circulations (recharges) to conduct comprehensive equipment testing.

Expenditures on energy during the start-up and adjustment period can be expressed by the formula:

$$Э_п = W T_o P_э П_у T_э, \quad (7)$$

where $Э_п$ is start-up period energy expenditure, in kW-hr;

W is total engine power, in kW-hr;

T_o is comprehensive equipment testing period, in hours;

$P_э$ is the energy expenditure norm per unit of finished output.

The wage expenditures for workers participating in production start-up can be determined using the formula:

$$З_{пл} = H_{об} N Ф_{ст} K_з T_п, \quad (8)$$

where $З_{пл}$ is worker wages in the start-up period;

$H_{об}$ is equipment servicing norms;

N is amount of equipment (work front);

$Ф_{ст}$ is average daily wage rate;

$K_з$ is the coefficient of wage rate overrun during the start-up period as a function of working conditions;

$T_п$ is the production start-up period, in days.

Hence, the operational portion of start-up expenses consists of the following basic expenditure elements:

$$C_{эр} = M_п Ц_м + Э_п Ц_т + З_{пл} + Ц_р, \quad (9)$$

where $Ц_м$ is the price of a unit of raw and other materials consumed, in rubles

$Ц_т$ is the rate per kW-hr, in rubles;

$Ц_р$ is shop expenses to support engineering-technical personnel taking part in production start-up, in rubles

Moreover, these expenses include other types of energy consumed: steam, water, inert gas to fill systems, which are used in starting up new production.

All the expenses expressed by these formulas relate to the first part of start-up expenses, operational ones.

The second portion of start-up expenses of newly operation production are those to pay for agreements with specialized organizations drawn into start-up and adjustment work. Under the agreement, a specialized organization takes it upon itself to render technical assistance in start-up and adjustment work to ensure preparation for start-up and the utilization of production capacities.

The cost of this work complex is determined by an Orgkhim price list which reflects the complexity of starting up new facilities. In the price list, work cost is determined based on total labor expenditures on starting up production and the "cost" cf a production administration specialist man-day according to the calculation.

The calculation indicates daily rates (in rubles) by position:

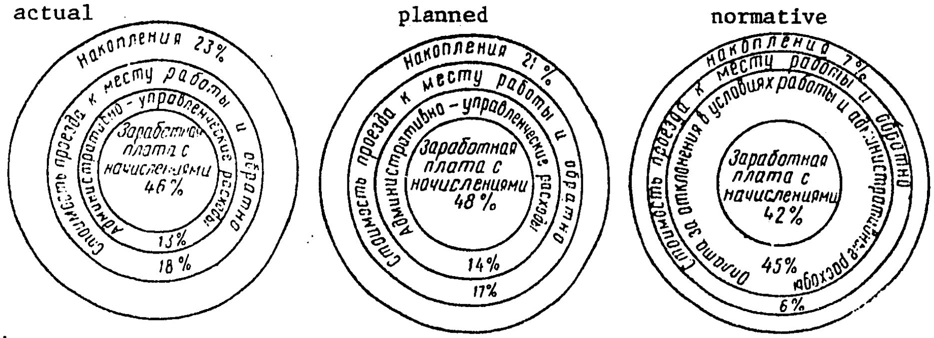
department head	8.39
technological sector chief	7.48
senior work producer	6.89
wing or installation chief	6.69
sector or shift chief	5.71
senior engineer	4.84
engineer	4.33
foreman	4.45
technician	3.62
instrument control person, mechanic, highly skilled worker	4.65

According to the Orgkhim price list, the basic wage of personnel participating in the start-up is 42 percent of the work cost (Figure 8). In addition to the basic wage, average monthly wages, according to the calculation, include (in percent):

engineering and technical worker bonuses to basic wages	30
worker bonuses to basic wages	25
payment for time en route and for organizational work	14
supplemental wages	7.8
per diems, apartment payments and training to start up new production (for start-up work at facilities in other cities)	14

Figure 8. Structure of Orgkhim Expenditures

actual planned normative



Key:

(outer, fourth, circle) Accumulations
(third circle) Cost of travel to and from job site
(second circle) Administrative-managerial expenses
(inner, first circle) Wages and supplements

General overheads comprise 23 percent of direct production start-up expenditures to which the wages of production-administrative personnel are related. With consideration of all expenditures, the average cost of a day is 16.43 rubles.

At the time the assignment is carried out, workers are awarded 50 percent of the bonus due, the remainder being paid after the work is complete. This system of awarding bonuses is aimed at preventing personnel turnover during the start-up of production. When start-up and adjustment work is done on facilities being built based on complex imported items, the cost of the work is adjusted by a factor of 1.2. Then start-up and adjustment work is done on production with prototype, unique basic equipment, a factor of 1.2 is used, and when work is done in the winter in unheated premises or open yards a factor of 1.1 is used. Orgkhim trust planned accumulations comprise seven percent of the work cost, according to the price list. In the price list, the cost of the work does not include operating expenses, which are borne by the enterprise during the start-up of production. The structure of Orgkhim expenditures on start-up and adjustment work are given for individual facilities in Table 14 [following page].

A temporary price list taking into account basic chemistry production start-up experience was drawn up for start-up and adjustment work being done by the Lenniigiprokhim UPNR [start-up and adjustment administration].

The estimated cost of start-up and adjustment work is determined based on the time scheduled to complete the work, the deployment of specialists, the number of specialists and the "cost of one man-day" based on Lenniigiprokhim UPNR calculations. According to the calculation, the transfer cost (D_3) of the work equals

$$D_3 = A \cdot 25.4 \cdot 2.6 \cdot 30.5 + 0.5 \cdot 30.5, \tag{10}$$

where A is the daily rate of a specialist, without consideration of travel expenses, which is used for the calculation;
25.4 is the average monthly number of work days;
2.6 is per diem;
30.5 is average number of calender days in a month;
0.5 is apartment payments.

Travel costs are taken into account supplementally. The basic wage according to the Lenniigiprokhim price list is 44.8 percent of the work cost.

Of the total work cost, according to the price list, the engineering supervision period accounts for 20 percent, the start-up period 60 percent and the utilization period 20 percent.

It follows from the above that specialized start-up and adjustment organization expenditures $C_{тп}$ can be expressed by the following formula:

$$C_{тп} = \left[\sum_{1}^{n} Ш_т AT_{п.н.р.} \left(1 + \frac{a_1 + a_2 + a_3 + a_4 + б}{100}\right) K_1 K_2 \frac{P}{100}, \tag{11}$$

Table 14. Actual Orgkhim Expenditures on Start-Up and Adjustment Work For a Number of Facilities Put Into Operation

(1) Предприятия	(2) Единица измерения	(3) Заработная плата производственного персонала	(4) Начисления на заработной плате	(5) Командировочные	(6) Организационная подготовка к пуску	(7) Накладные расходы	(8) Накопления	(9) Объем выполненных работ
(10) Гомельский суперфосфатный химический завод								
(11) Производства:								
(12) серной кислоты	(28) тыс. руб.	27	2,2	8,8	0,3	8	26,5	72,8
	%	37	3,1	12,1	0,4	11	36,4	100
(13) суперфосфата	тыс. руб.	27	2,4	11,4	0,6	8,9	13,1	63,4
	%	42,6	3,8	18	0,9	14	20,7	100
(14) Крымский завод двуокиси титана								
(15) Производство серной кислоты	тыс. руб.	51,3	14,4	6,1	0,9	14.8	47,2	134.7
	%	38,1	10,7	4,5	0,7	11	35	100
(16) Алмалыкский завод бытовой химии								
(17) Производство амофоса	тыс. руб.	113,9	10,3	53	2,5	34,4	19,8	233,6
	%	48	4,4	22,7	1,1	14,7	8,5	100
(18) Актюбинский химический комбинат								
Производства:								
(19) простого суперфосфата	тыс. руб.	26,1	2	10,7	0,7	8	7,5	55
	%	47,4	3,7	19,5	1,2	14,6	13,6	100
(20) гранулированного суперфосфата	тыс. руб.	40,4	2,5	15,8	5,0	10,5	34,25	108.45
	%	34	2,4	17,1	4,9	10	32,6	100
(21) Солигорский калийный комбинат								
(22) Производство калийных удобрений	тыс. руб.	17,4	1,7	5,5	—	5,1	6,8	36,97
	%	47	4,6	15	—	14	18,4	100
(23) Товары бытовой химии	тыс. руб.	44,3	3,8	19,4	—	14,4	31,35	113,2
	%	39,2	3,4	17,1	—	12,8	27,5	100
(24) Ангарский завод химических реактивов								
(25) Производство химреактивов	тыс. руб.	11,3	0,9	5,8	—	3,6	8	29,7
	%	38,2	3	19,8	—	12	27	100
(26) Невинномысский завод бытовой химии								
(27) Производство аэрозолей	тыс. руб.	24,9	2,1	14,1	—	8	6,1	55,2
	%	45	3,8	25,6	—	14,5	11,1	100

[Key on following page]

Key (to Table 14, preceding page):
1. Enterprise
2. Unit of measure
3. Production personnel wages
4. Wage supplements
5. Travel expenses
6. Organization preparation for start-up
7. General overheads
8. Accumulations
9. Amount of work done
10. Gomel'skiy Superphosphate Chemical Plant
11. Production:
12. Sulfuric acid
13. Superphosphate
14. Krymskiy Titanium Dioxide Plant
15. Sulfuric acid production
16. Almalykskiy Household Chemicals Plant
17. Ammophos production
18. Aktyubinskiy Chemical Combine
19. Simple superphosphate
20. Granular superphosphate
21. Soligorskiy Potassium Combine
22. Production of potassium fertilizers
23. Household chemicals
24. Angarskiy Chemical Reagents Plant
25. Production of chemical reagents
26. Nevinnomysskiy Household Chemicals Plant
27. Production of aerosols
28. 1,000 rubles

where $Ш_т$ is the number of engineering-technical workers participating in start-up and adjustment work, by occupation (n);

A is the daily rate for a specialist;

$T_{п.н.р}$ is the start-up and adjustment period

a_1 is bonuses;

a_2 is moving and work organization expenses;

a_3 is additional wages;

a_4 is per diem, apartment payments, and so on;

$б$ are general overheads;

K_1 is the equipment complexity factor;

K_2 is the working conditions factor;

P is planned accumulations, in percent.

The entire complex of start-up and adjustment work done by Orgkhim administrations is determined by a program (Table 15) in which the list and cost of work stages are indicated for a newly operating facility. A work program is developed for a specific production facility of a prescribed capacity and anticipates the work to be done by Orgkhim specialists during the engineering supervision, start-up and utilization periods, taking into account their duration and labor intensiveness. The work program for individual facilities is the basis for the price list developed by the Orgkhim for start-up and adjustment work.

Table 15. Work and Cost Program for a Facility to Produce 120,000 Tons of Weak Nitric Acid Per Year at a Pressure of 7.3 Atmospheres

(1) № п. п.	(2) Этапы	(3) Стоимость работ, руб.	Этапы работ в % к общему объему (4)
1	(5) Рассмотрение проектной технической документации	2028	3,9
2	(6) Надзор за выполнением строительно-монтажных работ и их очередность в соответствии с проектом	4786	9,1
3	(7) Инженерный контроль при выполнении монтажа отдельных агрегатов	1522	2,9
4	(8) Выявление дополнений к проекту в процессе монтажа	1622	3,1
5	(9) Осмотр и проверка оборудования с составлением дефектных ведомостей	1873	3,6
6	(10) Разработка технических планов пуска и графиков пусконаладочных работ	1015	1,9
7	(11) Руководство работами технологического оборудования, арматуры, запорных устройств	1135	2,1
8	(12) Подготовка эксплуатационной документации	4655	8,9
9	(13) Подготовка и обучение эксплуатационного персонала	3818	7,3
10	(14) Подготовка оборудования к сдаче его Горгостехнадзору с оформлением соответствующей документации	1083	2,1

[Continued on following page]

Table 15 (continued from preceding page)

11	(15) Надзор за опрессовкой оборудования и коммуникаций и разработка схем установки заглушек	1135	2,2
12	(16) Инженерный контроль при индивидуальном испытании оборудования вхолостую	3602	6,9
13	(17) Подготовка оборудования к пуску на рабочих средах. Пробный пуск одной технологической нитки производства по инструкции	6474	12,4
14	(18) Наладка технологического режима	8245	15,7
15	(19) Определение фактической производственной мощности	2879	5,5
16	(20) Разработка мероприятий и выдача рекомендаций по улучшению технологического режима	392	0,7
(21)	Итого пусковой период	46 264	88,4
17	(22) Разработка технической документации	2028	3,9
18	(23) Обеспечение вывода производства на проектную мощность и контроль за выполнением выданных рекомендаций	3042	5
19	(24) Надзор за работой объекта на проектной мощности в соответствии с нормами времени непрерывной работы	1014	1,9
(25)	Стоимость всего комплекса работ	52 348	100

Key:

1. Number, in sequence
2. Stage
3. Work cost, in rubles
4. Work stage, in percent of total amount
5. Reviewing technical planning documentation
6. Supervising construction-installation work and work sequence according to the plan
7. Engineering supervision of installation of individual units
8. Revealing supplements to the plan during the installation process

[Key continued on following page]

(Key to Table 15, continued from preceding page)

9. Inspecting and checking equipment, drawing up notices of defects
10. Developing technical start-up plans and schedules for start-up and adjustment work
11. Supervising operation of technological equipment, fittings and shut-off installations
12. Preparing operations documentation
13. Training and preparing operating personnel
14. Preparing equipment for release to the Gorgostekhnadzor [not further identified] and drawing up the appropriate documentation
15. Supervision of equipment and utilities pressure testing and development of seal plans
16. Engineering supervision during individual equipment testing at idle
17. Equipment preparation for operation in working media, test release of one technological thread in accordance with the instruction
18. Adjusting the technological conditions
19. Determining actual production capacity
20. Developing measures and issuing recommendations on improving technological conditions
21. Total for start-up period
22. Development of technical documentation
23. Ensuring that production reaches planned capacity and monitoring carrying out of recommendations made
24. Supervision of facility operation at planned capacity in accordance with norms for continuous operation
25. Cost of entire work complex

The price list covers branches of the chemical industry. It determines the cost of having a complex of start-up and adjustment work done by branch and specialized production administrations of the Orgkhim (Table 16) [following page]. The cost of work not indicated in the price list is taken for similar production.

The price list anticipates that work will be done under the following conditions:

a) technological equipment must be installed in accordance with the plan and its condition must conform to the rules and norms of technical operation;

b) the customer submits all the necessary materials, raw materials, energy resources in conformity in quantity and quality to the plan and also allocates operating personnel.

The price list reflects only the cost of the technological portion of the facility and does not anticipate payment for start-up and adjustment work on ventilation systems, check and test points and automatic machinery, refrigeration units, electrical equipment or water purification facilities.

The cost of work on auxiliary systems is determined in other price lists. Thus, the adjustment of mechanical technological equipment is based on a

Table 16. Cost of Start-Up and Adjustment Work at Operating Production Facilities of the Chemical Industry (using the Orgkhim price list)

(1) Отрасли промышленности	(2) Годовая мощность, тыс. т	(3) Стоимость пуско-наладочных работ, тыс. руб.	(4) Долевое соотношение по этапам, %		
			(5) инженерный надзор	(6) период пуска	(7) период освоения мощностей
(8) Азотная					
(9) Производство:					
(10) аммиака	100	198	50	37	13
(11) карбамида	180	135,5	58,5	29,5	12
(12) Основной химии					
(9) Производство:					
(13) двойного суперфосфата	350	82	32	55	13
(14) гранулированного аммофоса	400	72	37	48	15
(15) Химических волокон					
(16) Производство вискозного корда	17	310	41,5	45	13,5
. . . .					
. . . .					

Key:
1. Branch of industry
2. Annual capacity, in 1,000 tons
3. Cost of start-up and adjustment work, in 1,000 rubles
4. Proportion, by stage, in percent
5. Engineering supervision
6. Start-up period
7. Utilization period
8. Nitrogen
9. Production:
10. Ammonia
11. Carbamide
12. Basic chemistry
13. Compound superphosphate
14. Granular ammophos
15. Chemical fibers
16. Viscose cord production

price list worked out by the TsPKB Glavmontazh [Central Planning and Design Bureau of the USSR Main Administration for Installation Work] and approved by the USSR Gosstoy on 11 July 1969; heat-engineering equipment -- in accordance with RSFSR Gosplan Price List No 260.501; automatic devices and machinery -- in accordance with a price list approved by the USSR Gosstroy on 1 April 1969; electric power engineering equipment -- in accordance with a price list approved by the USSR Gosstroy on 1 January 1969; ventilation systems -- in accordance with a price list from the State Committee for Construction Affairs (USSR Gosstoy), approved on 1 April 1969. With consideration of the start-up of auxiliary systems, the factor by which the cost of start-up and adjustment work on the technological portion of newly operating facilities increases averages 1.7 to 2.3. This ratio can be traced using the data given in Table 17.

Table 17. Cost of Start-Up and Adjustment Work for Enterprise Basic and Auxiliary Systems (data from Lenniigiprokhim UPNR)

(1) Состав пусконаладочных работ	(2) Производство триполифосфата натрия	(3) Производство желтого фосфора	(4) Производство двойного суперфосфата	(5) Производство гидрата окиси бария и углекислого бария	(6) Удельный вес в общей стоимости ПНР стоимости основных и вспомогательных участков производства в %
(7) Общая стоимость пусконаладочных работ (ПНР), тыс. руб.	966,5	920	2532	220,6	100
(8) В том числе:					
(9) 1. Технологическая часть	212,8	261,5	1465,9	99,7	45,3
(10) 2. Механическая часть	253,8	264,9	612,5	81,6	27
(11) 3. Теплотехническая часть	116	39,2	72,5	8,3	5,2
(12) 4. Вентиляционная часть	27,5	108,9	315	—	10
(13) 5. Электротехническая часть	215,1	—	—	8,5	5
(14) 6. Химическая водоочистка	24,6	—	—	—	0,5
(15) 7. КИП и автоматика	86,5	139,8	65,9	22,4	7

Key:

1. Composition of start-up and adjustment work
2. Potassium tripolyphosphate production
3. Phosphorous production
4. Compound superphosphate production
5. Production of barium hydroxide and barium carbonate
6. Proportion of cost of basic and auxiliary production sectors in total cost of PNR, in percent
7. Total cost of start-up and adjustment work (PNR), in 1,000 rubles
8. Including:
9. Technological portion
10. Mechanical portion
11. Heat-engineering portion
12. Ventilation portion
13. Electrical engineering portion
14. Chemical water purification
15. Check and test points and automatic machinery

Based on the above, start-up expenses are enterprise operating expenses in the start-up period and the cost of technical services rendered by specialized organizations on start-up and adjustment work on basic production, with consideration of cost increases for services to start-up auxiliary systems of the facility being put into operation, K_a. Start-up expenses can be decreased by the cost of output suitable for sale which is manufactured during the start-up period, $B_п$.

$$C_{п.н.р.} = \left[\sum_{1}^{n} C_{эр} + \left(\sum_{1}^{m} C_{тн}\right) K_a\right] - B_п. \qquad (12)^*$$

Thus, start-up expenses are expenditures to prepare capacities for release for full-time industrial operation. The start-up expenses estimate must be drawn up in the planning stage. Start-up expenses include enterprise operating expenditures during the production start-up period and technical assistance by specialized start-up and adjustment organizations. They are recompensed after the facility has been put into operation through its current activity.

Having examined the composition of start-up expenses, how they are shaped and the sources for recompensing them, we can move on to analyzing actual expenditures (total and specific) on the start-up of various types of chemical industry production: comparing with expenditures on capital construction and with equipment cost, tracing the degree to which they influence the net cost and profitability of new production.

Section 3. Expenditures of the Start-Up Period

In this section, we examine start-up expenses for newly operating facilities which are accepted as the basis for enterprise estimates and Ministry of Chemical Industry reporting, which reflects the influence of expenditures on putting new enterprises and individual production facilities into operation on output net cost.

The initial data have been systematized, processed and are given in tables which reflect expenditures on the start-up and adjustment of specific production, their weighted-mean values per unit of capacity, and norms for writing off start-up expenses to the net cost of a unit of output.

Specific start-up expenses (in rubles) per unit of capacity, derived from a generalization of data from similar production, are:

Industry:		Production:	
mining chemistry	up to 2.7	extruded plastic items	up to 327
basic chemistry	up to 14	lacquers and dyes	up to 403
nitrogen	up to 95	chemical fibers	up to 516
plastics and resins	up to 165	chemical reagents	up to 1154

----

*See formula (5) for key.

In connection with the existing system of recompensing start-up expenses over a two-year period following start-up of the facility through enterprise activity, the expenditure write-off norms set for newly operating production are 1.5- to two-fold lower than their specific values per unit of capacity. Comparison shows that the proportion of start-up expenses under the recompensation norms relative to net cost per unit of output reach 3.5 to 30 percent in various types of production facility, as is evident from Table 18.

Table 18. Proportion of Start-Up Expenses in Net Cost of a Unit of Output at Newly Operating Production Facilities

(1) Предприятия	(2) Себестоимость продукции, руб.	(3) Пусковые расходы по нормам списания на себестоимость, руб/т	(4) Удельный вес пусковых расходов в себестоимости продукции, %
(5) Ионавский завод азотных удобрений			
(6) Карбамид	122,6	7,14	5,8
(7) Навоийский химкомбинат			
(8) Аммиачная селитра	61,58	2,13	3,5
(9) Сокальский завод химического волокна			
(10) Вискозное штапельное волокно	1724	241,6	14
(11) Энгельский комбинат химических волокон			
(12) Ацетилцеллюлоза	2321	695	30
(13) Калужский химико-металлургический комбинат			
(14) Полиэтилен	431	60	13,8

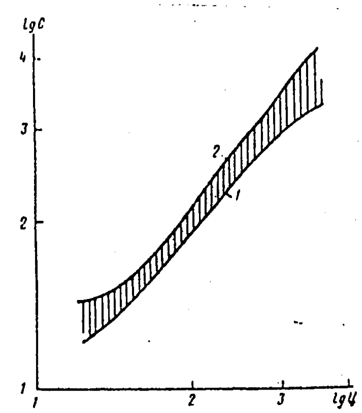
Key:
1. Enterprise
2. Output net cost, in rubles
3. Write-off norm start-up expenses to net cost, in rubles per ton
4. Start-up expenses as a proportion of output net cost, in percent
5. Ionavskiy Nitrogen Fertilizers Plant
6. Carbamide
7. Navoiyskiy Chemical Combine
8. Ammonium nitrate
9. Sokal'skiy Chemical Fiber Plant
10. Viscose staple fiber
11. Engel'skiy Chemical Fiber Combine
12. Cellulose acetate
13. Kaluzhskiy Chemical-Metallurgical Combine
14. Polyethylene

The total start-up expenses subject to write-off in a year is 1.5 to 14 percent of the net cost of enterprise commodity output released.

This is to be explained by the partial recompensation of expenditures associated with the start-up of new production, through the assortment of output of existing production.

It is not a matter of indifference to the enterprises that the proportion of start-up expenses in commodity output net cost at the moment production is put into operation is so considerable, since expenditures per ruble of commodity output during this period exceed the established price level 1.2- to 2.2-fold, which considerably postpones the time of economic mastering of the economic indicators of the new production. The gap between level of average branch output net cost and the net cost of output by new production is shown in Figure 9.

Figure 9. Deviation of Net Cost Value for Output of Newly Operating Production from Average Branch Net Cost



Key:
1. Branch-average net cost
2. Output net cost at moment of start-up

When comparing specific start-up expenses and the net cost of a unit of output we can establish that specific start-up expenses are also high for the most expensive types of output. For example, specific start-up expenses for ammonium are 14.6 rubles, given a net cost of 77.7 rubles; for plastic items -- 366.6 rubles, given a net cost of 1,659.8 rubles per ton; for acetate silk -- 412 rubles, given a net cost of 3,890.5 rubles per ton.

Thus, production features, their materials- and energy-intensiveness, and labor expenditures, help shape expenditures in the test-run period of production, as well as during enterprise operating activity. This interrelationship can be traced using correlation analysis of indicators.

In order to reveal the nature of start-up expenses as expenses necessary to bring installed capacities up to full operating readiness, it is of interest to compare them with capital expenditures. As is shown in Table 19 (following page), start-up expenses comprise 30-45 percent of capital expenditures, averaging 20 percent. The initial data for the comparison were the capital expenditures for individual types of production indicated in SNiP III-A.3-57, specific capital investment normatives approved by the USSR Gosstroy, and the "Reference Materials and Normatives for Methods of Determining Economic Effectiveness" developed by the All-Union Scientific Research and Design Institute of Chemical Machine Building.

That this proportion of start-up expenses relative to capital investments is so high is confirmed by the considerable expenditures enterprises bear in putting a facility into operation. Start-up expenses for newly operating production are 2-6 million rubles. Deviations in facility start-up expenditures can be explaned by the influence of a whole series of factors:

work organization during the period of start-up and adjustment work;

complexity of equipment and technology set-up;

sequence in which facilities are put into operation and the write-off of start-up expenses as anticipated by the estimate for one of the facilities being put into operation;

lack of normatives enabling the enterprise being planned to control the size of start-up expenses.

Along with this, the cost of start-up and adjustment work being done by the Orgkhim for individual production facilities is 100,000 to 500,000 rubles. And actual Orgkhim expenditures are tending to decrease as compared with work cost according to the price list. The proportion of Orgkhim expenditures in enterprise start-up expenses for production facilities are up to 30 percent (Table 20) [second page following]. It should be noted that enterprises do not always use the technical assistance of specialized start-up and adjustment organizations, so this figure is lower for the branch as a whole.

As start-up expenses increase, the proportion of start-up and adjustment work in them decreases. Thus, given start-up expenses of six million rubles for a facility, the proportion of expenditures for start-up and adjustment work is one percent; five million -- five percent; two million -- 10 percent; one million -- 20 percent. This is to be explained by the fact that start-up expenses differ significantly in their operating portion for the different types of production, more so than do Orgkhim expenditures.

Relative to capital expenditures on individual types of chemical industry production, expenditures on start-up and adjustment work are 0.6 to 2.7 percent, as is shown in Table 21 [fourth page following]. According to the calculations given, start-up expenses account for 16 to 450 rubles per 1,000 rubles of capital expenditures and expenditures on start-up and adjustment work account for three to 26 rubles per 1,000 rubles of capital expenditures.

Table 19. Specific Start-Up Expenses in Chemical Industry

(1) Отрасли химической промышленности	(2) Величина пусковых расходов на 1000 руб. капитальных вложений, руб.	(3) Затраты на единицу мощности пусковых расходов руб/т	(4) Доля пусковых расходов по отношению к капитальным вложениям, %
(5) **Азотная**			
(6) *Производство:*			
(7) аммиака	146	14,6	14,6
(8) слабой азотной кислоты	77	3,85	7,7
(9) аммиачной селитры	194	3,1	19,4
(10) ацетилена	93	59,4	9,3
(11) уксусной кислоты	209	19,2	20,9
(12) **Основной химии**			
Производство:			
(13) простого суперфосфата	45,4	0,74	4,54
(14) двойного суперфосфата	16,6	0,6	1,66
(15) гранулированного аммофоса	45	2,35	4,5
(16) сложных уравновешенных удобрений	450	5,9	45
(17) фосфорной кислоты	91	2,2	9,1
(18) желтого фосфора	163	73,2	16,3
(19) **Химические волокна**			
Производство:			
(20) вискозного штапельного волокна	211	272,5	21,1
(21) вискозного шелка	207	1425	20,7
(22) ацетатного шелка	77	412	7,7
(23) синтетического шелка	67	286	6,7
(24) **Пластические массы и их переработка**			
Производство:			
(25) ацетилцеллюлозы	459	918,7	45,9
(26) поливинилацетатной дисперсии	73	22	7,3
(27) карбамидных смол	285	85,4	28,5
(28) капролактама	68,5	128	6,85
(29) двуокиси титана	245	406	24,5

Key:

1. Branch of chemical industry
2. Start-up expenses per 1,000 rubles of capital investment, in rubles
3. Expenditures per unit of capacity started up, in rubles per ton
4. Proportion of start-up expenses relative to capital investments, in percent

[Key continued on following page]

Key (to Table 19, continued from preceding page):

5. Nitrogen
6. Production
7. Ammonia
8. Weak nitric acid
9. Ammonium nitrate
10. Acetylene
11. Acetic acid
12. Basic chemistry
13. Simple superphosphate
14. Compound superphosphate
15. Granular ammophos
16. Complex balanced fertilizers
17. Phosphoric acid
18. Phosphorous
19. Chemical fibers
20. Viscose staple fiber
21. Viscose silk
22. Acetate silk
23. Synthetic silk
24. Plastics and their processing
25. Cellulose acetate
26. Polyvinylacetate dispersion
27. Carbamide resins
28. Caprolactam
29. Titanium dioxide

Table 20. Orgkhim Start-Up and Adjustment Work Expenditures Relative to Enterprise Start-Up Expenses

(1) Отрасли химической промышленности	(2) Величина затрат на пуск производства на 1 тыс. руб. капитальных вложений (в руб.)		(5) Доля затрат Оргхима в пусковых расходах предприятий
	(3) по предприятиям	(4) Оргхима	
(6) Азотная			
(7) *Производство:*			
(8) аммиака	146	17,2	12
(9) слабой азотной кислоты	77	9,9	12,9
(10) ацетилена	93	12	5
(11) уксусной кислоты	209	26,6	12,7
(12) Основная химия			
(7) *Производство:*			
(13) простого суперфосфата	45,4	6,3	14
(14) двойного суперфосфата	16,6	6,5	39,2
(15) аммофоса	45	3,4	7,6
(16) сложных уравновешенных удобрений	450	13,6	3
(17) фосфорной кислоты	91	11,7	12,9
(18) Химические волокна			
(7) *Производство:*			
(19) капронового шелка	67	18,5	27,7
(20) ацетатного »	77	7,5	9,8
(21) вискозного штапельного волокна	211	15	7,1
(22) Пластические массы и их переработка			
(7) *Производство:*			
(23) ацетилцеллюлозы	459	7	1,5
(24) поливинилацетатной дисперсии	73	12	16,5
(25) карбамидных смол	285	10	3,5

[Key on following page]

Key (to Table 20, preceding page):

1. Branch of chemical industry
2. Production start-up expenditures per 1,000 rubles in capital investment (in rubles)
3. By enterprises
4. By the Orgkhim
5. Proportion of Orgkhim expenditures in enterprise start-up expenses
6. Nitrogen
7. Production
8. Ammonia
9. Weak nitric acid
10. Acetylene
11. Acetic acid
12. Basic chemistry
13. Simple superphosphate
14. Compound superphosphate
15. Ammophos
16. Complex balanced fertilizers
17. Phosphoric acid
18. Chemical fibers
19. Capron silk
20. Acetate silk
21. Viscose staple fiber
22. Plastics and their processing
23. Cellulose acetate
24. Polyvinylacetate dispersion
25. Carbamide resins

Thus, start-up expenses have a significant influence on the net cost of new production output, causing production outlays to exceed the cost of output sold. Certain difficulties arise at the very outset of facility functioning.

The increase in start-up expenses occurs foremost through the operating portion of their expenditures. Specialized organization services in starting up production must be viewed as the rendering of necessary /skilled/ assistance by personnel with adequate work experience at similar facilities.

The assistance of specialized organizations in starting up production well facilitates reducing the time capital investments must be diverted from circulation and accelerating receipt by the national economy of needed consumer valuables.

In order to draw a conclusion as to the closeness with which individual indicators are linked and to recommend normatives for start-up expenses for different types of production, we need to make a special analysis of actual data.

Section 4. Correlation Analysis of Indicators of Start-Up Expenses

Economic research makes extensive use of mathematical methods to examine economic phenomena not in isolation, but interlinked, in order to draw scientific and practical conclusions. A large section of mathematical statistics is concerned with correlation theory, which is used to analyze interconnections among values given the influence of numerous factors.

The use of correlation theory in resolving the tasks of substantiated forecasting consists in finding the limits within which the value interesting us is contained if other values associated with it are given certain values.

Table 21. Specific Start-Up and Adjustment Work Expenditures in Chemical Industry (using Orgkhim normatives)

(1) Отрасли химической промышленности	(2) Стоимость пуско-наладочных работ на 1000 руб. капиталовложений, руб.	(3) Затраты на единицу мощности, руб/т	(4) Доля пусконаладочных работ к капиталовложениям, %
(5) **Азотная**			
(6) *Производство:*			
(7) аммиака	17,2	1,66	1,7
(8) слабой азотной кислоты	9,9	0,47	1
(9) уксусной кислоты	26,6	2,47	2,7
(10) ацетилена	12	7,67	1,2
(11) **Основная химия**			
(6) *Производство:*			
(12) двойного суперфосфата	6,5	0,24	0,65
(13) гранулированного аммофоса	3,4	1,78	0,34
(14) сложных уравновешенных удобрений	13,6	0,18	1,4
(15) сернистого натрия	26,4	2,64	2,6
(16) нитрита аммония	13,7	0,89	1,37
(17) желтого фосфора	14	6,6	1,4
(18) фосфорной кислоты	11,7	0,45	1,17
(19) триполифосфата натрия	10	0,66	1
(20) **Химические волокна**			
(6) *Производство:*			
(21) капронового шелка	18,5	78,8	1,85
(22) ацетатного шелка	7,5	40,5	0,65
(23) штапельного волокна	15,1	60,5	1,5
(24) **Пластмассы и их переработка**			
(6) *Производство:*			
(25) полиэтилена высокого давления	5,4	2,75	0,6
(26) ацетилцеллюлозы	7	14	0,7
(27) винилацетата	14,1	5,14	1,4
(28) поливинилацетатной дисперсии	12	3,6	1
(29) карбамидных и фенолформальдегидных смол	10	2,5	1
(30) калийных удобрений	6,8	0,1	0,7

Key:
1. Branch of chemical industry
2. Cost of start-up and adjustment work per 1,000 rubles in capital investment, in rubles
3. Expenditures per unit of capacity, in rubles per ton
4. Start-up and adjustment work as a percentage of capital investment

[Continued on following page]

(Key to Table 21, continued from preceding page):

5. Nitrogen
6. Production of:
7. Ammonia
8. Weak nitric acid
9. Acetic acid
10. Acetylene
11. Basic chemistry
12. Compound superphosphate
13. Granular ammophos
14. Complex balanced fertilizers
15. Sodium sulfide
16. Ammonium nitrite
17. Phcsphorous
18. Phosphoric acid
19. Sodium tripolyphosphate
20. Chemical fibers
21. Capron silk
22. Acetate silk
23. Staple fiber
24. Plastics and their processing
25. High-pressure polyethylene
26. Cellulose acetate
27. Vinyl acetate
28. Polyvinylacetate dispersion
29. Carbamide and phenol-formaldehyde resins
30. Potassium fertilizers

Correlation methods enable us, in particular, to determine a numerical value for start-up expenses in various types of chemical industry production based on their interrelationships with other indicators.

Correlation links are not cause-and-effect, but probabilities in which the connection between values is displayed in the fact that one of them reacts to change in another by changes in its own law of distribution. This provides an opportunity for revealing the distribution of values in combination with each other. In this section, we examine the interrelationship between start-up expenses and the "cost" of start-up and adjustment work and capital investments in individual types of production, as well as with output net cost. We examine the closeness of this connection and change in indicators by branch of the chemical industry in accordance with the indicated values.

The fact that there is a functional dependence between the values and the form of the connection were established on the basis of correlation tables and a correlation field.

The form of the connection was studied by obtaining on a graph an empirical regression line showing change in y as a function of x (argument function). The process of finding a theoretical regression line is commonly called straightening the empirical regression line. The type of curve was chosen based on the outward appearance of the empirical regression graph, which is curvilinear or rectilinear.

Proceeding from the proposition that the regression line is rectilinear, it is calculated using a straight-line equation:

$$y_x = a + bx. \tag{13}$$

Given a curvilinear function, it has the form of a parabolic curve

$$y_x = a + bx + cx^2, \tag{14}$$

where a, b and c are the parameters being defined.

Calculating the equation parameters enabled us to find a theoretical regression line. To determine the unknown parameters, we used the method of least squares, in which we had to meet the condition that the sum of the squares of correlation field point deviations from the line adopted must be minimal:

$$\sum_{i=1}^{n} (y - \bar{y}_x)^2 = \min. \qquad (15)$$

We calculated a theoretical regression line from the terms of the least squares and determined coefficients in the equation given above by solving a system of normal equations:

$$\Sigma y_i = na + b\,\Sigma x_i;$$
$$\Sigma x_i y_i = a\,\Sigma x + \Sigma x_i^2, \qquad (16)$$

where n is the size of the sample.

We determine values a and b using the following formulas:

$$a = \bar{y} - b\bar{x} = \frac{\Sigma x^2\, \Sigma y - \Sigma x\, \Sigma x y}{n\,\Sigma x^2 - (\Sigma x)^2}; \qquad (17)$$

$$b = \frac{n \Sigma xy - \Sigma x \Sigma y}{n \Sigma x^2 - (\Sigma x)^2}. \qquad (18)$$

We adopted a correlation factor as criteria of the degree of proximity of the correlation bond to a linear function

$$r_{xy} = \pm \frac{n \Sigma xy - \Sigma x\, \Sigma y}{\sqrt{n\,\Sigma x^2 - (\Sigma x^2)}\ \sqrt{n\,\Sigma y^2 - (\Sigma y)^2}} \qquad (19)$$

We accept a bond closeness as being satisfactory if $r_{xy} > 0{,}5$.

Using the methods given, we can study the connection between start-up expenses and capital expenditures.

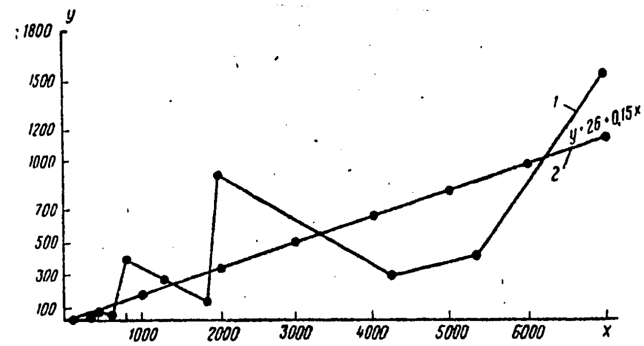
In order to do this, we must establish the forms and type of correlation dependence between start-up expenses y and capital expenditures x , assuming that

$$y = f|x|. \qquad (20)$$

Based on the data from Table 19, above, we set up a graph (Figure 10, page following). The form of the correlation field indicates the possibility of assuming a linear function. After compiling a computer program, we determine regression curve parameters, which are:

$$a = 25{,}927;$$
$$б = 0{,}147.$$

Figure 10. Graph of Dependence of Start-Up Expenses and Capital Expenditures



Key:
- y -- start-up expenses (rubles per ton)
- x -- capital expenditures (rubles per ton)
1. empirical regression line
2. theoretical regression line

The theoretical regression line equation showing the dependence of start-up expenditures and capital expenditures takes the form:

$$y = 25,927 + 0,147x. \qquad (21)$$

We then determine the degree of closeness of the bond using a correlation factor:

$$r_{xy} = 0,799.$$

However, in view of the large gap between indicators for different chemical industry production, in order to derive the most characteristic form of bond for the individual branches, all production was distributed into three groups whose indicators are within the following limits, in 1,000 rubles:

1) $10 \leqslant K \leqslant 100$;

2) $100 \leqslant K \leqslant 1000$;

3) $1000 \leqslant K \leqslant 7000$.

For the first group of production facilities, the theoretical regression line equation takes the form

$$y = -1,59 + 0,168x. \qquad (22)$$

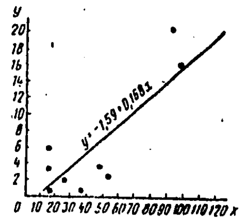
For the second group of production facilities, the theoretical regression line equation found for the chemical branch of industry as a whole [equation (21)] is characteristic.

For the third group of production facilities, the theoretical regression line equation takes the form

$$y = 85{,}8 + 0{,}13x. \tag{23}$$

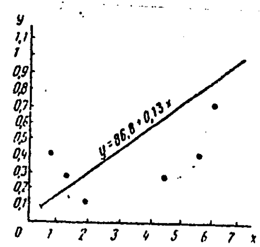
The interconnection of the indicators is represented graphically in Figures 11 and 12. The equations were used to find theoretical start-up expenses normatives for individual types of chemical industry production.

Figure 11. Function of Start-Up Expenses to Capital Expenditures



Key:
y -- start-up expenses; x -- capital expenditures $(10 \leqslant 10 \leqslant 100)$

Figure 12. Function of Start-Up Expenses to Capital Expenditures



Key:
y -- start-up expenses; x -- capital expenditures $(1000 \leqslant K \leqslant 700)$

Changes in expenditures of the start-up period in accordance with change in capital investments (in 1,000 rubles) are given in the chart at the top of the following page.

Research has shown that as the start-up expenses value increases, the correlation connection between them and capital investment values decreases.

Thus, for the third group $r_{xy}=0{,}35$. This testifies to the fact that, along with equipment complexity, production features also shape start-up expenses: materials- and energy-intensiveness, complexity of the technological process. The necessity therefore arises of tracing the connection between start-up expenses and output net cost.

Капитальные вложения (1)	10	50	100	500	1 000	2 000	3 000	4 000	5 000
Пусковые расходы (2)	1	6,8	15,2	101	176	346	476	606	736
Затраты на пусконаладочные работы (3)	0,47	0,7	1,55	6,35	12,35	24,35	36,35	49,35	60,35

Key:

1. Capital investments
2. Start-up expenses
3. Expenditures on start-up and adjustment work

A closer interconnection has been established between capital investments in individual chemical industry production types and expenditures on Orgkhim start-up and adjustment work. Based on calculations using data given in Table 21, the theoretical regression line parameters are as follows:

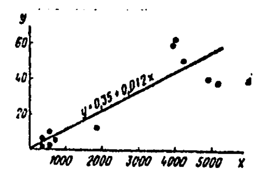
$$a = 0{,}348;$$
$$б = 0{,}012.$$

The theoretical regression line equation showing the dependence of start-up and adjustment work cost and capital expenditures takes the form

$$y = 0{,}35 + 0{,}012x. \qquad (24)$$

Empirical and theoretical regression lines for start-up and adjustment work cost and capital investments are represented graphically in Figure 13.

Figure 13. Dependence of Start-Up and Adjustment Work Cost and Capital Expenditures



Key:
y -- start-up expenses; x -- capital expenditures

The correlation coefficient determining the closeness of the bond between these indicators is high,

$$r_{xy} = 0{,}91.$$

Using research data, we derive theoretical start-up and adjustment work cost normatives and set them relative to the derived theoretical start-up expenses (Table 22).

Table 22. Theoretical Normatives of Start-Up Expenses and Expenditures on Start-Up and Adjustment Work (in rubles per ton)

(1) Производства химической промышленности	(2) Пусковые расходы на единицу производственной мощности	(3) Затраты на пусконаладочные работы
(4) Сложные удобрения	0,6	0,5
(5) Аммиачная селитра	1,1	0,54
(6) Простой суперфосфат	1,2	0,54
(7) Фосфорная кислота	2,5	0,64
(8) Двойной суперфосфат	4,5	0,69
(9) Слабая азотная кислота	5,4	0,92
(10) Гранулированный аммофос	6,2	0,98
(11) Нитрит аммония	9,83	1,13
(12) Уксусная кислота	13,9	1,45
(13) Синтетические моющие средства	14,7	1,51
(14) Аммиак	15,2	1,55
(15) Лаки и краски	23,6	2,15
(16) Карбамидные смолы	70	3,95
(17) Полиэтилен высокого давления	100	6,35
(18) Ацетилен	120	8,03
(19) Вискозное штапельное волокно	254	15,9
(20) Капролактам	328	22,8
(21) Ацетилцеллюлоза	346	24,35
(22) Ацетатный шелк	784	64,8

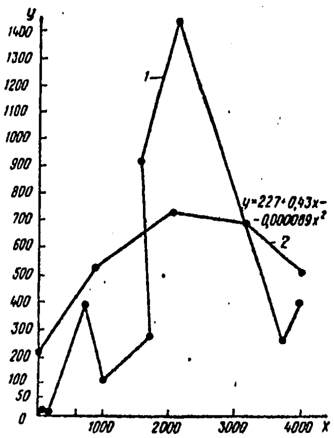
Key:
1. Chemical industry production
2. Start-up expenses per unit of production capacity
3. Expenditures on start-up and adjustment work
4. Complex fertilizers
5. Ammonium nitrate
6. Simple superphosphate
7. Phosphoric acid
8. Compound superphosphate
9. Weak nitric acid
10. Granular ammophos
11. Ammonium nitrite
12. Acetic acid
13. Detergents
14. Ammonia
15. Lacquers and dyes
16. Carbamide resins
17. High-pressure polyethylene
18. Acetylene
19. Viscose staple fiber
20. Caprolactam
21. Cellulose acetate
22. Acetate silk

By studying changes in the values of start-up expenses (y) in accordance with the value of output net cost (x) for individual types of chemical industry production, we set up a graph whose correlation field shows that there exists a curvilinear dependence in the form of a parabolic curve (Figure 14, following page). The coefficient values found are substituted into the equation and we obtain a theoretical regression line with the form

$$y = 227 + 0,43x - 0,000089x^2. \quad (25)$$

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300040039-2

Figure 14. Graph of Dependence of Specific Start-Up Expenses and Output Net Cost



Key:

y -- start-up expenses
x -- output net cost
1 -- empirical regression line
2 -- theoretical regression line

The correlation ratio of the curvilinear regression $\theta = 0.633$.

The coefficient of correlation between start-up expenses write-off norms y and output net cost x describes a very close link between these indicators $r_{xy}=0{,}9$. The theoretical regression line equation showing the dependence between start-up expenses and write-off norms and output net cost takes the form

$$y = 181 + 0.1195x. \tag{26}$$

By studying the degree to which start-up expenses based on write-off norms x influence output net cost y during the mastering of new production, using data from Table 18, we can set up an experimental regression line (Figure 15). The shape of the graph's correlation field indicates the possibility of a linear dependence.

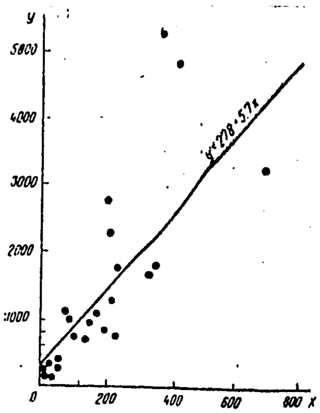
The theoretical regression line equation takes the form

$$y = 278 + 5.74x. \tag{27}$$

The results of the correlation analysis are summarized in Table 23 [following page] in the form of indicator interrelationships and the closeness of the connection between indicators.

Based on the research done, we can conclude that there exists a close link between start-up expenses to put an enterprise into operation and capital expenditures to build the facility, a link which is most often to be traced in the shaping of expenditures on start-up and adjustment work.

Figure 15. Dependence of Output Net Cost and Start-Up Expenses Write-Off Norms



Key:
y -- output net cost;
x -- norms for writing off start-up expenses to output net cost

Table 23. Summary Table of Indicator Interrelationships

(1) Функция (y)	(2) Аргумент (x)	(3) Форма корреляционной зависимости — теоретическая линия регрессии	(4) Теснота связи — коэффициент корреляции
(5) Пусковые расходы	(6) Капитальные затраты	$y=25{,}927+0{,}147x$	0,79
(7) Затраты на пусконаладочные работы	(6) Капитальные затраты	$y=0{,}35+0{,}12x$	0,91
(5) Пусковые расходы	(8) Себестоимость продукции	$y=227+43x-0{,}000089x^2$	0,63*
(8) Себестоимость продукции	(9) Нормы списания пусковых расходов	$y=278+5{,}74x$	0,76

Key:
1. Function (y)
2. Argument (x)
3. Correlation dependence form -- theoretical regression line
4. Closeness of connection -- correlation coefficient
5. Start-up expenses
6. Capital expenditures
7. Expenditures on start-up and adjustment work
8. Output net cost
9. Start-up expenses write-off norms

(*) Correlation ratio of the curvilinear regression (θ)

Table 24. Interconnection of Items in the Operational Portion of Start-Up Expenses and the Variable Portion of Output Net Cost

(1) № п.п.	(2) Наименование показателей по видам продукции	(3) Статьи затрат, руб/т			
		сырье (4)	энергия (5)	заработная плата (6)	итого (7)
1	(8) Аммиак (9) Эксплуатационная часть пусковых расходов	2,08	3,63	2,2	7,8
	(10) Структура затрат	26	46	28	100
	(11) Переменная часть себестоимости	46,76	3,1	10,33	60
	(10) Структура затрат	77,7	5,2	17,1	100
2	(12) Аммиачная селитра (9) Эксплуатационная часть пусковых работ	1,83	0,23	1,75	3,81
	(10) Структура затрат	48	6	46	100
	(11) Переменная часть себестоимости	46,54	2,64	1,64	50,23
	(10) Структура затрат	92,6	5,3	2,1	100
3	(13) Карбамид (9) Эксплуатационная часть пусковых расходов	3,35	1,83	0,72	5,9
	(10) Структура затрат	56,8	31	12,2	100
	(11) Переменная часть себестоимости	59	10,4	0,8	70,2
	(10) Структура затрат	84,1	14,8	1,1	100
4	(14) Капролактам (9) Эксплуатационная часть пусковых расходов	16,52	9,8	15	41,3
	(10) Структура затрат	40	23,7	36,3	100
	(11) Переменная часть себестоимости продукции	791,4	106,5	10	907,9
	(10) Структура затрат	87,2	11,7	1,1	100
5	(15) Ацетилцеллюлоза (9) Эксплуатационная часть пусковых расходов	429,5	27,1	38,8	495,4
	(10) Структура затрат	86,7	5,5	7,8	100
	(11) Переменная часть себестоимости	1810,5	243,7	232	2286,2
	(10) Структура затрат	79,2	10,7	8,1	100
6	(16) Шелк синтетический (9) Эксплуатационная часть пусковых расходов	13,8	8,1	8,5	30,4
	(10) Структура затрат	45,4	26,6	28	100
	(11) Переменная часть себестоимости продукции	969	206,2	268	1443,2
	(10) Структура затрат	67,1	14,3	18,6	100
7	(17) Волокно «лавсан» (9) Эксплуатационная часть пусковых расходов	35,1	43,5	41,3	119,9
	(10) Структура затрат	29,3	36,3	34,4	100
	(11) Переменная часть себестоимости продукции	1133,4	116,7	166,7	1416,8
	(10) Структура затрат	80	8,2	11,8	100

[Key on following page]

Key (to Table 24, preceding page):
1. Number, in sequence
2. Indicator name, by output type
3. Expenditure item, rubles/ton
4. Raw material
5. Energy
6. Wages
7. Total
8. Ammonia
9. Operating portion of start-up expenses
10. Expenditure structure
11. Variable portion of net cost
12. Ammonium nitrate
13. Carbamide
14. Caprolactam
15. Cellulose acetate
16. Synthetic silk
17. "Lavsan" fiber [Dacron]

Recompensing start-up expenses through enterprise current expenditures determines to a significant extent the level of output cost in new production, which is borne out by the correlation coefficient, which describes quite a high level of closeness in the connection between the indicators.

The correlation dependence forms found enable us to derive theoretical indicators which can be used to determine start-up expenses normatives.

In order to determine the influence of several factors simultaneously on the value being studied (which is start-up expenses, in this case), we find a multiple regression equation. The basic paired functions of raw material and energy costs, wages and the constant portion of output net cost are taken to be rectilinear. The multiple regression equation can be written as follows:

$$\Phi_{M,Э,З,C} = a + bM + cЭ + dЗ + eC, \qquad (28)$$

where M is the cost of raw material in output net cost, in rubles per ton;

$Э$ is the cost of energy in output net cost, in rubles per ton;

$З$ is the value of production personnel wages in output net cost, in rubles per ton;

C is the constant portion of output net cost, in rubles per ton;

a, b, c, d, e are unknown parameters which must be calculated.

When studying the dependence of start-up expenses level on several factors simultaneously, we used the method of paired correlation coefficients in the multiple regression equation, which is represented in Tables 25, 26 and 27.

Table 25. Interrelationship of Start-Up Expenses With Their Individual Expenditure Items (Arguments)

Аргумент (x_i) (1)	Теоретическая линия регрессии (2)	Коэффициент корреляции r_{xy} (3)
(4) Сырье	$y_1=85{,}156+1{,}39x_1$	0,893
(5) Энергия	$y_1=21{,}216+12{,}165x_2$	0,79
(6) Заработная плата производственного персонала	$y_1=15{,}04+12{,}9x_3$	0,92
(7) Пусконаладочные работы	$y_1=-4{,}705+2{,}768x_4$	0,858

Key:
1. Argument (x_i)
2. Theoretical regression line
3. Correlation coefficient rxy
4. Raw material
5. Energy
6. Product:on personnel wages
7. Start-up and adjustment work

Table 26. Interrelationship of Individual Expenditure Items

(1) Функция (y)	(2) Аргумент (x)	(3) Теоретическая линия регрессии	(4) Коэффициент корреляции r_{xy}
(5) Сырье	(6) Энергия	$y_2=10{,}256+0{,}0445x$	0,441
»	(9) Заработная плата производственного персонала	$y_3=10{,}3+0{,}07x$	0,645
(6) Энергия	(9) Заработная плата производственного персонала	$y_3=1{,}318+1{,}05x$	0,961
(7) Пусконаладочные работы	(5) Сырье	$y_4=49{,}9+0{,}259x$	0,536
(8) То же	(6) Энергия	$y=5{,}986+4{,}645$	0,973
»	(9) Заработная плата производственного персонала	$y_4=1{,}9026+4{,}305x$	0,987

[Key on following page]

Key (to Table 26, preceding page):
1. Function (y)
2. Argument (x)
3. Theoretical regression line
4. Correlation coefficient rxy
5. Raw material
6. Energy
7. Start-up and adjustment work
8. Same
9. Production personnel wages

Table 27. Paired Correlation Coefficients

(1) Факторы исследования	(2) Эксплуатационная часть пусковых расходов	(3) Сырье	(4) Энергия	(5) Заработная плата	(6) Пусконаладочные работы
(2) Эксплуатационная часть пусковых расходов	—	0,893	0,79	0,919	0,858
(3) Сырье	0,893	—	0,441	0,645	0,536
(4) Энергия	0,79	0,441	—	0,961	0,973
(5) Заработная плата	0,92	0,645	0,961	—	0,987
(6) Пусконаладочные работы	0,858	0,536	0,973	0,987	—

Key:
1. Research factors
2. Operating portion of start-up expenses
3. Raw material
4. Energy
5. Wages
6. Start-up and adjustment work

The multiple regression equation was calculated on a standardized scale. Given such a scale, the arithmetic mean value is adopted as the start for reading each variable, and the mean square deviation value is adopted as the unit of measure.

Using the standardized scale, we first need to express all the variables and functions among them through the scale, using the conversion formula:

$$t_x = \frac{x - \bar{x}}{\sigma_x}, \tag{29}$$

where t_x is the corresponding value of the sign in the standardized scale;

x is the value of the sign in the natural scale;

$\bar{x}$ is the arithmetic mean value of the sign;

σ_x is the mean square deviation of the sign.

In the standardized scale for this research, the multiple rectilinear regression equation takes the form:

$$\bar{t}_{1,2,3,4,5} = \beta_2 t_2 + \beta_3 t_3 + \beta_4 t_4 + \beta_5 t_5, \tag{30}$$

where $\bar{t}_{1,2,3,4,5}$ is the mean value of the standardized variable t_1 corresponding to the assigned values of variables t_2, t_3, t_4, t_5;

$\beta_2, \beta_3, \beta_4, \beta_5$ are standardized multiple regression coefficients; $\beta_1 = 0$, so it is not incorporated in the equation;

t_2, t_3, t_4, t_5 are standardized coefficients of variables $M, Э, З, C$.

Using the paired correlation coefficients given in Table 27, we find the standardized multiple regression coefficients:

$$0{,}893 = \beta_2 + \beta_3 \cdot 0{,}441 + \beta_4 \cdot 0{,}645 + \beta_5 \cdot 0{,}536;$$
$$0{,}79 = 0{,}441\beta_2 + \beta_3 + 0{,}961\beta_4 + 0{,}973\beta_5;$$
$$0{,}919 = 0{,}645\beta_2 + 0{,}961\beta_3 + \beta_4 + 0{,}987\beta_5;$$
$$0{,}858 = 0{,}536\beta_2 + 0{,}973\beta_3 + 0{,}987\beta_4 + \beta_5;$$
$$0{,}893 = \beta_2 + \beta_3 \cdot 0{,}441 + \beta_4 \cdot 0{,}645 + \beta_5 \cdot 0{,}536;$$
$$1{,}791 = \beta_2 + \beta_3 \cdot 2{,}268 + \beta_4 \cdot 2{,}179 + \beta_5 \cdot 2{,}206;$$
$$1{,}425 = \beta_2 + \beta_3 \cdot 1{,}49 + 1{,}55 \cdot \beta_4 + \beta_5 \cdot 1{,}53;$$
$$1{,}603 = \beta_2 + \beta_3 \cdot 1{,}815 + \beta_4 \cdot 1{,}841 + 1{,}866 \cdot \beta_5;$$
$$0{,}898 = 1{,}827 \cdot \beta_3 + 1{,}534 \cdot \beta_4 + 1{,}676 \cdot \beta_5;$$
$$-0{,}366 = -0{,}778\beta_3 - 0{,}629\beta_4 - 0{,}676\beta_5;$$
$$0{,}178 = 0{,}325\beta_3 + 0{,}291\beta_4 - 0{,}326\beta_5;$$
$$0{,}492 = \beta_3 + 840\beta_4 + 0{,}914\beta_5;$$
$$0{,}470 = \beta_3 + 0{,}808\beta_4 + 0{,}869\beta_5;$$
$$0{,}548 = \beta_3 + 0{,}895\beta_4 + 1{,}034\beta_5;$$
$$-0{,}022 = -0{,}032\beta_4 - 0{,}045\beta_5;$$
$$0{,}078 = 0{,}087\beta_4 + 0{,}165\beta_5;$$
$$0{,}638 = \beta_4 + 1{,}406\beta_5;$$
$$0{,}897 = \beta_4 + 1{,}897\beta_5;$$
$$0{,}209 = 0{,}491\beta_5;$$
$$\beta_5 = 0{,}426;$$

[Continued on following page]

$$\beta_4 = 0{,}897 - 1{,}897 \cdot 0{,}426 = 0{,}897 - 0{,}808 = 0{,}089;$$
$$\beta_4 = 0{,}089;$$
$$\beta_3 = 0{,}492 - 0{,}84 \cdot 0{,}089 - 0{,}914 \cdot 0{,}426 = 0{,}028;$$
$$\beta_2 = 0{,}893 - 0{,}441 \cdot 0{,}028 - 0{,}645 \cdot 0{,}089 - $$
$$- 0{,}536 \cdot 0{,}426 = 0{,}596.$$

Substituting the coefficient values obtained in the multiple regression equation in the standardized scale for this particular study, we obtain:

$$\bar{t}_{1,2,3,4,5} = 0{,}596 t_2 + 0{,}028 t_3 + 0{,}089 t_4 + 0{,}426 t_5, \qquad (31)$$

where $\bar{t}_{1,2,3,4,5}$ is the mean value of start-up expenses;
t_2 is the standardized value of raw material cost in output net cost;
t_3 is the standardized value of energy cost in output net cost;
t_4 is the standardized value of production worker wages in output net cost;
t_5 is the constant portion of output net cost.

Multiple regression equation coefficients $\beta_2, \beta_3, \beta_4, \beta_5$ demonstrate the speed of change in the mean value of the function under the influence of one of the arguments, given constant values for the other arguments.

All the variables of equation (31) are expressed in comparable units of measurement, that is, in mean square deviations of the factors being examined. Consequently, coefficients $\beta_2, \beta_3, \beta_4, \beta_5$ show the comparative force of the influence of change in each argument on change in the function. According to the equation, raw material cost has the greatest influence on the level of start-up expenses.

For practical application, the multiple regression equation must be expressed in a natural scale.

Given five variables, the multiple regression equation takes the following form in a natural scale

$$\bar{y}_{1,2,3,4,5} = b_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 \qquad (32)$$

and corresponds to equation (28).

To compute coefficients $b_2, b_3, b_4, b_5,$ given in equation (32) we use the following formula:

$$b = \beta_i \frac{\sigma_1}{\sigma_i}, \qquad (33)$$

where β_i are standardized coefficients of the multiple regression equation and i = 2, 3, 4, 5 for this particular study;

[where] σ_i is the mean square deviation of the corresponding factors.

The arithmetic mean values of the function and arguments ($\bar{y}$ and $\bar{x}$) are determined using the following formulas:

$$\bar{y}_i = \frac{\Sigma n y_i}{\Sigma n}; \quad \bar{x}_i = \frac{\Sigma n x_i}{\Sigma n}. \tag{34}$$

Value b_1 is determined using the following equation:

$$b_1 = \bar{y} - b_2 x_2 - b_3 x_3 - b_4 x_4 - b_5 x_5. \tag{35}$$

The mean square deviation of the function and arguments (σ_y and σ_x) is determined using the following formulas:

$$\sigma_y = \sqrt{\frac{\Sigma n (y_i)^2}{\Sigma n} - (\bar{y}_i)^2}; \qquad \sigma_x = \sqrt{\frac{\Sigma n (x_i)^2}{\Sigma n} - (\bar{x}_i)^2}, \tag{36}$$

where n is the size of the sample.

Product calculations $\bar{y}_i$, $\bar{x}_i$ and σ_i are given in Table 28 by function and argument for this study.

Table 28.

(1) Признак	(2) Показатели	
	(3) среднеарифметическое отклонение функции и аргументов	(4) среднеквадратичное отклонение функции и аргументов
(5) Эксплуатационная часть пусковых расходов	$\bar{y} = 184{,}9$	$\sigma_1 = 228{,}1$
(6) Стоимость сырья пусковых расходов	$\bar{x}_2 = 71{,}7$	$\sigma_2 = 146{,}4$
(7) Стоимость электроэнергии в пусковых расходах	$\bar{x}_3 = 13{,}5$	$\sigma_3 = 14{,}74$
(8) Заработная плата в пусковых расходах	$\bar{x}_4 = 15{,}5$	$\sigma_4 = 16{,}2$
(9) Пусконаладочные работы	$\bar{x}_5 = 68{,}5$	$\sigma_5 = 70{,}78$

Key:
1. Criterion
2. Indicators
3. Mean arithmetic derivation of function and arguments
4. Mean square deviation of function and arguments
5. Operating portion of start-up and adjustment expenses

(Key continued on following page)

(Key to Table 28, preceding page, continued)

6. Cost of raw material in start-up expenses
7. Cost of electric power in start-up expenses
8. Wages in start-up expenses
9. Start-up and adjustment work

We find value b based on the mean square deviations of the function and arguments:

$$b_2 = \beta_2 \frac{\sigma_1}{\sigma_i} = 0{,}928;$$

$$b_3 = \beta_3 \frac{\sigma_1}{\sigma_i} = 0{,}433;$$

$$b_4 = \beta_4 \frac{\sigma_1}{\sigma_i} = 1{,}253;$$

$$b_5 = b_5 \frac{\sigma_1}{\sigma_i} = 1{,}373;$$

$$b_1 = 184{,}9 - 0{,}928 \cdot 71{,}7 - 0{,}433 \cdot 13{,}5 - 1{,}253 \cdot 15{,}5 - 1{,}373 \cdot 68{,}5 = -1.$$

In a natural scale, the regression equation takes the form

$$y_{1,2,3,4,5} = -1 + 0{,}928x_2 + 0{,}433x_3 + 1{,}253x_4 + 1{,}373x_5$$

or, based on the notation adopted:

$$\Phi_{M,Э,З,C} = -1 + 0{,}928 \cdot M + 0{,}433 \cdot Э + 1{,}253 \cdot З + 1{,}373 \cdot C.$$

The equation reflects the influence of several factors simultaneously on start-up expenses.

The multiple correlation factor is determined based on standardized multiple regression factors and paired correlation factors.

For the calculation, we use the formula

$$R_{1,2,3,4,5} = \sqrt{\beta_2 r_{1,2} + \beta_3 r_{1,3} + \beta_4 r_{1,4} + \beta_5 r_{1,5}}\,. \tag{37}$$

For a multiple regression equation with five variables, the correlation factor is: $R_{1,2,3,4,5} = 0.9$

The possibility of making practical use of multiple regression equations lies in the fact that they can be used to evaluate the value of start-up expenses on putting enterprises of the chemical industry into operation. For example, using output net cost data for the Rovenskiy Nitrogen Fertilizers Plant, specific values for start-up expenses will be:

$$\bar{\Phi}_{\text{расч}} = -1 + 0{,}928 \cdot 1{,}64 + 0{,}433 \cdot 3{,}45 + 1{,}253 \times 0{,}8 + 1{,}373 \cdot 4{,}95 = 9{,}8 \text{ rubles per ton.}$$

For an ammonia production volume of 100,000 tons per year, start-up expenses will be

$$9.8 \cdot 100 = 980{,}000 \text{ rubles}$$

Deviations from actual data are about nine percent.

Thus, the multiple regression formula derived enables us to adjust start-up expenses estimates when they are verified by superior organizations.

Chapter III. Schedules for Starting Up New Production

Section 1. Setting Schedules for Starting Up New Production

The start-up period for new production is set for the various branches of the chemical industry on the basis of "Start-Up and Adjustment Work Duration Norms for Finished New and Expanded Production of the Chemical Industry." The existing norms, in this regard, do not take into account the duration of work done by Orgkhim specialists in the prestart-up and production capacities utilization periods. Under the normatives, the duration of production start-up averages 3-4 months for the branch.

In order to determine the duration of Orgkhim representatives' participation in mastering newly operating production capacities, we use the "Normatives of Planned Capacities Mastering Schedules" in effect in the chemical industry.

Just as in the "Norms of Time Required to Master Planned Capacities Being Put Into Operation At Enterprises," these normatives also do not take into account the time needed for start-up and adjustment work.

The established norms for capacities mastering duration were developed with consideration of the technical complexity of the production and are given in the SNiP both for the enterprise as a whole and for individual lines, shops, flow lines, units and installations.[1]

When enterprises are put into operation by line (start-up complex), the mastering duration norm for the first line is taken at 50 percent of the norm approved for the enterprise as a whole; for subsequent lines, the norms together total the overall norm. For expanded enterprises, the duration of mastering planned capacities is set at 15 percent less than the norms set for a similarly specialized new enterprise; for renovated enterprises -- 20 percent less. When the increment in capacity at renovated enterprises occurred without increasing production area, the norm is reduced by 30 percent.

---

1. For example, depending on enterprise capacity, 8-18 months for ammonia production; 12 months for chemical mining enterprises mining and enriching apatites (first line); same production, second line -- 12 months; same production, third line -- eight months; for enterprises producing high-pressure polyethylene -- six months; low-pressure polyethylene -- 12 months.

In multiple-assortment production (aniline dyes, lacquer and paints), the degree of capacity utilization is determined using the output assortment actually being produced during the mastering period, with consideration of the production complexity factor for the remaining products.

Normative schedules for mastering capacities in the chemical industry are set at from six months to two years. A normative year is considered to be a full actual year of enterprise operation, not counting the month the production is put into operation.

Given a long mastering period of up to three years, it is recommended that utilization of up to 25 percent of the planned capacity be planned for the first year, up to 65 percent the second year, and up to 90 percent the third.

In the prestart-up period, when engineering supervision and preparing production for start-up are underway, we are governed by norms for planning and surveying work which have been developed for the chemical industry by the USSR Ministry of Chemical Industry's GIAP and which were approved in 1967 by the USSR Gosstroy, as well as by the Construction Duration Norms. Following the SNiP, the "Norms of Construction Duration for Enterprises, Lines, Start-Up Complexes, Shops, Production Facilities, Installations, Buildings and Structures" take into account the time needed to comprehensively test equipment and adjust it for chemical industry facilities.

Overall construction duration norms cover longer periods that the distribution of capital investments by year, due to the fact that the SNiP's anticipate the time needed to start-up production, although start-up expenses are not a part of the estimated cost of the facility.

The duration of participation by specialists in carrying out the entire complex of start-up and adjustment work for individual types of production is reflected in the Orgkhim price list. The relationship of work duration in the prestart-up period, the start-up period and the utilization period, as outlined by the price list, is given in Table 29 [following page].

The start-up period itself accounts for about 10 percent of the total duration of start-up and adjustment work.

In practice, the following work accounts for the following proportions of the total production start-up period duration, in percent:

comprehensive testing	50-60
eliminating equipment defects revealed in the testing and equipment design adjustments	20-25
production's reaching a steady technological routine and obtaining the first lots of standard output	25-30

The normatives being extablished must reflect objective factors determining start-up schedules for various types of production, such as: scale of production, level of production specialization and combining, nature of production, degree of production process complexity, production cycle length, equipment complexity, output innovativeness.

Table 29. Start-Up and Adjustment Work Duration, based on Orgkhim price list

(1) Производство	(2) Годовая мощность, тыс. т	(3) Продолжительность пусконаладочных работ, мес	(4) Период инженерного надзора: (5) на стадии рассмотрения проекта	(4) Период инженерного надзора: (6) на стадии строительно-монтажных работ	(7) Пусковой период	(8) Период освоения мощности
(9) Аммиак	170	45	4	23	3	15
(10) Крепкая азотная кислота	309	27	1	23	4	9
(11) Уксусная кислота из ацетальдегида	25	22	1	12	3	6
(12) Двойной гранулированный суперфосфат	350	30	1	13	4	12
(13) Капроновый шелк	4,7	50	3	24	3	20
(14) Вискозная целофановая пленка	9	45	4	20	3	18
(15) Лаки и эмали на полимеризационных смолах	26	24	2	12	2	3
(16) Калийные удобрения	1200	40	2	22	4	12
(17) Полиэтилен высокого давления	60	24	2	12	4	16
(18) Полиэфирные смолы	5	16	1	7	2	6

Key:
1. Production
2. Annual capacity, in 1,000 tons
3. Duration of start-up and adjustment work, in months
4. Engineering supervision period
5. At plan review stage
6. At construction-installation work stage
7. Start-Up Period
8. Capacities utilization period
9. Ammonia
10. Strong nitric acid
11. Acetic acid from acetaldehyde
12. Compound granular superphosphate
13. Capron silk
14. Viscose cellophane film
15. Polymerized resin lacquers and enamels
16. Potassium fertilizers
17. High-pressure polyethylene
18. Polyester resins

I. A. Cherevko recommends that standard new production utilization normatives be set on the basis of classification charts with consideration of factors influencing their duration.

Normatives must be classified for new and renovated enterprises with consideration of universal factors characteristic for all branches and with consideration of the specific factors relating just to individual branches of industry.

Universal factors include the division of production into discontinuous, continuous, and conditionally continuous.

Specific factors are the technological specialization of different branches, the complexity of the output, production volume and working conditions. The standard normatives for starting up and utilizing production can be grouped as follows: by branch of industry, by type of production processes or type of equipment, by enterprise or production sector capacity, by continuousness of production processes, by output complexity group, by level of mechanization and automation, for new and renovated enterprises.

The anticipated time needed to master the technology itself t_m can be calculated using the following formula:

$$t_m = LK_u \frac{vst_u}{K_p} + t_n, \tag{38}$$

where v is the factor for complexity of following technological routine;
s is the equipment complexity factor;
t_u is the production cycle duration, in days;
K_p is a factor taking into account production personnel work habits;
K_u is the number of cycles needed;
L is the number of flow lines being mastered sequentially or parallel-sequentially;
t_n is the duration of the process.

In view of the differing duration of manufacturing output in individual types of chemical industry production, t_u and t_n are given in hours in the formula, but will be in days in subsequent calculations.

Based on the formula given above and the coefficients found empirically and recommended by I. A. Cherevko, we calculated the duration of technology mastering.

The calculation results, done for chemical industry production, are compared (in Table 30, following page) with normative and actual new production start-up and utilization schedules.

The anticipated time needed to start-up individual types of chemical industry production was determined based on the time needed to master the technology and the duration of comprehensive equipment testing:

Table 30. Comparison of Calculated Technology Utilization Duration With Normative Start-Up and Utilization Duration, in months

(1) Производства	(2) Мощность, тыс. т в год	(3) Длительность освоения технологии	(4) Фактическая длительность пуска и освоения мощности	(5) Норматив (6) пуска	(7) освоения
(8) Аммиак	200	1	5	3	8
(9) Карбамид	180	3,5	9	3	12
(10) Аммиачная селитра	450	1,5	8	2	4
(11) Двойной суперфосфат	360	4	12	4	15
(12) Серная кислота	300	2	7	3	9
(13) Каустическая сода	120	1	5	4	10
(14) Хлор	100	6	8	3	10
(15) Смолы	60	2,5	2	6	5
(16) Пластмассовые изделия	8	2,5	Н/д	Н/д	11
(17) Ацетатный шелк	13,6	10	8	3	18
(18) Химические реактивы	1 млн. руб. (19)	22	20	Н/д	Н/д (20)

Key:
1. Production
2. Capacity, in 1,000 tons per year
3. Technology mastering duration
4. Actual duration of capacities start-up and utilization
5. Normative
6. Start-up
7. Utilization
8. Ammonia
9. Carbamide
10. Ammonium nitrate
11. Compound superphosphate
12. Sulfuric acid
13. Caustic soda
14. Chlorine
15. Resins
16. Plastic items
17. Acetate silk
18. Chemical reagents
19. One million rubles
20. [not further identified]

$$T_{п} = t_{к.о} + t_m, \tag{39}$$

where $T_{п}$ is production start-up duration;

$t_{к.о}$ is comprehensive equipment testing duration (consideration should be given to SNiP requirements for mandatory testing of individual units for 72 hours of continuous operation;

and t_m is technology set-up duration where $K_н$ depends on how well previous work (construction-installation, comprehensive equipment testing) was done and can equal 1 if good-quality output is obtained in the first lot.

In order to check the feasibility and substantiation of the recommended schedules for start-up and adjustment work, we did variance and correlation analysis using data on actual schedules for starting up Orgkhim projects.

Based on the analysis of variance, conclusions can be drawn as to the actual schedules for start-up and adjustment work which are most characteristic of the different chemical industry production. And researching the correlation function between start-up and adjustment work schedules and capital expenditures, equipment cost and duration of construction-installation work enable us to derive theoretical normatives reflecting the features and complexity of the production.

Section 2. Analysis of Schedules for Carrying Out Start-Up and Adjustment Work

1. Analysis of Variance of Schedules for Carrying Out Start-Up and Adjustment Work

Analysis of variance is done based of discrete random values. In this research, the discrete random values are considered the schedules for carrying out start-up and adjustment work and deviations from them. The law of distribution of discrete random values gives a list of possible values X_i and probabilities corresponding to them.

As the probability, we adopt its relative frequency:

$$P_i = \frac{m}{n}.$$

In this instance, m is the number of enterprises for which carrying out the work within certain time periods X_i is characteristic and n is the number of enterprises put into operation. When making an analysis of variance, we examine the start-up schedules followed by Orgkhim production subunits for new facilities.

Let's calculate the mathematical expectation of normative start-up period schedules in comparison with actual schedules for carrying out start-up and adjustment work at chemical industry facilities being put into operation. In accordance with Table 31 [following page], mathematical expectation $m_н^*$ of the normative production start-up schedule is

$$m_н^* = \sum_{i=1}^{6} x_i^н P_i^н \tag{40}$$

($m_н^* = 2.9$ months).

Table 31. Calculating the Mathematical Expectation of Normative Production Start-Up Schedules

Нормативные сроки пуска (месяцы) $X_i^н$ (1)	Количество предприятий m (2)	Вероятность получения данного нормативного срока пуска $P_i^н = \frac{m}{n}$ (3)	Фактические сроки проведения пуска (месяцы) $X_i^ф$ (4)	Количество предприятий m (2)	Вероятность выполнения пусконаладочных работ в соответствующее количество месяцев $P_i^ф$ (5)
1	3	0,05001	1	2	0,03334
			1,5	1	0,01667
2	13	0,21671	2	6	0,10002
			2,5	1	0,01667
3	32	0,53344	3	4	0,06668
4	8	0,13336	4	6	0,10002
5	3	0,05001	5	4	0,06668
6	1	0,01667	6	6	0002
7			7	6	0,10002
			8	6	0,10002
			9	1	0,01667
			10	5	0,08335
			11	4	0,06668
			12	4	0,06668
			13	1	0,01667
			14	1	0,01667
			15	1	0,01667
			16	Не вводились (7)	
			17	1	0,01667
Всего (6)	60=n	1		60=n	1

Key:

1. Normative start-up schedules, in months
2. Number of enterprises
3. Probability of obtaining the given normative start-up schedule
4. Actual start-up time, in months
5. Probability that start-up and adjustment work will be done in the appropriate number of months
6. Total
7. Not incorporated

The mathematical expectation m_Φ^* of the actual schedule for carrying out the entire complex of start-up and adjustment work is:

$$m_\Phi^* = \sum_{i=1}^{17} x_i^\Phi P_i^\Phi \tag{41}$$

($m_\Phi^* = 6.6$ months).

It is evident from a comparison of the research results that the participation of Orgkhim specialists goes beyond the framework of the start-up period. Actual time involved in carrying out the entire complex of start-up and adjustment work is 6.6 months, instead of the 2.9 months using norms for just production start-up. This conforms to the provisions on the composition of work done by Orgkhim production subunits in which, along with production start-up, their participation is anticipated in the prestart-up period and in rendering assistance in utilizing production capacities after the facility has been released for operation.

The magnitude of the deviation of actual start-up and adjustment work time from the normative start-up schedules fluctuates within broad limits for the individual branches of the chemical industry.

The deviation dispersion for the chemical industry is evaluated using the formula

$$Д^* = \frac{\Sigma (x_i - m^*)^2 n_i}{n-1};$$

$$\text{where } \Sigma (x_i - m^*)^2 n_i = 772{,}586; \qquad (42)$$

$$Д^* = \frac{772{,}5}{60-1} = 13 \text{ months.}$$

The mathematical expectation of summary normative start-up and utilization schedules for newly operating production is 13 months, which exceeds twofold the actual schedules for start-up and adjustment work by Orgkhim production subunits.

The deviations of actual start-up and adjustment schedules from normative start-up and utilization schedules for 60 production facilities put into operation are as follows:

Magnitude of deviation of actual schedules from normative ones, in months	-1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15 -16 -19 +2 +8
Number of production facilities	4 4 5 2 7 5 7 1 7 3 4 2 1 1 1 1 1 2 2 1

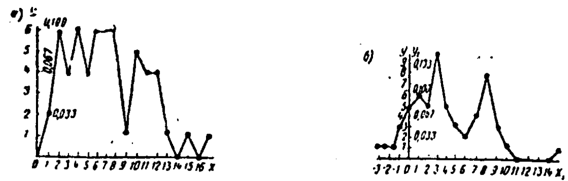
The law of distribution of a discrete random value can be depicted in graph form, in which points connected by a broken line are set in a rectangular system of coordinates. The figure obtained represents a distribution polygon.

Using the data from Table 31, we set up a distribution polygon for the magnitude of the actual duration of start-up and adjustment work and its deviation from normative production start-up schedules (Figure 16 a, b).

Using the data from Table 32 [second page following], we set up a distribution polygon for normative production start-up and utilization schedules and the magnitude of the deviation of actual start-up and adjustment work schedules (Figure 17 a, b).

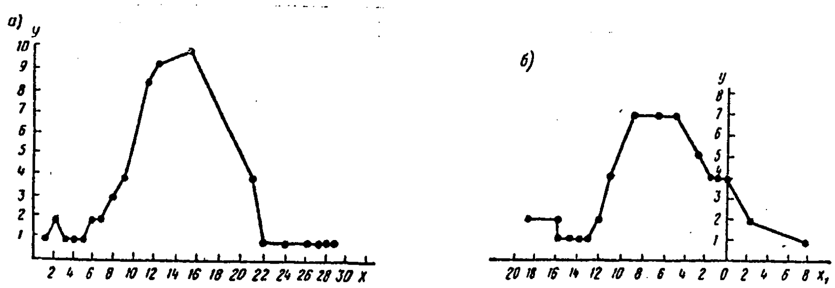
A comparison of actual schedules for carrying out start-up and adjustment work with the summary normative production start-up and utilization times

Figure 16. Distribution Polygon



Key:
- a. Magnitude of actual start-up and adjustment schedules
- b. Deviation of actual production start-up schedules from normative
- y -- number of production facilities
- y_1 -- probability of deviation
- x -- actual start-up and adjustment duration, in months
- x_1 -- deviation of actual production start-up schedules from normative

Figure 17. Distribution Polygon



Key:
- a. Normative start-up and utilization schedules
- b. Deviation from normative start-up and adjustment work schedules
- y -- number of production facilities
- x -- normative start-up and utilization duration
- x_1 -- deviation of actual start-up and utilization schedules from normative ones, in months

will obviously not be characteristic for the Orgkhim, since the participation of specialists from this organization throughout the production mastering period is not anticipated by the existing provisions.

The values of deviation of actual Orgkhim start-up and adjustment work schedules from normative ones are given for individual branches of the chemical industry in Table 33 [second page following].

Analysis of variance data testify to the presence of considerable reserves in the schedules for carrying out start-up and adjustment work.

EC -UP
AND ADJUSTMENT OF NEW PRODUCTION
22 OCTOBEER 1980 BY G. A. KASHLINSKAYA 2 OF 2

Table 32. Calculating the Mathematical Expectation of Summary Normative Production Start-Up and Utilization Schedules

Нормативные сроки пуска и освоения мощностей (месяцы) $X_i^н$ (1)	Количество предприятий, m (2)	Вероятность получения нормативных сроков $P_i^н = \frac{m}{n}$ (3)	Математическое ожидание суммарного нормативного срока пусконаладочных работ $m_н^* = \sum_{i=1}^{29} X_i^н P_i^н$ (4)
1	1	0,015	0,015
2	2	0,03	0,06
3	1	0,015	0,045
4	1	0,015	0,06
5	1	0,015	0,075
6	2	0,03	0,18
7	2	0,03	0,21
8	3	0,0448	0,358
9	4	0,058	0,522
11	8	0,12	1,32
12	9	0,135	1,62
13	3	0,0448	0,584
14	5	0,0747	1,045
15	10	0,15	2,25
17	2	0,03	0,5
19	2	0,03	0,57
21	4	0,058	1,218
22	1	0,015	0,33
24	1	0,015	0,36
26	1	0,015	0,39
27	1	0,015	0,405
28	2	0,015	0,420
29	1	0,015	0,435
(5) Всего	$67=n$	1	13,08

Key:
1. Normative schedules for starting up and utilizing capacities, in months
2. Number of enterprises
3. Probability of obtaining normative schedules
4. Mathematical expectation of a summary normative schedule of start-up and adjustment work
5. Total

The analysis of variance done here enables us to judge what start-up schedules are most characteristic of the different branches of the chemical industry.

2. Correlation Analysis of Schedules for Carrying Out Start-Up and Adjustment Work

Table 33. Summary Table of Results of Deviation of Start-Up and Adjustment Work (PNR) Schedules

(1) Отраслевые объединения	(2) Количество произв. объектов	(3) Нормативные сроки проведения ПНР (в месяцах)			(6) Фактические сроки ПНР* (в месяцах)			(7) Отклонение фактических сроков ПНР от нормативных (в месяцах)						
		(4) наименьший	(5) наибольший	$m^*_н$	(4) наименьший	(5) наибольший	$m^*_ф$	(4) наименьший	(5) наибольший	m^*	(8) не позже срока: (10) количество	(8) не позже срока: (11) вероятность	(9) позже срока: (10) количество	(9) позже срока: (11) вероятность
(12) «Союзхлор»	11	2	4	3,268	1	11	5,273	—1	7	2,909	4	0,36364	7	0,63636
(13) «Союзазот»	24	2	6	3,417	2	15	7,459	0	9	4,032	1	0,04167	23	0,95833
(14) «Союзгорхимпром»	5	1	4	2,0	2	12	7,4	+1	8	5,4	0	0	5	1
(15) «Союзхимпласт» и «Союзхимволокно»	5	2	4	3,0	1	17	6,1	—1	13	3,1	3	0,6	2	0,4
(16) «Союзкраска»	8	2	3	2,375	2	12	5,5	0	9	3,125	3	0,375	5	0,625
(17) «Союзосновхим»	7	2	4	2,429	2,5	12	7,359	+0,5	8	4,501	0	0	7	1
(18) Всего по объединениям	60	1	6	2,895	1	17	6,601	0	11	3,960	11	0,18337	49	0,81663

* С учетом сроков освоения мощностей; m^* — математическое ожидание сроков.

Key:
1. Branch associations
2. Number of production facilities
3. Normative PNR schedules, in months
4. Least
5. Greatest
6. Actual NPR schedules, in months
7. Deviation of actual PNR schedules from normative, in months
8. Not later than scheduled
9. Later than scheduled
10. Number
11. Probability
12. "Soyuzkhlor"
13. "Soyuzazot"
14. "Soyuzgorkhimprom"
15. "Soyuzkhimplast" and "Soyuzkhimvolokno"
16. "Soyuzkraska"
17. "Soyuzosnovkhim"
18. Total for all associations

(*) With consideration of schedules for mastering capacities; m*=mathematical expectation of the schedules

In accord with the SNiP, schedules for starting up different chemical industry production differ insignificantly (by 3-4 months), which does not reflect the features and degree of complexity of setting up the equipment and technology of individual types of production. In order to reveal, using correlation analysis, the duration of production start-up as a function of a number of determining factors, we examined actual schedules for the participation of Orgkhim production subunits during start-up of facilities and finishing production capacities.

The interrelationship of actual start-up and adjustment work schedules with a number of indicators enables us to draw conclusions as to the theoretical schedules for starting up production in different branches of the chemical industry. Calculations have shown the presence of a close correlation between actual start-up and adjustment schedules and capital expenditures, equipment cost, and normative construction-installation schedules.[1] A correlation factor describing the degree of connection between the indicators and equations of theoretical regression lines which represent the form of this connection are given in Table 34 and Figures 18, 19 and 20.

Table 34. Summary Table of Results of Calculations of the Connection Between Actual Start-Up and Adjustment Work Schedules With Different Indicators

(1) Показатели	(2) Коэффициент корреляции	(3) Теоретическая линия регрессии
(4) Капитальные затраты на строительство	0,799	$y_x = 3,61 + 0,19$
(5) Стоимость оборудования	0,788	$y_x = 3,65 + 0,388$
(6) Нормативные сроки строительно-монтажных работ	0,779	$y_x = 1,45 + 0,5$

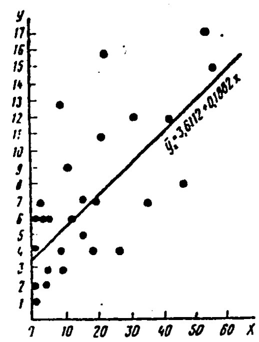
Key:
1. Indicators
2. Correlation factor
3. Theoretical regression line
4. Capital expenditures on construction
5. Cost of equipment
6. Normative construction-installation work schedules

The presence of a close interconnection between start-up and adjustment work schedules and such indicators as start-up expenses and expenditures on start-up and adjustment work has not been established. The correlation factor between start-up expenses and schedules for carrying out start-up and adjustment work is $r_{xy} = 0.4$, that is, an inadequate connection. The absence of such a connection is also supported by the fact that start-up expenses for

---

1. SNiP, part III, section A, paragraph 5.

Figure 18. Correlation Connection Between Actual Start-Up and Adjustment Work Schedules and Capital Investments

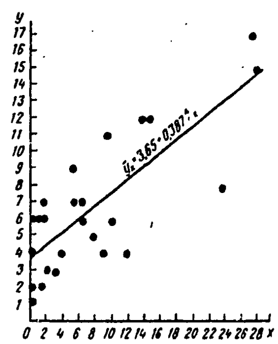


Key:

y -- actual start-up and adjustment work schedules

x -- capital investments

Figure 19. Correlation Connection Between Actual Start-Up and Adjustment Work Schedules and Equipment Cost



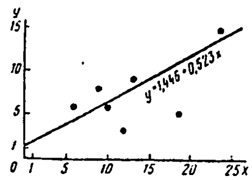
Key:

y -- actual start-up and adjustment work schedules, in months

x -- equipment cost, in millions of rubles

different types of production differ considerably, given the exact same schedules for starting up chemical production, depending on their features. For example, given a work duration of eight months, start-up expenses for an acetate silk production facility are 5,600,000 rubles; with a work duration of 10 months, start-up expenses for a polyvinylchloride production facility are 272,000 rubles, and for a caprolactam production facility -- 5,740,000 rubles.

Figure 20. Correlation Connection Between Actual Start-Up and Adjustment Work Schedules and Construction-Installation Work Schedules, in months



Key:

y -- actual start-up and adjustment work schedules

x -- construction-installation work schedules (normative)

Neither was a strong correlation connection discovered when comparing schedules for carrying out start-up and adjustment work with their cost $r_{xy}=0.3$ for newly operating chemical industry production. However, the function of these indicators for production of the same type is satisfactory. Thus, the correlation factor between the schedules and cost of start-up and adjustment work for ammonia production $r_{xy}=0.6$; for sulfuric acid production $r_{xy}=0.8$. When we attempted to compare actual schedules for carrying out start-up and adjustment work with the designed ease of equipment maintenance for different types of production,[1] an unsatisfactory connection was revealed $r_{xy}=0.25$; there was no connection $r_{xy}=0.03$ when compared with the cost of planning the technological portion of chemical industry production.[2]

The forms of correlation connection established for the indicators enable us to derive theoretical schedules for carrying out start-up and adjustment work (Table 35, following page).

Thus, correlation analysis demonstrated a close dependence between schedules for carrying out start-up and adjustment work and capital expenditures and construction-installation work schedules for chemical industry projects, and it enabled us to establish the form of the connection and to derive theoretically possible schedules for starting up and adjusting capacities being put into operation.

----

1. "Sistema planovo-predupreditel'nogo remonta khimicheskogo oborudovaniya i transportnykh sredstv na predpriyatiyakh khimicheskoy in neftekhimicheskoy promyshlennosti" [System of Planned Preventive Maintenance for Chemical Equipment and Transport at Chemical and Petrochemical Enterprises], Scientific Research Institute of Technical-Economic Research, Moscow, 1967.

2, Section 12, "Chemical Industry," in "Sbornik tsen na proyektnyye i izyskatel'skiye raboty dlya stroitel'stva" [Price Handbook for Construction Planning and Surveying], Moscow, Izd-vo Stroyizdat, 1969.

Table 35. Theoretical Norms of Start-Up and Utilization Duration for New Production Capacities, derived based on regression equations

(1) Производства	(2) Годовая мощность, тыс. т	(3) Теоретические нормы пуска и освоения мощностей в месяцах	(4) Фактические сроки пуска и освоения мощностей в месяцах	(5) Отклонения сроков
(6) Аммиак	100	6,5	5*	+1,5
»	400	14	15	—1
(7) Серная кислота	180	5	2,8*	+2,2
(8) То же	300	6,5	7	—0,5
»	360	7	7	—
(9) Уксусная кислота	25	4	6	—2
(10) Простой суперфосфат	540	5	4	+1
(11) Двойной суперфосфат	700	9	12	—3
(12) Аммофос	400	7,5	11	—3,5
(13) Нитрит аммония	45	4	6	—2
(14) Метанол	100	5,8	6	—0,2
(15) Карбамид	180	5,6	9	—3,4
(16) Аммиачная селитра	400	6	8	—2
(17) Калийные удобрения	2400	11,5	12	—0,5
(18) Венилацетат	11	4	7	—3
(19) Ацетатный шелк	13,6	12	8*	+4
(20) Вискозный корд	17,5	14	17	—3
(21) Полиэфирный лак	2,5	3,7	4	—0,3

* Частичное участие специалистов Оргхима в освоении производственных мощностей.

Key:
1. Production
2. Annual capacity, in 1,000 tons
3. Theoretical capacity start-up and utilization norms, in months
4. Actual capacity start-up and utilization norms, in months
5. Deviations of schedules
6. Ammonia
7. Sulfuric acid
8. Same
9. Acetic acid
10. Simple superphosphate
11. Compound superphosphate
12. Ammophos
13. Ammonium nitrite
14. Methanol
15. Carbamide
16. Ammonium nitrate
17. Potassium fertilizers
18. Vinylacetate
19. Acetate silk
20. Viscose cord
21. Polyester lacquer

(*) Partial Orgkhim specialist participation in mastering production capacities

Section 3. Using Network Planning to Reduce Schedules for Carrying Out Start-Up and Adjustment Work

Comprehensive testing and the test start-up and utilization of production capacities can be done intensively, at speeds and under conditions close to planned conditions. In this regard, energy expenditures and production wastes are generally high.

A gradual, extensive development of capacities is also possible, beginning with minimal speeds and performance. In this instance, the work schedule is prolonged, but losses are less. Intensive start-up and adjustment work is justified when the servicing shops are ready and are ensuring corresponding rates of capacity increase.

In order to obtain technically substantiated normatives for carrying out start-up and adjustment work schedules, we need to break the entire production start-up process down into parts and analyze the influence of various factors on its duration.

The total time needed to carry out start-up and adjustment work can be reduced by reducing the duration of individual jobs by doing them in tandem and eliminating gaps between related work stages.

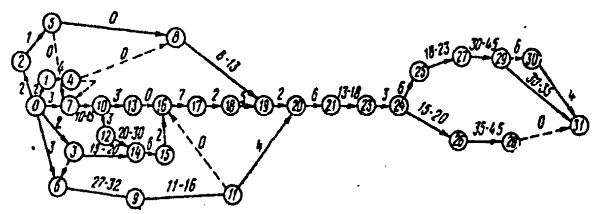
This is facilitated in considerable measure by network schedules and finding the critical path which determines the start-up and adjustment work schedule and which enables us to reveal reserves for reducing overall duration of the start-up period. At present, network start-up schedules are being drawn up for several newly operating facilities by the Orgkhim and Lenniigiprokhim UPNR, whose positive experience enables us to conclude that it is necessary to continue expanding this work.

Standard network schedules for start-up and adjustment work for similar types of production are among those schedules with the most current interest.

Drawing up and optimizing network models enables us to reduce the overall time involved in start-up and adjustment work and thus ensures the accelerated release of the facility for industrial operation, high economic effectiveness of expenditures, and the release of additional output for the national economy. The use of network planning and management (SPU) in starting up and utilizing, for example, an installation to produce polyvinyl dispersion at the Severodonetskiy Chemical Combine enabled Orgkhim specialists to reduce the start-up period by 20 days and the utilization period by 18 days as against the normative schedules.

According to calculations by the author, minimizing the total time needed to carry out that program provided the national economy with additional output worth five million rubles and ensured an enterprise profit of 732,000 rubles, recompensing expenditures on Orgkhim technical assistance to the enterprise in 20 days. The Severodonetskiy Chemical Combine used a standard schedule to plan and manage start-up and adjustment work on the polyvinyl acetate dispersion production facility (Figure 21). It was adjusted to conform to actual work progress in the preparatory and start-up period. Events 16 and 24 divide the entire schedule into three periods (preparatory -- 0-16, start-up -- 16-24, utilization -- 24-31).

Figure 21. Network Schedule for Start-Up and Adjustment Work for a Polyvinyl Acetate Dispersion Production Facility



Period I equals 53 calendar days; II -- actually is 40 days, instead of the 60 according to the normatives; III -- actually 72, instead of 180.

The critical path passes through events: 0 1 4 7 10 12 14 15 16 17 18 19 20 23 24 25 27 29 30 31.

We also calculated the parameters of the network models of start-up and adjustment work by type of production:

chemical fiber (figure 22);
ammonia (Figure 23);
thermic phosphoric acid (Figure 24).

The schedule network model of start-up and adjustment work contains the following calculations:[1]

1. A list of the events, jobs and connection between them, the schedule cross-linking.

2. A definition of the anticipated duration of the work $t_{ож}$ in accord with the beta-distribution law:

$$t_{ож} = \frac{t_{min} + 4t_{н.в} + t_{max}}{6} \text{ (days)}, \tag{43}$$

where t_{min} is the minimum possible time for doing the work;

t_{max} is the maximum time for doing the work, given an extremely unfortunate coincidence of circumstances;

$t_{н.в}$ is the most probable time needed to do the work.

The dispersion determining the probability of deviation from calculated $\sigma^2_{t_{ож}}$ value

$$\sigma^2_{t_{ож}} = \frac{(t_{max} - t_{min})^2}{6}. \tag{44}$$

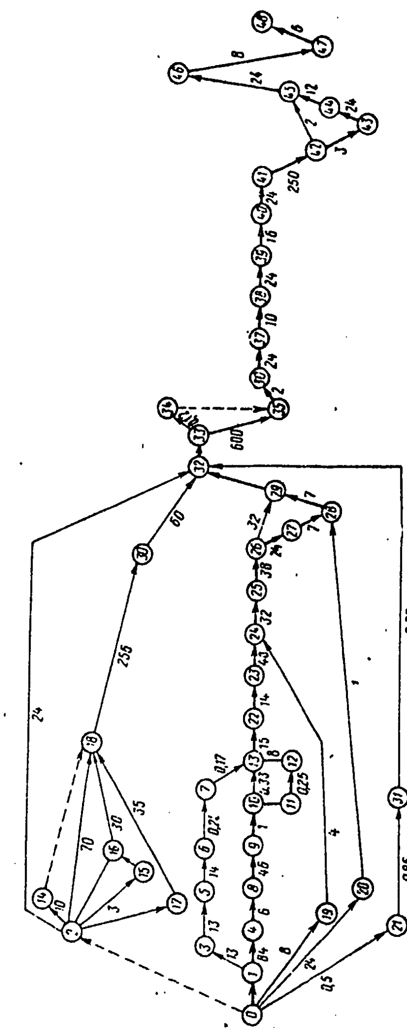


Figure 22. Network Schedule of Start-Up and Adjustment Work for A Chemical Fibers Plant

Figure 23. Network Schedule of Start-Up and Adjustment Work for an Ammonia Production Facility

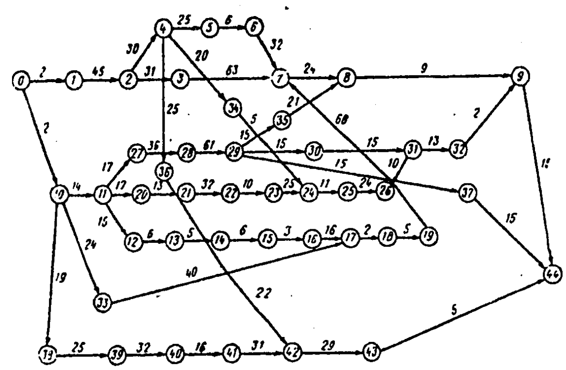
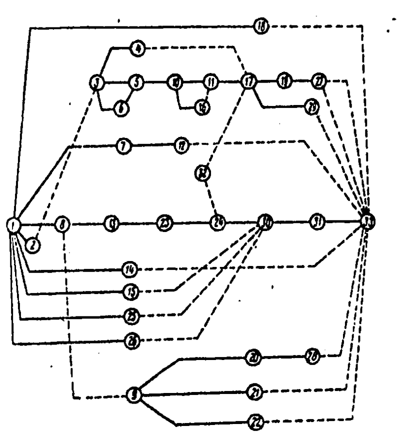


Figure 24. Network Schedule for Start-Up of a Thermic Phosphoric Acid Production Facility



3. Determining event (R_0) time reserves:

$$R_0 = T_{nj} - T_{pj}, \qquad (45)$$

where T_{nj} is the latest of the permissible schedules for accomplishing the event;
T_{pj} is the earliest possible schedule for accomplishing the event.

4. Finding the critical path in terms of maximally early time and minimumally late time for accomplishing events having a zero time reserve.
5. Determining the full time reserve for jobs R_{nij}, which do not coincide with the critical path:

$$R_{nij} = T_{nj} - T_{pi} - t_{ij}, \tag{46}$$

where T_n is the late time;
T_p is the early time;
i is the initial event of the job;
j is the final event of the job;
t_{ij} is the duration of the job.

6. Calculating partial time reserves for jobs where paths of differing duration intersect:
a) first type -- jobs following events at which paths intersect:

$$R'_{nij} = T_{nj} - T_{ni} - t_{ij}; \tag{47}$$

b) second type -- jobs immediately preceding events where paths intersect:

$$R''_{nij} = T_{pj} - T_{pi} - t_{ij}. \tag{48}$$

7. Using time reserves to restructure the schedule in order to optimize it.
8. Determining work strain factors (K_{nij}), used to judge the sequence in which the work is to be done, to judge how freely available reserves can be placed at one's disposal. The lower its value, the greater the relative reserves the given path in the network possesses:

$$K^{*}_{nij} = 1 - \frac{R_{nij}}{t(L_{\text{кр}}) - t'(L_{\text{кр}})}, \tag{49}$$

where $t(L_{\text{кр}})$ is the length of the critical path;
$t'(L_{\text{кр}})$ is the length of the segment coinciding with the critical path.

9. Determining early and late times for beginning and finishing individual jobs:
earliest possible time for starting a job $(T_{p.n.i.j})$ equals early time for the initial event (T_{pi});
latest permissible time for starting a given job $T_{n.o.ij}$ equals

$$T_{n\,n.ij} = T_{nj} - t_{ij}. \tag{50}$$

----
* See page 111 for the calculation for K_{nij} [formula (49)].

The earliest possible time for completing a job $T_{р.о.ij}$ equals:

$$T_{р.о.ij} = T_{рi} + t_{ij}. \tag{51}$$

The latest permissible time for completing a job $T_{п.о.ij}$ equals the late time for the final event $(T_{пj})$.

All the enumerated calculations are represented in the "Network Parameters" tables (Tables 36, 37, 38, 39).

Table 36. Network Parameters for Start-Up and Adjustment Work on a Polyvinyl Acetate Dispersion Production Facility

(1) Начальное событие i	(2) Конечное событие j	(3) Временная оценка $t_{ож}$	(4) Ранний срок свершения события $T_р$	(5) Поздний срок свершения события $T_п$	(6) Резерв времени событий R	(7) Полный резерв времени работы $R_{пij}$	(8) Частный резерв времени работы I порядка $R'_{пij}$	(9) Частный резерв времени работы II порядка $R''_{пij}$
0	1	2	2	2	0	0	0	0
0	2	2	2	5	3	3	3	0
0	3	2	2	11	9	9	9	0
0	6	3	3	11	8	8	8	0
0	7	3	3	6	3	3	3	0
0	18	3	3	61	59	59	59	0
1	4	4	6	6	0	0	0	0
2	5	1	3	6	3	3	0	0
3	6	0	2	11	9	9	0	0
3	8	0	2	57	55	55	46	0
3	14	17	18	45	26	26	17	0
4	7	0	6	6	0	0	0	0
4	8	0	6	57	51	51	51	0
5	7	0	3	6	3	3	0	0
5	8	0	3	57	54	54	51	0
6	9	29	32	40	8	8	0	0
7	10	12	18	18	0	0	0	0
8	19	10	16	67	51	51	0	0
9	11	13	45	53	8	8	0	0
9	14	0	32	45	13	13	5	0
10	12	3	21	21	0	0	0	0
10	13	3	21	53	32	32	32	0
10	16	3	21	53	32	32	32	0
11	6	0	45	53	8	8	0	0
11	20	4	49	69	20	20	12	0
12	14	24	45	45	0	0	0	0
13	16	0	21	53	32	32	0	0
14	15	6	51	51	0	0	0	0
15	16	2	53	53	0	0	0	0

(continued on following page)

Table 36 (continued)

16	17	7	60	60	0	0	0	0
17	18	2	62	62	0	0	0	0
18	19	5	67	67	0	0	0	0
19	20	2	69	69	0	0	0	0
20	21	6	75	75	0	0	0	0
21	22	10	85	90	5	5	5	0
21	23	15	90	90	0	0	0	0
22	23	0	85	90	5	5	0	0
23	24	3	93	93	0	0	0	0
24	25	6	99	99	0	0	0	0
24	27	15	108	119	11	11	11	0
24	26	17	110	110	0	0	0	0
25	27	20	119	119	0	0	0	0
27	29	36	155	155	0	0	0	0
26	28	39	149	149	0	0	0	0
29	30	6	161	161	0	0	0	0
30	31	4	165	165	0	0	0	0

Key:
1. Initial event
2. Final event
3. Time estimate
4. Early time for accomplishing the event
5. Late time for accomplishing the event
6. Event time reserve
7. Full job time reserve
8. Partial job time reserve, I order
9. Partial job time reserve, II order

Table 37. Network Parameters for Start-Up and Adjustment Work on a Chemical Fibers Plant

(1) Количество предшествующих работ	(2) Код работ ij	(3) Продолжительность работ t_{ij}	(4) Раннее начало работы $t_{ij}^{р.н}$	(5) Раннее окончание работы $t_{ij}^{р.о}$	(6) Позднее начало работы $t_{ij}^{п.н}$	(7) Позднее окончание работы $t_{ij}^{п.о}$	(8) Полный резерв работ $R_{пij}$	(9) Резерв времени событий R_i
0	0--1	720	0	720	0	720	0	0
0	0--19	8	0	8	909	917	909	0
0	0--20	24	0	24	992	1016	992	0
0	0--21	0,5	0	0,5	1057	1058	1057	0
1	1--2	0	720	720	727	727	7	0
1	1--3	13	720	733	819	832	99	0
1	1--4	84	720	804	720	804	0	0
1	2--14	10	720	730	787	797	67	0
1	2--15	3	720	723	764	767	44	0

(continued on following page)

Table 37 (continued from preceding page)

1	2—16	40	720	760	727	767	7	0
1	2—17	20	720	740	742	762	22	0
1	2—18	70	720	790	727	797	7	0
1	2—32	24	720	744	1079	1103	359	359
1	3—5	13	733	746	832	845	99	0
1	4—8	6	804	810	804	810	0	0
1	5—6	14	746	760	845	859	99	0
1	6—7	0,25	760	760	859	859	99	0
1	7—13	0,17	760	760	859	859	99	99
1	8—9	46	810	856	810	856	0	0
1	9—10	1	856	857	856	857	0	0
1	10—11	0,25	857	857	857	857	0	0
1	10—13	0,33	857	857	859	859	2	2
1	11—12	0,25	857	857	857	857	0	0
1	12—13	2	857	859	857	859	0	0
3	13—22	1,5	859	861	859	861	0	0
1	14—18	0	730	730	797	797	67	60
1	15—16	0	723	723	767	767	44	37
1	16—18	30	760	790	767	797	7	0
1	17—18	35	740	775	762	797	22	15
4	18—30	256	790	1046	797	1053	7	0
1	19—24	4	8	12	917	921	909	4
1	20—28	1	24	25	1016	1017	992	0
1	21—31	0,25	0,5	0,75	1058	1058	1057	0
1	22—33	14	861	875	861	875	0	0
1	23—24	46	875	921	875	921	0	0
2	24—25	32	921	953	921	953	0	0
1	25—26	32	953	985	953	985	0	0
1	26—27	24	985	1009	985	1009	0	0
1	26—29	32	985	1017	991	1023	6	6
1	27—28	74	1009	1083	1009	1083	0	0
1	28—29	7	1016	1023	1016	1023	0	0
2	29—32	80	1023	1103	1023	1103	0	0
1	30—32	50	1046	1096	1053	1103	7	7
1	31—32	0,33	0,75	1008	1102	1103	1101	1101
4	32—33	32	1103	1135	1103	1134	0	0
1	33—34	0,12	1135	1135	1134	1735	599	0
1	33—35	600	1135	1735	1135	1735	0	0
1	34—35	0	1135	1135	1735	1735	599	599
2	35—36	2	1735	1737	1735	1737	0	0
1	36—37	24	1735	1761	1737	1761	0	0
1	37—38	10	1761	1771	1761	1771	0	0
1	38—39	24	1771	1795	1771	1795	0	0
1	39—40	16	1795	1811	1795	1811	0	0
1	40—41	24	1811	1835	1811	1835	0	0
1	41—42	250	1835	2085	1835	2085	0	0
1	42—43	3	2085	2088	2085	2088	0	0
1	42—45	2	2085	2087	2122	2124	37	37
1	43—45	24	2088	2112	2088	2112	0	0
1	44—45	12	2112	2124	2112	2124	0	0
2	45—46	24	2124	2148	2124	2148	0	0
1	46—47	8	2148	2156	2148	2156	0	0
1	47—48	6	2156	2162	2156	2162	0	0

[Key on following page]

Key (to Table 37, preceding two pages):

1. Number of preceding jobs
2. Job code
3. Job duration
4. Early start of job
5. Early finish of job
6. Late start of job
7. Late finish of job
8. Full job reserve
9. Event time reserve

Table 38. Network Parameters for Start-Up and Adjustment of an Ammonia Production Facility

i	j	$t_{ож}$	T_{pi}	$T_{пi}$	R_{o}	$R_{пij}$
0	1	2	2	3	1	1
1	2	45	47	48	1	1
2	3	31	78	79	1	1
2	4	30	77	79	2	2
3	7	63	142	142	0	1
4	5	25	102	104	2	2
5	6	6	108	110	2	2
6	7	32	142	142	0	2
7	8	24	166	166	0	0
8	9	9	175	175	0	0
9	44	15	190	190	0	0
4	36	25	102	134	32	22
4	34	20	97	100	3	3
34	24	15	112	115	3	3
36	42	22	125	156	31	32
35	8	21	165	166	0	0
29	37	15	145	175	30	30
37	44	15	190	190	0	30
11	12	15	31	31	0	0
12	13	6	37	37	0	0
13	14	5	42	42	0	0
14	15	6	48	48	0	0
15	16	3	51	51	0	0
16	17	16	67	67	0	0
17	18	2	69	69	0	0
18	19	5	74	74	0	0
19	7	68	142	142	0	0
10	33	24	26	27	0	9
33	17	40	67	33	34	0
10	38	19	21	52	31	31
38	39	25	46	77	31	31
39	40	32	78	109	31	31
40	41	16	94	125	31	31
41	42	31	125	156	31	31
42	43	29	154	185	31	31
43	44	5	190	190	0	31

Table 39. Network Parameters for Start-Up and Adjustment Work for a Thermic Phosphoric Acid Furnace Shop

i	j	$t_{ож}$	$T_р$	$T_н$	$R_о$	$R_{пij}$	$R'_{пij}$	$R''_{пij}$	$T_{рнij}$	$T_{поij}$	$T_{роij}$	$T_{пнij}$
1	2	3	3	30	27	27	27	0	0	30	3	27
1	7	3	3	28	27	27	27	0	0	28	3	25
1	8	6	6	7	1	1	1	0	0	7	61	1
1	18	31	31	31	0	0	0	0	0	31	31	0
1	14	13	13	31	18	18	18	0	0	31	31	18
1	15	11	11	15	4	4	4	0	0	15	15	4
1	25	11	11	15	4	4	4	0	0	15	11	4
1	26	10	10	15	6	5	5	0	0	15	10	5
2	3	0	3	17	27	27	0	0	3	17	6	17
3	4	3	6	30	24	24	0	0	3	30	6	27
3	5	1	6	19	15	14	3	2	3	19	4	18
3	6	3	6	21	15	15	0	0	3	21	6	18
4	17	0	6	27	14	21	0	0	6	27	6	27
5	10	1	7	22	15	15	0	0	6	22	7	21
6	5	0	6	19	16	15	0	0	6	19	6	19
7	12	3	6	31	25	15	0	0	3	31	6	28
8	13	4	10	11	1	1	0	0	6	11	10	7
10	11	3	10	23	13	13	9	0	7	23	10	20

(continued on following page)

Table 39 (continued)

10	16	1	8	23	15	15	0	0	7	23	8	22
11	17	7	17	30	13	13	0	0	10	30	17	23
12	33	0	31	31	0	15	0	25	6	31	6	31
13	23	2	12	13	1	0	0	0	10	13	12	11
14	33	0	31	31	0	18	0	18	13	31	13	31
15	30	0	14	15	1	4	0	3	11	15	14	15
16	11	0	8	23	15	15	0	0	3	23	8	23
17	19	3	20	30	10	21	0	0	17	30	20	27
17	29	1	18	31	13	14	0	0	17	31	18	30
18	33	0	31	31	0	0	0	0	31	31	31	31
19	27	1	21	31	10	10	0	0	17	31	21	30
23	24	1	13	14	1	1	0	0	31	11	13	13
21	30	1	14	15	1	1	0	0	13	15	11	14
25	30	0	14	16	1	4	0	3	11	15	11	15
26	30	0	14	15	1	5	0	4	10	15	10	15
27	33	0	31	31	0	10	0	10	21	31	21	31
29	33	0	31	31	0	13	0	13	18	31	18	31
30	31	1	15	16	1	1	0	0	11	16	15	15
31	33	15	31	31	0	1	0	1	15	31	30	16

Network schedules can be computed not only in time terms, but also in terms of cost of carrying out individual work stages, anticipating the distribution of materials, energy and labor resources.

The use of network schedules for carrying out start-up and adjustment work enables us to determine precisely the amount of work and coordinate all the jobs anticipated by the program, their mandatory sequence and interconnection, the demand for resources at all work stages. The network model provides an opportunity to represent the entire program graphically, to determine the optimum path leading to the final goal, to substantiate the planned schedule for completing all work, to delineate the most important work and strengthen operational control over the course of carrying out that work, to distribute and maneuver resources correctly.

Various paths lead from the initial event to the final one; the longest of them is the critical path. In the diagram (Figure 21), it passes through events 0 1 4 7 10 12 14 15 16 17 18 19 20 21 23 24 25 27 29 30 31. Jobs 24-26 and 26-28 are not included in the complex of work to master the production facility and for that reason need not be taken into account when calculating the network schedule to choose the critical path.

To reveal the degree of strain in carrying out individual jobs with time reserves available, we derive K_{nij}.

Calculation of the strain factors:

$$t_{5-7} K_{nij} = 1 - \frac{3}{165-(165-6)} = 0{,}5;$$

$$t_{3-14} K_{nij} = 1 - \frac{26}{165-(165-45)} = 0{,}42;$$

$$t_{9-14} K_{nij} = 1 - \frac{13}{165-(165-45)} = 0{,}711;$$

$$t_{13-16} K_{nij} = 1 - \frac{32}{165-(165-53)} = 0{,}395;$$

$$t_{0-7} K_{nij} = 1 - \frac{3}{165-(165-6)} = 0{,}5;$$

$$t_{11-16} K_{nij} = 1 - \frac{8}{165-(165-53)} = 0{,}849;$$

$$t_{10-16} K_{nij} = 1 - \frac{32}{165-(165-53)} = 0{,}396;$$

$$t_{0-18} K_{nij} = 1 - \frac{59}{165-(165-62)} = 0{,}05;$$

$$t_{0-19} K_{nij} = 1 - \frac{51}{165-(165-67)} = 0{,}24;$$

$$t_{11-20} K_{nij} = 1 - \frac{20}{165-(165-69)} = 0{,}71;$$

$$t_{22-23} K_{нtj} = 1 - \frac{5}{165-(165-90)} = 0,445;$$

$$t_{24-27} K_{нtj} = 1 - \frac{11}{165-(165-119)} = 0,9075,$$

where t is the job designation.

In order to coordinate performing jobs and work stages in terms of time, labor and material resources, in addition to network schedules, the Orgkhim draws up mock-ups for similar production facilities. The mock-up is a graphic linking of the performance of construction-installation work for pre-start-up period work done by Orgkhim production subunits to jobs in the production start-up period and the capacities utilization period.

The availability of a mock-up enables us to anticipate the most responsible sectors, to plan the worker's job with a maximum load at each stage, and to blend work performance in time.

The initial data for drawing up the mock-up and distributing resources are:
a work organization plan and schedule of construction-installation work;
a start-up and adjustment work schedule for the start-up period, an agreement to do start-up and adjustment work, and the cost of the work based on a price list or on calculation;
the quantitative and skills composition of the production subdivision and its degree of participation in work stages in terms of time.

The mock-up of start-up and adjustment work organization must be used in the daily operational work of the production subunit. The complex of all work to be done is determined by the program, and the purpose of drawing it up is to improve the organization and quality of the work done.

The availability of mock-ups for each individual production facility enables us to merge a number of work stages for several production facilities at the same time and, in so doing, to lower expenditures on start-up and adjustment work. The savings in labor and material resources and in time in performing start-up and adjustment work can be judged by the given mock-up of work organization at sulfuric acid production facilities (Table 40, following page).

The drawing up of start-up and adjustment work organization schedules takes into account that they will be carried out in parallel, thanks to which it is possible to reduce these expenditures as against the normative as early as the planning stage.

It is evident from Table 40 that labor expenditures on start-up and adjustment work are 60 percent below the normative and that work cost is 53 percent below the normative.

Table 40. Comparison of Actual Data on Start-Up and Adjustment Work (PNR) for Similar Production Facilities to Normative Data

(1) Показатели	(2) Норматив	(3) Химический завод				(8) Другие предприятия	(9) Среднефактическая продолжительность работ	(10) Отклонения от норматива
		(4) Бийский	(5) Гомельский	(6) Уваровский	(7) Новокемеровский			
(11) Продолжительность пусконаладочных работ (в месяцах)*	34,5	21	21	26,5	29,5	30,5	26	8,5
(12) Число производственного персонала в пусковой период	55	38—52	25—62	8—22	12—24	16—34	—	—
(13) Человеко-дни	7343	4827	3903	955	2491	2704	2976	43 677
(14) Стоимость пусконаладочных работ, тыс. руб.	140	82,7	75,3	20,3	55,6	92,9	65,4	74,6

* Принимается по следующим периодам: инженерного надзора, освоения мощности.

Key:
1. Indicator
2. Normative
3. Chemical plant
4. Biyskiy
5. Gomel'skiy
6. Uvarovskiy
7. Novokemerovskiy
8. Other enterprises
9. Average actual work duration
10. Deviation from normative
11. Duration of start-up and adjustment work, in months
12. Number of production personnel in the start-up period
13. Man-days
14. Cost of start-up and adjustment work, in 1,000 rubles

----
*Adopted for the following periods: engineering supervision, utilization of capacities

One day of the start-up period accounts for an average of:

	normative	actual
work cost, in rubles	709	362
labor expenditures, in man-days	36	17

Analysis of actual data from the Orgkhim for a number of production facilities enables us to conclude that there are significant reserves for reducing the start-up period for sulfuric acid, ammonia, carbamide and compound superphosphate production.

Section 4. Economic Effectiveness of Reducing Start-Up Schedules for New Production Facilities

Reducing capital investment "lag," that is, the time from the start of the investment to its used in production in the prescribed amount, with optimum economic parameters, is of great importance in increasing the effectiveness of social production. In order to determine the average time capital investments are withdrawn from circulation during construction, V. V. Novozhilov recommends using the following formula:

$$T_0 = \frac{\sum_{t=1}^{T} K_t (T_0 - t_t + 1)}{K_0}, \qquad (52)$$

where T_0 is the average time capital investments are out of circulation during the construction period;

K_t is capital investments for a calendar year of construction, T;

t_t are calendar periods in which capital investments are made;

$(T_0 - t_t + 1)$ is the time separating year of investment from completion of construction;

K_0 is the estimated cost of construction.

In order to increase the intensiveness of the output reproduction process, the fixed assets reproduction cycle must be shortened. Academician S. G. Strumilin notes in "Faktor vremeni v proyektirovanii kapitalovlozheniy" [The Time Factor in Planning Capital Investments] that, in connection with technical progress, production assets depreciate with time by the value

$$C_T = \frac{C_0}{(1+p)^t}, \qquad (53)$$

where C_T is the value of the assets in the T-th year;

C_0 is the initial value of the fixed assets;

p is the annual increment in labor productivity nationwide;

t is the time which has passed since the initial appraisal of the assets.

In this connection, according to the "Standard Methods of Determining Capital Investment Economic Effectiveness," when solving the problem of choosing the most optimum variant in terms of construction schedules and distribution of capital investments by year, capital investments are, with consideration of referring to these expenditures in time at the moment the construction is finished:

$$K_T = \sum_{t=1}^{T} K_{t_t} (1 + P_{\text{п}})^{t_t}, \tag{54}$$

where K_T are capital investments for the entire construction period, T;

$P_{\text{п}}$ is the normative to determine expenditures at various times. Its value cannot be higher than the rates of increment in national income which have evolved (it equals 0.08 using the standard methods);

K_{t_t} are capital investments in the year of the expenditures.

When evaluating capital investment effectiveness with consideration of the influence of the time factor, expenditures and results relating to different periods of time are made comparable using this particular formula.

However, giving capital expenditures with consideration of the time factor cannot, under the Standard Methods, serve as a basis for changing the estimated cost of construction.

V. G. Kiyevskiy proposes taking the time factor into account when estimating construction cost as well.

A. I. Zavulunov notes[1] that expenditures given for a certain year do not anticipate mastering of the planned indicators of the enterprises being put into operation. In order to take expenditures and results of social labor into account more fully and to determine the national economic effectiveness of capital investments and the time needed to recompense capital expenditures, the author proposes that we calculate, with consideration of time expenditures on construction, the mastering of planned indicators and the period for reimbursement of the state for these expenditures using the formula

$$T_{\text{ок}} = aT_{\text{с}} + O_{\text{п.п}} + \left(\frac{K_0}{\Pi}\right), \tag{55}$$

where $T_{\text{ок}}$ is the time needed to recompense capital investments;

a is a factor describing the relative degree of capital investment "freezing" depending on the distribution of financing by year;

----

1. Handbook of scientific information "Metodika i praktika opredeleniya effektivnosti kapital'nykh vlozheniy i novoy tekhniki" [Methods and Practice of Determining the Effectiveness of Capital Investments and New Equipment], 20th Edition, Moscow, Izd-vo Nauka, 1972.

and T_c is construction duration, by year;

$O_{п.п}$ is the normative time needed to master planned indicators, in years;

K_o are capital investments in the project, in rubles;

$П$ is the annual profit of the facility after it is in use.

In A. I. Zavulunov's opinion, "normative schedules for recompensing capital investments or normative effectiveness factors should be established with consideration of full expenditures from the moment the financing starts."

Reducing the time needed to create new production capacities is an enormous reserve for increasing the effectiveness of social production. In order to calculate the size of the economic impact of accelerating the start-up of new capacities, we recommend use of the following formula

$$Э = E_н Ф_д \Delta T - \Delta K, \tag{56}$$

where $E_н$ is the normative capital investment effectiveness factor;

$Ф_д$ is the value of fixed production assets being put into operation;

ΔT is the period by which construction duration is reduced;

ΔK are additional capital expenditures needed to accelerate putting production capacities into operation.

This formula expresses the benefit over a certain time segment from putting new production into operation ahead of schedule by reducing construction time, with consideration of the additional expenditures needed to do this.

The time interval between making the capital expenditures and obtaining the full results of operating new production includes not only the construction period, but also the start-up and full mastering of its production and economic indicators.

But the practical determination of time needed to recompense capital investments is based on the proposal that an enterprise begins paying for itself immediately after construction is complete. Thus, the economic effectiveness of capital investments should, in our opinion, be calculated with consideration of expenditures of time on starting up production and on the economic mastering of production indicators.

An enterprise recompenses expenditures when planned capacity and output net cost have been fully mastered. The fact that the time involved in starting up and mastering newly operating production capacities is not reflected in the existing methods for determining time needed to recompense capital investments can only be explained by the fact that expenditures on the start-up and utilization are made through enterprise basic activity (it should be noted that they are financed even before the start of smooth output release as expenditures of future periods) and are not anticipated in capital expenditures. Even putting up a facility in the capital construction process does not enable one to begin operating it. The start-up process is an embodiment of the labor results of adjustment personnel.

K. Marx distinguishes two types of activity: that producing results, and that which does not create consumer values, that is, which is related to the services sphere. He writes: "A known kind of /services/, in other words: /consumer values/ which represent the result of known types of activity or labor embodied in /goods/, but other services, on the contrary, do not leave tangible results which /exist separately/ from the providers of those services; in other words, their result is not a /commodity suitable for sale/."[1] This kind of services includes technical assistance to enterprises in starting up new production on the part of specialized organizations. Start-up and adjustment work is a necessary element in completing installation work at a facility. At the same time, test start-up of a facility to produce the first lots of output is the start of the production facility's operation.

As the facility is put into industrial operation, production assets whose consumption value is not equivalent to their estimated cost by the amount of the additional expenditures necessary to improve them enter the production sphere. These means must be anticipated in capital construction estimates which serve as the basis for coordinating capital construction plans and schedules for starting up production capacities and putting them into operation.

The date on which the production capacities created are put into industrial operation following the finish of start-up and adjustment work is the start of the return on capital investments through the release of output and the receipt of profit.

Planning the scheduled putting of new facilities into operation reduces to an effort to obtain an economic impact in the briefest possible period in order to free needed resources for other projects. Accelerating putting a facility into operation is also important to retaining the innovativeness of the equipment and technology, to minimizing equipment obsolescence.

That variant which requires the least expenditures of time and ensures the earliest return on capital investments and the greatest profit over the depreciation period should be considered the most effective. Failing to consider the time factor leads to a scattering of capital investments, to drawn out construction, start-up and utilization schedules, and as a result, to significant losses for the national economy as a whole.

Losses connected with failure to release a facility promptly for industrial operation can, at the author's suggestion, be represented as follows:

----

1. K. Marx and F. Engels, "Soch." [Works], 2nd Edition, Vol 26, Part I, p 414.

1) in the form of amount of commodity output shortfall as a consequence of failure to put the facility into operation promptly:

$$B_т = \sum_1^n B_c Ц \Delta T, \qquad (57)$$

where $B_т$ is the amount of reduction in proposed commodity release for the time segment exceeding normative scheduled release of the facility for operation;

B_c is release in a 24-hour period for the entire products list of output (n);

$Ц$ is price per unit;

ΔT is the time by which normative schedules for releasing the facility for operation are exceeded;

2) in the form of amount of commodity output shortfall in connection with the incomplete utilization of production capacities put into operation at the moment they are released for operation:

$$П_т = \sum_1^n B_c K_м Ц T_o, \qquad (58)$$

where $П_т$ is losses of commodity output production as a consequence of lower production volume than planned;

$K_м$ is the production capacities utilization factor;

T_o is the period of capacities utilization up to the amounts outlined by the plan;

3) in loss of enterprise profit as a consequence of incomplete utilization of technical-economic indicators:

$$У_п = \sum_1^n B_c (Ц - C) T, \qquad (59)$$

where $У_п$ is losses of enterprise profit during the start-up and utilization of capacities, r ;

C is the net cost of a unit of output during the utilization of capacities;

4) in the increase in the amount of capital expenditures as a consequence of failure to start-up production capacities promptly and of the increase in the amount of time they are withdrawn from circulation.

Here, the losses are expressed in the amount by which the cost of capital expenditures $K_п$ is exceeded due to the time factor:

$$K_п = K_т - K_о. \qquad (60)$$

The effect of accelerating capacities start-up $E_{п.м}$ can be represented as the relationship of the additional cost of output produced as a result of shortened construction, start-up and utilization times to the expenditures involved to achieve this:

$$E_{п.м} = \frac{Д_п}{К_д + С_{пнр}}, \qquad (61)$$

where $Д_п$ is additional output produced during the period by which putting the production capacities into operation is accelerated;
$К_д$ is additional capital expenditures directed into reducing project construction time;
$С_{пнр}$ is expenditures of the start-up period.

The effect of reducing the start-up period $E_п$ can be expressed as the relationship of additional output produced due to start-up of capacities ahead of schedule as a consequence of reducing the start-up and utilization periods to start-up expenses:

$$E_п = \frac{Д_п}{С_{пнр}}. \qquad (62)$$

Reducing the time involved in building and starting up production and utilizing production capacities enables us to obtain a summary economic impact from accelerating putting the facility into industrial operation, which is expressed:

in increment in consumption values to meet national economic needs and in prompt provision of initial output from other types of production;

in additional enterprise profit;

in a reduction in the time capital expenditures are withdrawn from circulation;

in using the labor, materials and financial resources freed at other projects.

The time needed to recompense start-up expenses can be represented as the time in which these expenditures are replaced through profit at the newly operating enterprise:

$$T = \frac{С_{пнр}}{П}, \qquad (63)$$

where T is the recompensation time, in years;
$С_{пнр}$ are start-up expenses;
$П$ is annual profit,

$$П = П_1 M, \qquad (64)$$

where $П_1$ is profit per ton, in rubles;
M is enterprise capacity, in 1,000 tons per year.

The start-up expenses recompensation period varies within the following limits for different chemical industry production:

$$0,288 \leqslant T \leqslant 2,01.$$

The effectiveness factor also changes correspondingly

$$0,124 \leqslant E \leqslant 5,95.$$

This shows that each ruble of expenditures on starting up production accounts for up to 5.95 rubles of profit.

Nomograms can be used to show graphically the calculation of start-up period expenditures recompensation. They can be used to quickly evaluate the influence of any given variable in the value on the end result by means of a graphic depiction of functional dependencies.

In drawing up nomograms to determine the time needed to recompense start-up expenses (Figures 25, 26, 27), the author adopted as the x and y coordinate system the variables T and $C_{\text{пир}}$ (respectively); the size of the nomogram is 100x100 mm.

Figure 25. Nomogram to Determine Time Needed to Recompense Start-Up Expenses

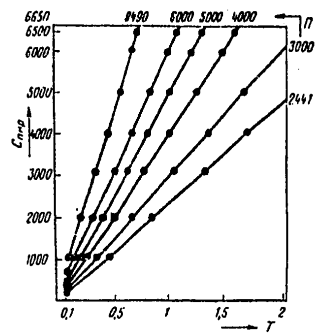


Figure 26. Nomogram to Determine Time Needed to Recompense Expenses on Start-Up and Adjustment Work (ammonia production facility)

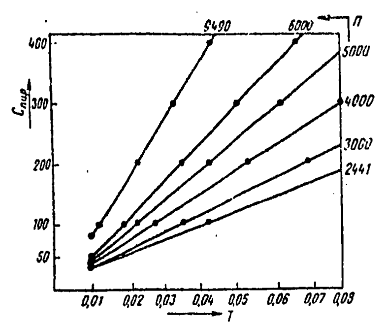
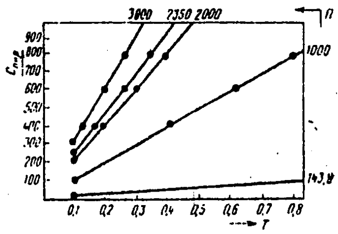


Figure 27. Nomogram to Determine Time Needed to Recompense Start-Up Expenses (sulfuric acid production facility)



The limits of change in variables for ammonia production are the following:

a) $0{,}288 \leqslant T \leqslant 2{,}01$;

b) $2441 \leqslant \Pi \leqslant 9490$;

c) $1060 \leqslant C_{\text{пйр}} \leqslant 6650$.

The moduli of the variables are:

$$M_{\text{т}} = \frac{100}{2{,}01 - 0{,}288} = \frac{100}{1{,}722} = 58 \text{ мм} = 5{,}8 \text{ см};$$

$$M_{\text{пр}} = \frac{100}{6650 - 1060} = 0{,}01 \text{ мм}.$$

Scales T_1 and $C_{\text{пйр}}$ are set up in terms of equations of variables:

$$x = M_{\text{т}} \cdot T = 58T;$$

$$y = M_{\text{пр}} C_{\text{пйр}} = 0{,}01 C_{\text{пйр}}.$$

The equation of the family of lines Π will have the form:

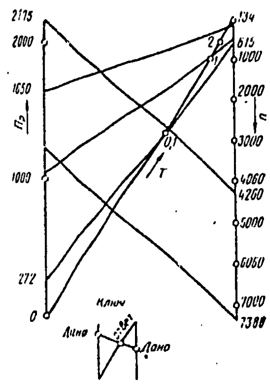
$$\Pi = \frac{C_{\text{пйр}}}{T}. \tag{65}$$

Introducing Π values sequentially, we obtain an equation of six straight lines (Figure 25). The family of variable Π is depicted by a bunch of straight lines passing through the start of the coordinates.

The nomograms determining the time needed to recompense start-up expenses for the chemical industry as a whole are represented in Figure 28.

In view of the fact that here, start-up expenses depend on the type of production and fluctuate within broad limits, it is appropriate to choose the following types of production (Table 41) in setting up the nomograms.

Figure 28. Nomogram to Determine Time Needed to Recompense Start-Up Expenses for the Chemical Industry



Key:
1. Key
2. Response
3. Given

Table 41. Start-Up Expenses for Chemical Industry Production Facilities

Продукт (1)	Прибыль, тыс. руб. (2)	Пусковые расходы, тыс. руб. (3)	Срок окупаемости пусковых расходов, годы (4)
(5) Аммиак	4260	2175	0,714
(6) Серная кислота	1569	770	0,477
(7) Кабельный пласт	609,3	680	1,114
(8) Переработка пластмасс	514	1056	2,15
(9) Карбамидные смолы	2439	854	1,05
(10) ПВХ пленка с подклеенным слоем	617	272	0,441
(11) Этилхлорсилан	1188	354	0,298
(12) Карбамид	3598	1710	0,476
(13) Фосфорная кислота	7380	1240	0,168
(14) Фосфорная мука	1431	620	0,432
(15) Целлафан	134	1650	1,231

Key:
1. Product
2. Profit, in 1,000 rubles
3. Start-up expenses, 1,000 rubles
4. Time needed to recompense start-up expenses, in years
5. Ammonia
6. Sulfuric acid

[Key continued on following page]

(Key to Table 41, continued from preceding page)

7. Cable sheet
8. Plastics processing
9. Carbamide resins
10. Polyvinyl chloride film with backing
11. Ethylchlorsilan
12. Carbamide
13. Phosphoric acid
14. Phosphate fertilizer
15. Cellophane

According to the data in the table, the limits of change in the values are the following:

a) $272 \leqslant C_{\text{пнр}} \leqslant 2175;$

b) $134 \leqslant \Pi \leqslant 7380;$

c) $0,168 \leqslant T \leqslant 2,15.$

We determine the modulus of the nomogram scales for time involved in recompensing start-up expenses for the chemical industry:

$$M_{\text{cпнр}} = \frac{200}{2175 - 272} = 0,105 \approx 0,1;$$

$$M_{\Pi} = \frac{200}{7380 - 134} = 0,027 \approx 0,03.$$

Length L of scales $C_{\text{пнр}}$ and Π are 200 mm.

Nomogram width $h = \frac{5}{7}\ 200 \approx 140$ mm.[1]

The equation of the third (planned) scale:

$$x_3 = h:(1 + Mc_{\text{пнр}})\, f_3, \qquad (66)$$

where $f_3 = T$.

When $f_3 = 1,\ x_3 = 32,4$ мм ; when $f_3 = 2,\ x_3 = 16,2$ мм.

When setting up the nomogram, we used the data from Table 42 [second page over]. The nomograms we propose can be used practically to preliminarily evaluate time needed to recompense start-up expenses in the chemical industry at the planning stage.

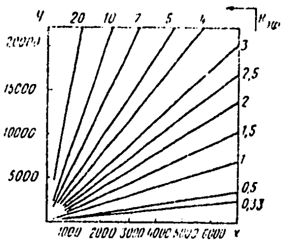
As the calculations show, the time needed to replace start-up expenses and expenditures on start-up and adjustment work by specialized organizations is not great. This testifies to the fact that expenses associated with the

---

1. Ordinarily, $h = \frac{5}{7}L$ is chosen.

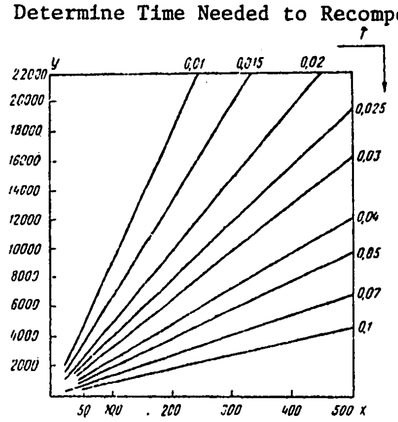
start-up of new production are insignificant in comparison with that revenue brought by putting chemical industry facilities into operation. The profit from these production facilities is 0.3 to 19 rubles per ruble of start-up expenses, and 12 to 40 rubles relative to Orgkhim expenditures on start-up and adjustment work, which is reflected in the effectiveness factors. We might also propose for practical use the nomograms for determining effectiveness factors for start-up expenses in the chemical industry (Figure 29) and for Orgkhim expenditures (Figures 30 and 31).

Figure 29. Nomogram for Determining Effectiveness of Start-Up Expenses for the Chemical Industry



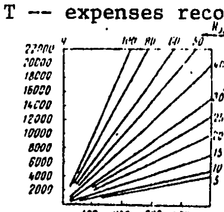
Key:
y -- profit; x -- start-up expenses

Figure 30. Nomogram to Determine Time Needed to Recompense Orgkhim Expenses



Key:
y -- profit; x -- start-up expenses; T -- expenses recompensation time

Figure 31. Nomogram to Determine Effectiveness of Orgkhim Expenditures



Key:
y -- profit; x -- Orgkhim expenses

Table 42. Calculating Recompensation Period and Effectiveness Factor for Start-Up Expenses, With Consideration of Start-Up and Adjustment Work

(1) Производства	(2) Предприятия химической промышленности	(3) Годовая прибыль, тыс. руб.	(4) Пусковые расходы	(5) Пусконаладочные работы	(6) Срок окупаемости		(9) Коэффициент эффективности	
					общий (7)	в том числе пусконаладочных работ (8)	общий (10)	в том числе пусконаладочных работ (11)
(12) Аммиак	Воскресенский (28)	2800	1730	156,1	0,618	0,558	1,633	17,9
	Новгородский (29)	5160	2020	380,4	0,3918	0,0736	2,552	15,58
	Ровенский (30)	2441	1730	60,8	0,708	0,0248	1,412	40,3
	Руставский (31)	3680	1060	257,8	0,288	0,7700	3,47	14,28
	Ферганский (32)	2800	2500	144,8	0,894	0,0517	1,118	19,34
	Черкасский (33)	9490	5600	411	0,591	0,0434	1,69	23,04
	Череповецкий (34)	3320	6650	258	2,01	0,0777	0,4975	12,87
(13) Серная кислота	Гродненский (35)	1960	616	144,8	0,315	0,0737	3,174	13,57
	Крымский (36)	2350	739,9	101,1	0,315	0,0431	3,174	23,2
	Новомосковский (37)	1174	555	16,3	0,476	0,0139	2	71,94
	Гомельский (38)	1174	555	74,5	0,476	0,0635	2,1	15,75
	Химический завод имени Карпова (39)	143,8	67,9	48,7	0,472	0,0338	2,119	29,58
	Уваровский (40)	1174	970	—	0,827	—	1,209	—
(14) Кабельный пластик	Нижнетагильский (41)	1569	770	83,4	0,477	0,045	—	—
		975	1089	—	1,114	—	0,897	—
		1340	1495	83,1	1,115	0,0621	0,897	16,1
(15) Переработка пластмасс	Нелидовский (42)	609,3	680	83,1	1,115	0,062	—	—
		616	1042	—	1,69	—	0,5917	—
		411	1070	—	2,61	—	0,3831	—
(16) Карбамидная смесь	Калушский (43)	514	1056	—	2,15	—	—	—
		2439	2559	75	1,05	0,0108	0,952	92,59

[Key on second page following]

(Table 42, continued)

(17) ПВХ пленка	Северодонецкий (44)	617	272	—	0,441	—	2,27	—
(18) Каустическая сода	Усольский (45)	1162	—	117,3	—	0,0101	—	99
(19) Этилхлорсилант	Усольский (45)	1188	354	—	0,298	—	3,35	—
(20) Капролактам	Гродненский (46)	22 790	5740	—	0,252	—	3,968	—
(21) Карбамид	Новгородский (47)	3598	2216	126,9	0,476	0,035	2,1008	28,3
(22) Фосфорная кислота	Воскресенский (48)	7380	1240	52,7	0,168	—	5,95	—
(23) Метанол	Ионавский (49)	253,9	2040	147,9	8,05	0,583	0,1242	—
(24) Фосфорная мука	Верхне-комсомольский фосфорный рудник (50)	143,1	620	—	0,432	—	2,314	—
(25) Сера комовая	Гаурданский (51)	2850	—	66,2	—	0,023	—	43,1
(26) Простой суперфосфат	Актюбинский (52)	7540	400	59,1	0,053	0,0078	18,79	128,2
(27) Целлофан	Балаковский (53)	134	1650	—	1,24	—	0,812	2

[Key on following page]

Key (to Table 42, preceding two pages):

1. Production
2. Chemical industry enterprises
3. Annual profit, in 1,000 rubles
4. Start-up expenses
5. Start-up and adjustment work
6. Recompensation period
7. Overall
8. Including start-up and adjustment work
9. Effectiveness factor
10. Overall
11. Including start-up and adjustment work
12. Ammonia
13. Sulfuric acid
14. Cable plastic
15. Plastics processing
16. Carbamide mixture
17. Polyvinylchloride film
18. Caustic soda
19. Ethylchlorsilant
20. Caprolactam
21. Carbamide
22. Phosphoric acid
23. Methanol
24. Phosphate fertilizer
25. Lump sulfur
26. Simple superphosphate
27. Cellophane
28. Voskresenskiy
29. Novgorodskiy
30. Rovenskiy
31. Rustavskiy
32. Ferganskiy
33. Cherkasskiy
34. Cherepovetskiy
35. Grodnenskiy
36. Krymskiy
37. Novomoskovskiy
38. Gomel'skiy
39. Chemical Plant imeni Karpov
40. Uvarovskiy
41. Nizhnetagil'skiy
42. Nelidovskiy
43. Kalushskiy
44. Severodonetskiy
45. Usol'skiy
46. Grodnenskiy
47. Novgorodskiy
48. Voskresenskiy
49. Ionavskiy
50. Verkhnye-Komsomol'skiy Phosphorous Mine
51. Gaurdanskiy
52. Aktyubinskiy
53. Balakovskiy

11052 END
CSO: 8144/1657