



RESEARCH ARTICLE

Evolution of the Maintenance and Repair System for Automotive and Tractor Equipment in the USSR

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Received: JUNE 06, 2026

Accepted: JUNE 23, 2026

Keywords

Internal combustion engine
 Technical maintenance
 Scheduled preventive repair
 Scientific management
 VIM
 Standard repair technology
 Standardization
 GOST 18322-78

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Introduction. The article presents a historical analysis of the evolution of approaches to the maintenance and repair (M&R) of internal combustion engines for automotive and tractor equipment, set against the backdrop of the development of scientific labor organization and the emergence of industrial production. The study traces the path from the foundational theoretical concepts of F.W. Taylor, who substantiated the necessity of distinguishing machine maintenance as a specialized managerial function, and H. Ford's ideas, which organized production as a continuous, standardized flow, to the establishment of a centralized system of scheduled preventive maintenance in the USSR. Materials and Methods. Particular attention is devoted to the work of the All-Union Institute of Agricultural Mechanization (VIM) in the 1930s. There, based on large-scale empirical research-including the micrometer measurement of parts from 300 controlled tractors and the collection of statistical data from 1,000 farms – the first scientifically substantiated maintenance regulations were developed. Results and Discussion. The article demonstrates that while the period of the Great Patriotic War caused a suspension of fundamental research, the post-war crisis, triggered by the catastrophic deterioration of machinery, provided a powerful impetus for the creation of the seminal work "Standard Repair Technology for Tractors and Combines" (1949–1953). This technology signified the transition from artisanal, brigade-based repair methods to an industrial, component-based repair approach and laid the institutional foundation for subsequent state standardization. The logical culmination of this process was the introduction of GOST 18322-78, which for the first time established a unified terminology and a system of concepts within the M&R sphere at the all-Union level.

INTRODUCTION

Over many years of use in mechanized systems for various processes, internal combustion engines have proven their efficiency and importance. However, for any mechanism, durability and reliability are among the most important factors. These factors can be improved by various methods and approaches. The main ways of improvement have included changes in manufacturing technologies, such as better materials for parts, improved manufacturing quality, and standardized inspection of parts. At the same time, improving the quality of maintenance and operating materials is also one of the most important factors.

With the development of scientific and technological progress, approaches to the operation of internal combustion engines, as well as the methods, means, and procedures for their maintenance, changed and developed.

The First Maintenance Regulations

The first clear regulations began to emerge with the formation of the first large production complexes and the transition from small private enterprises to large industrial complexes. This created a field for scientific research and practical work. The origin of the first works aimed at creating regulations is quite often attributed to American engineers. Frederick Winslow Taylor is

generally considered the founder of this approach.

Frederick Winslow Taylor stated that machine maintenance should be a distinct and specialized function, rather than a secondary task left to the discretion of the worker. In his system, a separate maintenance mechanic was responsible for repairing and maintaining equipment in working condition, rather than each individual machine operator. A machine had to be not merely operated, but regularly kept in serviceable condition. This corresponded to his general idea of scientific management: precise organization of labor, specialization, and control were to increase productivity and reduce time losses. Taylor described machine maintenance as a professional, planned, and separate managerial task essential for uninterrupted production.

The main followers of Frederick Winslow Taylor were Henry Ford and Harrington Emerson.

Frederick Taylor's ideas were built around one central principle: any work can and should be organized consciously and systematically. This requires a scientific approach involving full empirical study, observation, measurement, and precise analysis. One of his assertions was that every labor operation has an ideal way of being performed, that is, a standard. This standard must be identified and fixed. All workers must follow and implement it. To identify such standards, he introduced time studies, standardized the time required to perform operations, and standardized work methods so that each worker performed the task in accordance with a pre-established optimal method.

Taylor proceeded from the idea that low productivity is often associated with chaotic labor organization and improper motivation. He therefore proposed selecting workers for specific tasks, training them in correct methods, and establishing clear standards.

In practical terms, his approach led to a significant increase in productivity, clearer discipline, and more predictable enterprise performance. His ideas became the basis of the school of scientific management and strongly influenced the organization of modern management and production. Taylor in effect proposed making labor management as precise as an engineering calculation: measuring the process, standardizing it, training workers, and controlling execution so that the result would be systematic and achievable every day.

Henry Ford's ideas also tended toward labor rationalization, but the main emphasis shifted from the scientific organization of individual operations to the organization of the entire plant as a continuous flow. Ford set the goal of making machinery and production sufficiently accessible that the automobile would become a product for the masses rather than a luxury for the wealthy. To achieve this, he created a conveyor system that turned automobile assembly into a chain of simple, repeated operations carried out in a strict rhythm.

In his approach, the main factors were the speed of movement of the line, product standardization, and minimization of any time losses. Each worker performed only one element of the work, the machine and tool were adapted to the worker's movement, and the line itself set the rhythm in which the worker had to operate. This resulted in a radical reduction in assembly time, lower production costs, and the possibility of mass production of a technically complex product.

Ford divided labor and made it part of a unified flow in which the machine, tool, transport, and worker operated in a common rhythm. He focused on perfecting technology before launching mass production, rather than on constantly correcting shortcomings during the process. This meant that production had to be designed as a system in which every element was coordinated with the others and subordinated to the common goal of continuous, rapid, and low-cost output.

Ford transformed the scientific organization of labor into the organization of flow, in which the conveyor, standardization, and mass production became the main instruments of efficiency. His approach made production predictable, inexpensive, and scalable, and made machinery accessible to the masses. He created a model in which the plant operates as a unified system rather than as a set of separate workplaces, and in which success depends on precision, rhythm, and continuity of the process.

MATERIALS AND METHODS

The Emergence of the System: From Individual Solutions to Full-Fledged Regulations

The main reason for the emergence of regulations was the attempt to prevent the spontaneous nature of breakdowns. With the appearance of the first tanks, reliability became an acute issue. The military machine launched processes necessary for the transition from individual care to the first regulations, even at small enterprises, including those in the agricultural sector.

Large-scale studies began. The beginning of standardization can be associated with the appearance of the first sectoral standard, OST, in 1926. It described selected wheat grain varieties. Although this was unrelated to machines and mechanisms, it was an important stage in standardization. The All-Union Scientific Research Institute of Agricultural Mechanization, established in 1930, began studying the wear of parts of agricultural machines and preparing solutions for maintenance and repair. Thus, by 1930, several scientific works had appeared that became the basis of current maintenance regulations, and the first group of operating engineers was formed.

In post-revolutionary Russia, the issue of the food industry became acute. The period required mechanization of production. In 1929, the first trailed grain harvester appeared.



Figure 1: Stalinets-1 Grain Harvester, 1931

In 1930, the term MTS, or machine and tractor station, appeared. The main task of the MTS was to service agricultural tractors, traction engines, and combines.

Their appearance prompted the drafting of works such as Rules for Tractor Maintenance of 1932 and Rules for Tractor Maintenance and Field Repair of 1933. These pioneering treatises became the basis for subsequent works. A system of scheduled preventive repairs began to take shape. Empirical testing became its foundation.

Scheduled preventive repair is a system formed as a result of the data obtained. The first system included six maintenance items, divided into shift-based maintenance, analogous to daily technical maintenance, and periodic maintenance. In 1933, the system was reduced to five items by excluding some periodic maintenance items.

The methodological basis for the first regulations consisted not of engineering calculations, which were impossible because the designs of the machinery were borrowed, but of large-scale empirical studies. The key method was systematic observation of part wear under real operating conditions. For the SKhTZ tractor alone, 300 machines operating in 35 MTSs and at experimental stations in different climatic zones were monitored.



Figure 2: SKhTZ-15/30 Tractor

Every 300 operating hours, their parts were subjected to micrometric measurements according to a method first developed by L.G. Livshits, an employee of VIM. At the same time, extensive statistical data were collected: methodological instructions and unified tables for recording the service life of parts and cases of breakdowns were sent to 1,000 farms, and information on the most serious failures was transmitted to the institute by telegraph. In addition to failure statistics, the researchers deliberately summarized the best practices of the most successful tractor operators and mechanics, recording the content and frequency of the operations they performed. It was the synthesis of mass micrometric measurement data, technical and statistical accounting, and generalization of practical skills that made it possible to create the first scientifically based regulations within a short time.

RESULTS AND DISCUSSION

The Period of the Great Patriotic War. The initial period of the Great Patriotic War was marked by the almost complete cessation of planned research work in the field of technical operation of machines. Leading specialists of the All-Union Institute of Agricultural Mechanization (VIM), who had stood at the origins of the scheduled preventive repair system, were mobilized to the front. Among them were key figures who had determined the development of the sector in the prewar decade: S.A. Petrov, M.A. Lapitsky, A.I. Selivanov, and others. This led to the curtailment of fundamental studies of wear and part restoration processes, while the M&R system, which had only just taken shape in the form of the first regulations, remained unfinished.

Some of the scientific and teaching personnel evacuated to the rear regions of the country had to completely redirect their activity. They faced fundamentally different tasks far removed from theoretical research: accelerated mass training of machine operators to replace the men who had gone to the front and the development of operational technical solutions to assist the active army. For example, Professor V.I. Kazartsev in Kurgan and Professor I.E. Ulman in Chelyabinsk focused not on improving maintenance standards, but on solving applied wartime tasks. At the same time, the infrastructure of repair production in the occupied territories was completely destroyed. The buildings of many universities and laboratories were destroyed together with all experimental and test-bench facilities.

The main consequence of the wartime period for the M&R system was the critical degradation of the material and technical base and the catastrophic wear of the surviving machine and tractor fleet. By 1945, machinery was unable to perform its functions because of damage to the base surfaces of housing parts, while industry, reoriented toward military needs, could not replace losses with new machines. This acute crisis, however, served as a powerful impetus for the rapid development of repair technologies in the first postwar years. The need for the urgent restoration of hundreds of thousands of tractors and automobiles stimulated the creation of new methods for machining and restoring parts, which ultimately brought the domestic science of machine repair to a qualitatively new level.

Standard Repair Technology. A fundamental stage in the formation of the maintenance and repair system for machines in the USSR was the development and implementation of Standard Repair Technology for Tractors and Combines (1949–1953), which in its scale and significance had no analogues in the history of domestic repair production. This work, carried out by teams from leading research institutes (VIM, UNDIM, ChIMESKh, and VNIIMESKh) with the participation of manufacturing plants and advanced production workers under the general supervision of P.S. Kuchumov, comprised a set of 35 albums and books with a total volume of 2,200 printed sheets. The creation of such extensive documentation was dictated by the objective need to move from the then prevailing brigade repair method, characterized by the absence of documentation and labor specialization, to a progressive unit-based method based on the division of operations and the use of specialized equipment.

Structurally, Standard Repair Technology covered the entire production cycle of a repair enterprise and included schemes for organizing the production process, operation-by-operation process charts for disassembly, assembly, and adjustment, technical specifications for the inspection and defect identification of parts with tables of assembly fits, instructional guidelines for all types of machining operations, as well as lists of required equipment and drawings of nonstandard tooling

to be manufactured locally. A distinctive feature of this work was its comprehensive nature: for the first time, it systematized and coordinated not only technological methods and processing modes, but also standards for labor input, material consumption, and spare parts. This made it possible, for the first time in repair practice, to create a unified system of end-to-end standardization suitable for planning and accounting at enterprises of any scale.

The scientific significance of Standard Repair Technology was determined by the fact that it incorporated and summarized the enormous empirical material accumulated over the preceding decades. On the one hand, it reflected the results of many years of laboratory and field studies of wear conducted in different climatic zones of the USSR; on the other hand, it accumulated the advanced practical experience of thousands of machine operators and repair workers. It was precisely this synthesis of academic science and production practice that made it possible to formulate technically substantiated and at the same time practically feasible requirements that became a mandatory guide for all repair workshops and plants in the country. As emphasized in historical reviews, this document became a rich source for the further creative activity of thousands of new innovators.

The implementation of Standard Repair Technology had far-reaching organizational and economic consequences that extended beyond repair production itself. The widespread transition to the unit-based method using unified documentation reduced the time machines spent in workshops, increased labor productivity, and stabilized the wages of repair workers while also improving quality and reducing the cost of work. In a broader context, the creation of this technology laid the institutional and methodological foundations for the subsequent standardization of the entire technical operation system at the state level, preparing the ground for the introduction of all-Union regulatory documents such as GOST 18322-78, Maintenance and Repair System for Equipment. Terms and Definitions. Thus, Standard Repair Technology marked the end of the era of artisanal repair and the transition to an industrial model for organizing machine technical service.

The Appearance of GOST and the Current Maintenance System

The adoption of the first state standard regulating this field, GOST 18322-78, Maintenance and Repair System for Equipment. Terms and Definitions, became the most important milestone in the institutionalization of the technical operation system. This document, which incorporated many years of experience accumulated by sectoral science and previously summarized in Standard Repair Technology, for the first time at the all-Union level eliminated the terminological inconsistency that existed among different departments. It established unified, legally significant definitions of key concepts such as maintenance, current repair, major repair, and repair cycle, thereby creating a universal conceptual apparatus without which the further development and improvement of the entire scheduled preventive system would have been impossible.

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